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AN ANALYSIS OF THE PRICE BEHAVIOUR OF SELECTED VEGETABLES AT A
NEW ZEALAND AUCTION

A thesis presented in partial fulfillment of the
requirements for the degree of
Master of Business Studies
at Massey University

Stephen John Wright

1987

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I remember thinking, when I started this thesis, that someone, somewhere, had just finished one. It is nice to be finishing this thesis, and thinking that someone, somewhere, is just starting one!

ABSTRACT

The immediate and short run behaviour of prices and volumes of eighteen vegetables at auction are examined. The objectives were to describe the behaviour of weekly prices and volumes and to investigate various relationships.

The data analysed are weekly volume and turnover for eighteen vegetables at a Palmerston North auction for a three year period. Various climatological variables relating to the same period were also analysed.

Much of the descriptive analysis relies on the techniques of Exploratory Data Analysis; boxplots, letterplots, and a resistant smoother are used extensively. These methods facilitate the analysis of the behaviour of prices and volumes over time.

The auction marketing system is discussed at length, with particular emphasis on the effect of length of run on supply response.

Various relationships are examined predominantly using stepwise regression. These include: current price and quantity; current quantity and lagged price; quantity and month of the year; price and month of the year; price and various weather variables; quantity and various weather variables; current price and lagged price.

Some transformations are used to try to get a more linear relationship between price and quantity. This relied on fitting several resistant lines, another EDA technique.

The interdependence or interrelationship of prices was examined using Principal Components Analysis, and five principal components were extracted and described.

Some useful insights into the behaviour of the market are gained. Immediate run price variation, that is from week to week, is quite large and this is reflected in low R-squared values for the price-volume relationships. The relationship between current marketed volume and lagged prices was also investigated. The results indicate that in the immediate run, using weekly prices, this relationship is weak.

Arguably the most useful analysis was the monthly price boxplots which give a clear graphic display of the behaviour of prices. These and the other plots give indications as to when prices were highest and lowest. They may be useful to growers in planning production and harvesting.

It was discovered that weekly prices were more variable than weekly volumes for 10 vegetables, less variable for six vegetables, and equally variable for two vegetables. Often the highest weekly price did not coincide with the lowest weekly supply, and the lowest price did not correspond to the highest supply. This suggests that bidders under or over estimate the quantity on the floor and each other's requirements.

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CHAPTER 1 INTRODUCTION

1. Agricultural Price Analysis

There are two reasons for conducting research into the behaviour of prices. One aim is to explain and estimate the impact of certain variables on demand. For example, Tomek and Robinson (1981) state interest in estimating "specific economic coefficients (parameters) such as price and income elasticities of demand". Waugh (1964b) has pointed out that pricing studies contribute to the development of theories of demand.

Secondly, price analysis might provide "forecasts of prices or the variables affecting prices." (Tomek and Robinson, 1981). Waugh (1964b) comments that forecasts of future prices are needed by farmers to help them decide when to sell. Price forecasts could also help growers decide what to plant, when to plant, and when to harvest.

This study examines immediate and short-run price and quantity behaviour which might be useful for forecasting, although no formal forecast is made.

During the 1940s and 1950s much research was conducted on supply relationships in agriculture and there is a huge and diverse literature on the nature of agricultural supply. A useful review of this literature is provided by Tomek and Robinson (1977).

Heien (1977) notes that since the 1930s policy makers in the United States have been concerned with supply response, especially in relation to the problem of farm income. Tomek and Robinson (1977) point out that most research of this type has used time series data and single equation models estimated by least squares regression.

Much research on agricultural commodity prices deals with grains and livestock. More recently, some research dealing with fruit and vegetables has been undertaken. For example, Janssen (1978) studied short-range prices in German fruit markets, and Venzi (1974) applied time-series analysis to flowers and vegetables in Italy.

There are only a few studies dealing directly with the prediction of prices of vegetables at auction. For example, Lee (1973) analysed price formation at a New Zealand auction, and Goossens and Boddez (1986) examined price behaviour of vegetables at Belgian auctions.

2. New Zealand Vegetable Price Studies

Research concerning price formation of vegetables in New Zealand has been conducted by Enting et al (1965), Kitson (1968), Philpott and Bourke (1971), Ridler (1966) and Lee (1973). Lee (1973) suggests that the reason that little research has been conducted on short term price fluctuation is the "difficulty of obtaining and handling time series data." Another reason was the shortage of published statistical information on the vegetable industry. In fact, this data availability problem appears to be worsening, with collection of vegetable production and acreage figures by the Ministry of Agriculture and Fisheries being discontinued after 1982.

Studies of the price behaviour of fresh vegetables in New Zealand have found that prices at all distribution levels fluctuate considerably.

At the retail level, for example, 50 percent to 100 percent variations in the annual price per pound of cabbages were common in the period 1949 to 1964. Cauliflower retail prices behaved similarly, and the retail price of onions had an average annual fluctuation of 35 percent between 1950 and 1963 (Enting et al, 1965).

However, vegetable price fluctuations at auction were found to be even greater than at the retail level (Philpott and Bourke 1971).

Wholesale prices of onions in the years 1950 to 1963 had an average annual fluctuation of 54 percent, compared to the 35 percent retail price fluctuation previously mentioned. On the other hand, onion production levels, area and yield per acre had a lower average variation of 19 percent, 14 percent and 7 percent respectively. Intuitively, one can conclude that at that time, (and probably still), demand for onions was price inelastic.

The smaller price variations at the retail level have been attributed to the rigidity of fixed margins and marketing costs. Historically, retail prices have been flexible. According to Enting et al (1965), retail prices "sustantially reflect changes in the overall supply position between main crop seasons.....They may be more "sticky" as regards short term changes, such as week to week irregularity in auction supplies, but the variation in seasonal average prices undoubtedly indicates that the price mechanism does perform in some degree its function of clearing supplies of perishable produce." Kitson (1968) found that average retail margins ranged from 25 percent to 33 percent.

However, different factors explain changes in farm prices. Enting et al (1965) assert that retail margins were excessive and that their fixed nature contributed to farm price instability.

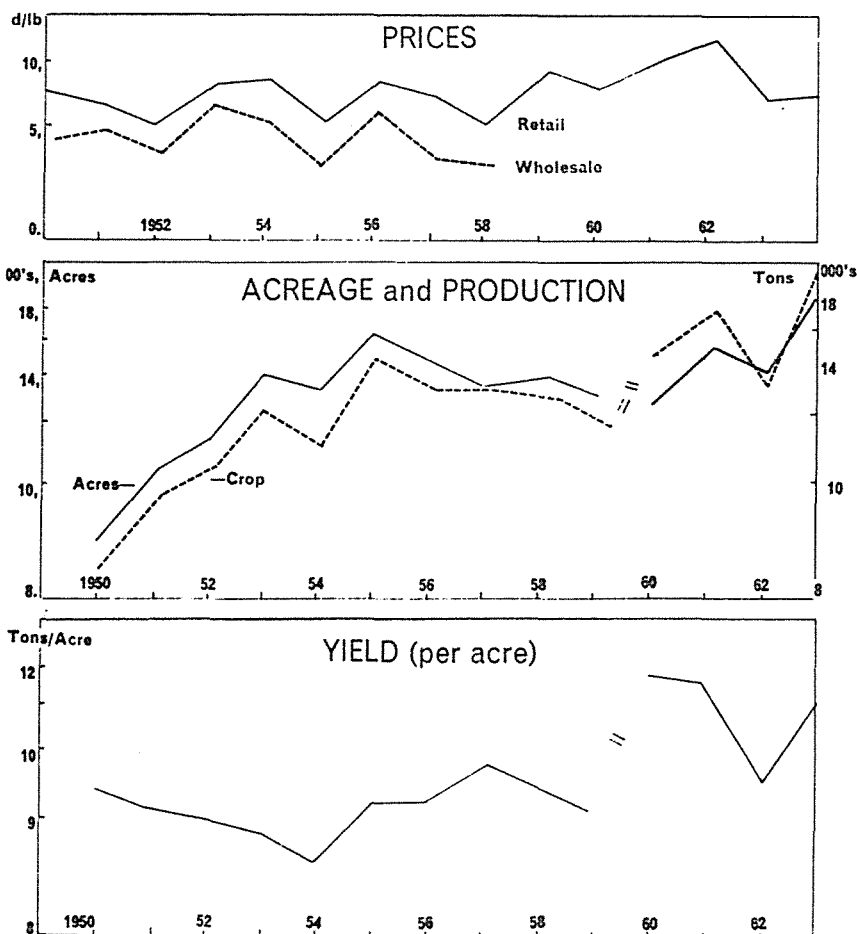
According to Ridler (1966), the volume which is supplied, the cost of marketing, and the flexibility of retail prices largely determine auction prices.

Enting et al (1965) found that the large variation in prices was not predominantly due to the effects of weather or other uncontrollable elements, but to changes in planned production. Examination of graphs of acreage, production, and prices for onions from the 1964 study by Enting et al (1965) reveal that acreage planted increases after a price increase and decreases after a price decrease. According to Enting et al acreage responds in general to the previous years prices and tends to move in the same direction. The writers of the report presume that the same might apply to other vegetables whose price behaves in a similar way to that of onions.

 ONIONS: Graphs from the 1964 study

ONIONS

Production and Prices in New Zealand 1950-64



However, Philpott and Bourke (1971) found that price changes were not followed by acreage changes in the same direction in the following year but that, for example, "a major price rise in 1965... (was)... followed by a reduction of onion acreage of some 100 acres in the following year." They found that when the retail price for onions was higher than the previous year, output was lower than the previous year, and that when prices were lower than the previous year, output was higher. They contend that low prices are primarily caused by variation in output, not by changes in demand.

3. The Effects of Price Instability

These farm price fluctuations are of particular concern for growers. In the 1964 study of the economic position of the fresh vegetable industry in New Zealand, the investigation panel had this to say about the market:

"The fresh vegetable market is subject to severe and unpredictable changes in prices, a situation which leads to social waste, prevents the efficient planning of production by the individual grower, and is the root cause of many of the difficulties for which the marketing system is blamed." (Enting et al, 1965).

Prices affect industry growth, the incomes and wealth of growers and auctioneers, the speed of growth, production decisions, and numerous other factors.

Daly (1958) notes that agricultural products have low price elasticity of demand and that when farm production differs much from quantity demanded growers experience considerable instability in prices and incomes.

Cochrane (1958) lists the problems of price variability as variable farm incomes, low incomes over extended periods, and uncertainty in planning production. He notes two types of price variability; price level fluctuations, which tend to be high during war years and boom times and low after wars and during recessions; and commodity price fluctuations. The first leads to an income problem in agriculture, the second leads to an uncertainty problem.

If prices are unstable, growers' gross incomes fluctuate. This has implications for financing decisions. An uneven cashflow will at times necessitate borrowing to finance production plans. At other times cash will be abundant and under utilised.

Seventy percent of the growers surveyed in the 1964 study financed operations out of current earnings, and this suggests that production plans change considerably.

Enting et al (1965) assert that the plans which are made as a result of price instability may tend to perpetuate instability. If prices are high and gross earnings are high it seems plausible that finance will be used to produce more of the high priced crop for the following season. Resources may be wasted because the marginal revenue may be greater from an alternative use of these funds, especially since the price is likely to fall when the resulting increase in production arrives at the market. Alternatively, when prices are low, planting may be cut back and investment reduced in what may be a growth product.

Rae (1976) asserts that instability obscures price trends and that this might subvert the efficiency of price as the director of economic resources. He also notes that price instability can result in over diversification.

4. Explanations of Price Instability

In the 1964 study of the fresh vegetable industry, Enting et al found that a third of growers reported withholding production from the market because of low prices. This points to overproduction as a possible cause of price instability.

However, in the same study the researchers concluded that there was no evidence to suggest that extreme overproduction was a major problem in the industry. ".the panel is of the opinion that instability of output and prices poses a much more serious problem for the industry than does overproduction" (Enting et al 1965, page 71).

At that time no downward trend in retail or auction prices was found among the vegetables studied. If this had been the case, it may have been that long-run supply was expanding at a greater rate than long-run demand.

Yet in a follow-up study Philpott and Bourke (1971) found that in general, from 1957/58 to 1968/69 vegetable production had increased while prices at wholesale had remained at about the same level. Using data mainly from Auckland markets, they found that auction prices of cabbage fluctuated more than for cauliflower, carrots, onions, or tomatoes. Sometimes cabbage prices at auction fluctuated by as much as 280 percent.

The table below indicates that in the five years to 1981 vegetable production increased in each successive year. More recent figures were not available.

 Table 1 Total vegetable production 1977-1981

	year ended March 31				
	1977	1978	1979	1980	1981*
gross production output value (\$ million nominal)	62	87	111	142	168
index of production volume output 1972 = 1000	884	1064	1091	1184	1204
index of production value	62	89	112	142	168
* provisional					

source New Zealand Official Yearbook 1983 pp 402-3.

Carson (1986) asserts that increased production has been necessary to maintain incomes. He claims that the industry is more concerned with improving efficiency and productivity (of existing lines) than with exploiting new opportunities. He cites tomato growers as examples of this "production - led" attitude.

Fluctuating supply levels are also identified as a probable reason for the wide variations in wholesale prices. Unstable supply supposedly leads to inefficient capital use and sometimes the need for emergency finance.

It is also, according to Enting et al (1965), responsible for unnecessary movement of firms in and out of horticulture, and loss of labour, manure, fuel, and use of land.

Carson (1986) comments that consumers' tastes have "widened from the restricted British conception of fresh food." Vegetables are being supplied to market which were not available commercially until recently. These include courgettes, capsicums, sprouting brocolli, and spinach.

He also asserts that tastes are no longer tied to a particular season, and many vegetables are now available throughout the year. This is probably true of tomatoes, lettuce, capsicum, spring onions, cabbage, cauliflower and others. The use of new varieties of vegetables means that it is now possible to extend seasons and to increase yields. Lettuces were once a summer vegetable only. Now they are available all year.

To maintain viability in light of these consumer trends, and more aggressive retailing, growers have improved productivity and have invested in new production methods. But according to Carson real returns from fresh vegetables are declining.

5. Growers' Response to Price Instability

Not only are farm price fluctuations seen as undesirable by growers, but also growers appear ill-equipped to take preventative measures in an attempt to reduce the risk involved.

Enting et al (1965) reported that for onions growers did not know that the peak or trough price had been reached and that it took some time for them to react. Interestingly, production of onions was still rising after a history of falling prices between, among other periods, 1956 and 1958.

It seems that most growers only perceive variation within a short time period, perhaps a week or a month. Perhaps they are not clear about the behaviour of prices over a longer period to time. This suggests that growers do not really know much about the seasonality of prices. They certainly are aware of the seasonality of production.

Yet, wholesale prices can be very useful to growers. In the short term they enable growers to decide how much to harvest and, sometimes, which competing market to sell in. If the grower has a choice between regional markets, or if he has the option to sell direct rather than on the auction floor there may be occasions when it is more profitable to do so.

In the longer term, prices help the grower decide his product mix and the level of investment. It would be foolish to invest heavily in pest destruction, for example, if the price of the affected crop was relatively low.

Cochrane (1958) notes that the full impact of retail price changes is felt at the producer level rather than at later stages in the distribution chain because of the fixed nature of marketing costs and margins. Yet growers have taken few steps to reduce the power of retailers over price formation.

The New Zealand Vegetable and Produce Federation (Inc) has acted on behalf of growers in an attempt to improve their influence on prices. Its activities have included lobbying retailers to discourage direct buying, stimulating primary demand at the consumer level through advertising, and research into vegetable marketing. This, however, is the only attempt to act collectively, and most growers' incomes are determined by their independent decisions.

Cochrane (1955) discusses the role of price uncertainty in production decisions. Growers are always uncertain of the prices which will be received for their crops at a future time. He notes that in seeking to minimise risk, growers will restrict the production of crops for which prices are very uncertain. Further, he asserts that new production methods and technology which require considerable resources will be adopted more quickly when prices are certain than when they are uncertain.

Rogers (1970) comments that supply is likely to be more uncertain in industries which are not very concentrated, which have generally undifferentiated products, and to which entry is not very restricted. This is largely due to fragmented decisions about output.

Not only are production decisions fragmented but also harvesting decisions are fragmented. Many growers might put forward or delay harvesting due to price conditions, which may contribute to price instability.

Finally, a grower might seek to increase revenues by supplying markets other than the local auctions. Additional transportation costs must be considered, but the higher price obtainable due to shortages may still make a distant market more attractive. Where many growers follow this option price instability will be caused.

Enting et al (1965) assert that in total, consumers and growers will not benefit from this so called "market chasing", since it may worsen price instability. They claim that for the majority of growers, it would be uneconomical to transport perishable production to distant markets. This practice is common in the 1980s, although not necessarily economical. Enting et al believe that any redistribution between regional markets should only be undertaken by auctioneers and large growers, for whom it might be profitable. Indeed auctioneers do act in this way to alleviate regional surpluses and shortages.

6. Summary

It is clear that vegetable prices are uncertain and subject to considerable instability. This affects production plans, incomes, cash flow, rates of return, and the adoption of new technology by growers.

Growers are faced with making production, harvesting and supply location decisions under great uncertainty, and appear to make little use of wholesale price and other data to reduce this uncertainty.

CHAPTER 2 OBJECTIVES

A better knowledge of immediate-run price and volume behaviour at a fresh vegetable market might be helpful to growers when making decisions about harvesting, production and which market to supply.

The objectives of this study are:

1. to describe the weekly and monthly price behaviour of various vegetables at a Palmerston North auction market
2. to investigate some of the factors which are believed to influence the price of vegetables at auction in Palmerston North. These were the quantity marketed, weather, price interrelationships, and past prices.

The study focussed on weekly price and quantity observations for eighteen vegetables over three years. Missing data meant that certain types of analysis used in the latter stages of the study were not performed on three vegetables: brussels sprouts, spinach, and leeks.

CHAPTER 3 RESEARCH METHOD

The method employed could be described as a teasing-out of the data to gain an understanding of the underlying behaviour. It focusses on prices at Arlidge Brothers Limited, one of the two produce auction markets in Palmerston North.

1. Consideration of the marketing system for fresh vegetables

First, a review of the literature concerning the marketing system was conducted and the effects this has on prices were considered.

Many visits were made to the market to observe auctions in process, and the functioning of the market was discussed with Mr Peter Arlidge, managing director of Arlidge Brothers Limited.

2. Exploratory data analysis

Next, for each vegetable some non-technical considerations of growing conditions are discussed. This gave indications as to how prices might be expected to behave. This was followed by a description of the behaviour of price and volume using the methods of Exploratory Data Analysis (Tukey 1977 and Velleman and Hoaglin 1981).

These techniques do not appear to have been used previously in the literature relating to analysis of agricultural product prices.

Stem-and-leaf displays were used to identify outliers and to search for discrepancies in the data. A number of errors were corrected. Some of the outliers which appeared to be data errors were in fact true values and often occurred in the two weeks prior to Christmas. The price and volume stem-and-leaf displays are not reproduced in this report.

Boxplots and Letter plots were used to display the series. A resistant smoother was used to smooth the series; this is discussed later in this chapter. Patterns were searched for and described.

High quality plots were produced both for the original and the smoothed volume and price series using the interactive SPSS graphics package, SPSSGRAF. The results of this part of the study are given in chapters 6 and 7.

3. Regression

1. Ordinary least squares regression was used to estimate the relationships of interest. These are described below.

a) Current price was regressed against current volume under the assumption that current price was largely determined by current volume marketed. This relationship was also estimated using logarithms and other transformations of the price and quantity variables. See chapter 8.

- b) Current volume was regressed against various lagged prices under the assumption that lagged prices cause volume marketed to change, either as a production response if the lag is long, or as a harvesting response if the lag is short. See chapter 8.
- c) Current price and volume were also regressed against various weather variables including an aridity index. Both current and lagged values of the independent variables were used. This is reported in chapter 10.
- d) Current price was regressed against prices with varying lags to determine how useful past prices might be at predicting current price. The autocorrelation function for the price of each vegetable was also produced; this was expected to reveal seasonal price patterns. Only the first four weeks and quarterly lags have been included. This is reported in chapter 11.
- e) Current price and quantity were regressed against month of the year to see if this could aid prediction of prices and volumes.

No attempt was made to arbitrarily define weeks as belonging to a particular season as there was no satisfactory manner of doing this. Quite detailed knowledge of climate patterns and growth requirements would be required to do this satisfactorily. The data were aggregated on a monthly basis and price and volume were regressed against months, each month being treated as a dummy variable.

Lee (1973), McIntosh and Hawkins (1971), and White and Nicholson (1984) for example, incorporated seasonal dummy variables in supply models.

Suits (1957), Tomek (1963), McIntosh and Hawkins (1971), and Nie et al (1975) discuss the incorporation of dummy variables in regression models. Only 11 dummy variables were included but SPSSx REGRESSION automatically drops one of the dummies if their number is equal to the number of categories. This is reported in chapter 12.

2. The stepwise procedure was used to identify the subset of independent variables which were best at predicting the dependent variable, when the relationship was unclear or there were many possible independent variables.

All regressions were conducted assuming linear relationships. An attempt was made to improve the linearity of the relationship between price and quantity for some of the vegetables. This was done by fitting a resistant line to the data and then transforming the variables in the manner suggested by the resistant line and resulting half-slope ratio. This is discussed in more detail in chapter 8.

3. The models estimated were evaluated by referring to adjusted r-squared, the F statistic, and the significance of the F statistic.

The measure of the proportion of variation in the dependent variable explained by the variation in the predictor variables is the coefficient of multiple determination, R-squared. In general, adjusted R-squared was used to measure the goodness of fit of the given model.

R-squared is calculated as:

$$R^2 = \frac{\text{total sum of squares of regression}}{\text{total sum of squares in dependent variable}}$$

Adjusted R-squared essentially makes the same calculation but explicitly takes into account the number of predictors in the model, and the sample size.

It is calculated as:

$$\text{Adjusted R-squared} = R\text{-squared} - [p(1-R\text{-squared})/(n-p-1)]$$

where n is the sample size, and p is the number of predictors in the model.

Using adjusted R-squared recognises the fact that R-squared is calculated from a sample and that the model will not fit the population as well as it fits the sample it is derived from.

A test of the statistical significance of the entire model is given by the significance of the F-statistic, which tests for a linear relationship between the dependent variable and all of the independent variables. It tests how well the model fits the data if the assumptions are met. The significance associated with the F-statistic gives the probability of getting the calculated value of F by chance. The F statistic takes into account the number of predictors used to estimate the relationship. Since F is calculated as mean square regression divided by mean square error, the greater the proportion of variance explained by regression, especially when this has required relatively few predictors, the greater the value of F.

SPSSx prints the t statistic and its associated two tailed significance level for each independent variable. This tests the hypothesis that there is no linear relationship between the particular independent variable and the dependent variable. The observed significance level gives the probability of obtaining a given t value by chance. Where this significance level is less than .05 it means that the relationship is significant at the 95 percent level.

Any significance probability greater than 0.05 means that the probability that a given partial regression coefficient, or regression coefficient, is equal to zero is rejected at the 95 percent level of confidence.

The stepwise procedure automatically excludes variables which have partial coefficients which do not meet the 5 percent significance test. Variables are entered if their probability of F is less than .05 and then all entered variables are re-examined and are removed if their probability of F, which is the probability of retaining the hypothesis of no linear relationship, exceeds 0.10.

This is useful as, for instance, Haitovsky (1969), demonstrated that adjusted r-squared is maximised by removing predictor variables with t-values less than 1.

For the relationship between price and quantity, and the logarithms of price and quantity, regression coefficients, constants, and the standard error of the coefficients are presented.

The smaller the standard error associated with a given regression or partial regression coefficient, the more confidence we can have in those coefficients.

Intercorrelations amongst the independent variables, or multicollinearity, is dealt with in SPSSx REGRESSION by calculating the minimum tolerance for each independent variable with the other independent variables as each is entered and excluding those which have small tolerance values. In effect, independent variables are regressed against each other, and those with high values for r-squared are excluded. (Norusis 1983).

Another problem to be considered is the existence of pattern in the residuals. This would suggest that a given model had been misspecified and may cause problems in interpreting the regression models.

Cochrane and Orcutt (1949), Box and Jenkins (1970), and Nelson (1973), suggest differencing to remove serial correlation.

Durbin and Watson (1951) formulated bounds for a test of the hypothesis that there is no time dependence between residuals, that is, $d=0$. Lee (1973) notes that when the sample size is greater than 100 the Durbin-Watson test is only an approximate test of autocorrelated residuals.

The tables of the D statistic given in Durbin and Watson (1951) indicate that for a sample size of 100 at the 5 percent level of significance d_L and d_U are:

number of predictors	d_L	d_U
1	1.65,	1.69
2	1.63,	1.72
3	1.61,	1.74
4	1.59,	1.76
5	1.57,	1.78

Gunst and Mason (1980) give the decision rule as; reject the null hypothesis if $D < d_L$, do not reject the null hypothesis if $D > d_U$, and draw no conclusion if $d_L < D < d_U$.

They outline two difficulties in applying the Durbin-Watson test. The first involves the problem of the observed value falling between the upper and lower bounds, and the second involves questions as to whether a model is correctly specified.

Nerlove and Addison (1958) note that if there is no serial correlation in the residuals the D statistic is approximately 2. Positive serial correlation tends to be indicated by values of D less than 2, and negative serial correlation by values greater than 2.

Lewis (1975) demonstrated that the Durbin-Watson statistic was of little value and points out that autocorrelation may not be of serious concern. Griliches (1967) points out it if it is used it should be used with caution.

It was expected that residuals would be serially correlated however this was not examined because the primary purposes of this research was exploratory and descriptive, rather than being a model building exercise. The Durbin-Watson statistic was given for many of the models but no comments have been made about it.

The main assumptions in using regression are:

1. that there is a causal relationship between the dependent variable and the predictor variables in the model. This is examined by considering the logic in specifying a particular model.
2. that the relationship between the dependent variable and each predictor variable is linear, or has been transformed to linearity. A low R-squared may indicate non-linearity, but this should first be examined by plotting each predictor against the dependent variable. This was done for the price volume relationships only.
3. that for a given value of a given predictor variable the values of the dependent variable are normally distributed with constant variance. This is a problem when the sample size is small. For this reason lagging was restricted to 52 weeks.

4. predictors are assumed to be independent. SPSSx REGRESSION automatically tests for this.

4. Principal components analysis

Principal components analysis was used to explore the interrelationship between current prices of the vegetables. This is reported in chapter 9.

5. Which price variable?

Askari and Cummings (1977) point out that the analyst must know what it is a farmer might do in order to specify the price variable. They suggest four possible price variables; the price received by farmers, a ratio of price received to some consumer price index, a ratio of price received to the costs of inputs, and a ratio of price to price of competing crops.

The price series were not deflated. Tomek and Robinson (1981) point out that if forecasts are required for production planning, they should be of the original values rather than being seasonally adjusted.

In this case, since emphasis is on the immediate run decisions of harvesting and distribution, nominal prices were used. Indications are given as to what nominal prices have been in certain weeks and months in the years under review.

6. Econometric model

No attempt was made to model the market system formally as this was not the objective and an entirely different methodology would have been employed. Information from both markets would need to have been collected, as well as more detailed information on planting and harvesting dates. Imports from other regions would need to have been accurately known, as well as many other variables.

7. Classical time series analysis

The high variability in price behaviour from week to week, and for the same week in different years, suggested that time series methods would have been of little use. If the series had been considerably longer, or variables were more aggregated, time series methods might have been employed. As it was, they were used in a fragmented manner.

8. The Data

The data were taken from computer printouts which were made available by the auctioneers, Arlidge Brothers Ltd. They spanned a period of 161 weeks and were summaries of weekly trading. The earliest available observations were for the week ending 5 March 1982. The data set ends on the week ending 29 March 1985.

Values for turnover, cumulative turnover to date, volume, and cumulative volume to date as at the end of each week were recorded for each of the eighteen vegetables in the study. Observations represented the full week's trading.

The price per case was calculated under the following assumptions:

1. a case was a constant unit of measurement
2. turnover per case was the best estimate of weekly price

The analysis assumes that turnover per case is a good estimate of the average price per case for the week in question. Mean price was calculated as dollar turnover in a week divided by the number of cases sold in that week. Variation within and between daily prices was not taken into account. Median price or modal price may have been better because prices can vary enormously during a day and within a week and large outliers can affect the mean considerably. Neither modal nor median price for a week were available. It should be recognised that the price calculated in this manner may have never actually have been received by growers.

Observations made at the auction market revealed that on occasion poor quality produce fetched as little as 10 percent of the price of the best quality produce. No data on quality were available. No distinction was therefore made between different levels of quality and no distinction was made between different varieties of the same vegetable.

The price variable thus represents an average price, for all produce of a particular line, regardless of quality and size variation, in a given week.

The auctioneers stated that for the three years in the study case size had remained constant.

Originally the data were recorded as weekly blocks. Each block contained the turnover and quantity values for each vegetable for a particular week.

This data set was rearranged and nineteen new data sets were produced. Eighteen of these were separate data sets, one for each vegetable, arranged chronologically. Each of these was then read by MINITAB and a separate worksheet for each vegetable was created.

The other data set was a file in which every eighteenth case contained a successive week's observations for a given vegetable. Each case contained values for cases sold, cumulative cases sold year to date, turnover, and cumulative turnover year to date for a particular vegetable for a given week. This data set was read by an SPSSx command file and an SPSSx system file was created.

MINITAB was primarily used for its EDA capabilities. SPSSx was used for estimating the relationships of interest and for exploring price interrelationships.

A complete listing of the single data set containing the values for all vegetables is not included due to confidentiality requirements of the auctioneers.

Weather data were supplied by Dr John Brock of the Grasslands Division, Department of Scientific and Industrial Research, Palmerston North. These data were average daily maximum and minimum air temperature, average daily rainfall, and average daily direct sunshine hours, for a given week. They were collected on the southern side of the Manawatu river near the DSIR complex.

The mean weekly air temperature was calculated by averaging the minimum and maximum daily air temperature for a given week. The weekly total rainfall was calculated by multiplying the week's daily average rainfall by seven. Direct sunshine hours was used in its original form.

A listing of the week numbers and the actual week end dates they correspond to is given in appendix 8.

9. Smoothing

The aim of smoothing was to remove the effects of random variation in each series thus revealing its underlying components.

There are many smoothing methods. Perhaps the simplest and most widely known are moving average smoothers, Mendenhall and Reinmuth (1982) Anderson, Sweeney, and Williams (1984).

A moving average smoother results in a smoothed series with M-1 less observations than the original series. M is the span of the smoother and refers to the number of observations which are averaged. The loss of M-1 observations occurs equally at the beginning and end of the series.

Tukey (1977), Velleman (1980) and Velleman and Hoaglin (1981) advocate using running medians as smoothers. The running median is particularly useful as it is resistant to outliers. Means are dominated by outliers, especially when the number of observations participating in the mean is small, say three or four, and the outlier is quite large relative to its surrounding values.

Median values are calculated on the basis of the depth of the median in an ordered batch or segment of a series, rather than on the basis of time order, which is the case for moving average smoothers. The depth of the median is given by $d(M) = (n+1)/2$, so the median of a segment is the $(n+1)/2$ th observation when the segment is placed in order of magnitude rather than sequence of time.

Velleman and Hoaglin comment that running medians of 3 or 5 are "fairly heavy-handed", that is they smooth the random variation considerably. They observe that, compared with running medians of 3, running medians of 5 or more are in general smoother but are less like the original series.

A running median of 4 was shown to be "slightly gentler" than running medians of 3 or 5, but requires the additional step of recentering.

It was decided to use the EDA smoother because of the nature of the weekly observations. Outliers dominate any pattern in the series and inspection of the original price series revealed that there were many outliers.

The EDA smoothers available in Minitab version 5.1 are the default, 4253H,twice; and 3RSSH,twice. Velleman and Hoaglin refer to these as compound smoothers.

Problems occur in producing smoothed values for the beginning and ending values of the series, and these are dealt with by special methods, which are discussed in Velleman and Hoaglin.

4253H,twice was used to smooth the price time series for each vegetable. Velleman and Hoaglin (op cit p 171) assert that this particular smoother has been found to be quite good. The resulting smoothed series made the pattern of price behaviour of all vegetables under study considerably easier to detect.

The smoother 4253H,twice involves six operations. The original series is first smoothed using a 4 week running median. Next, this series is recentered using a running median of span 2.

This series is then resmoothed using a running median of 5 weeks, the result of which is then resmoothed using a running median of 3 weeks.

The resulting series is then smoothed using a smoother developed by Hann as cited in Velleman and Hoaglin (p 167-70). The Hanning smoother is a weighted moving average denoted by H. In version 5.1 of Minitab it takes the form;

$$z(t) = .25y(t-1) + .5y(t) + .25y(t+1)$$

Tukey, and Velleman and Hoaglin refer to data being made up of the smooth and the rough i.e., $\text{data} = \text{smooth} + \text{rough}$. They comment that running median smoothers generally smooth too much and that the rough should be smoothed and added back to the smoothed series.

The final procedure in the 4253H, twice smoother is the smoothing of the rough which is then added back to the 4253H smoothed series. This operation is referred to as twicing.

Median smoothers with larger spans can resist more outliers than those with small spans. However, it is unlikely that there will be more than two outliers adjacent to each other.

The smoother 3RSSH,twice was also used for comparative purposes. It was no better than the default and has not been included in this report.

Smoothing a time series which has missing values is simple if they occur at the beginning and end of the series. Four of the vegetables under study had missing observations. To be smoothed, the series with missing values had to be closed-up.

Values were inserted in the original series so that they could be smoothed.

At this point it was decided to exclude brussels sprouts, leeks, and spinach from certain analyses. It was decided that the periods of discontinuity in the price time series of these vegetables were too long or too frequent to be closed-up and would present problems in subsequent analysis. It would have been possible to insert values but this may have led to misinterpretations of the results.

For garlic the mean of the observations preceeding and succeding each missing observation was calculated and inserted back into the original series.

Table 2 gives a summary of the missing values for the vegetables mentioned above.

Table 2		Missing observations					
Vegetable	Valid N	Missing	Case Nos	Week Nos	Number of weeks		
Brussel Sprouts	112	49	31 - 46	39 - 54	16		
			82 - 99	90 - 107	18		
			135 - 148	143 - 156	14		
			150	158	1		
Garlic	159	2	44	52	1		
			67	75	1		
Leeks	126	35	39 - 47	47 - 55	9		
			90 - 100	98 - 108	11		
			140 - 154	148 - 162	15		
Spinach	149	12	9 - 11	1 - 3	3		
			44 - 47	52 - 55	4		
			51	59	1		
			93	101	1		
			97	105	1		
			99	107	1		
		149	157	1			

CHAPTER 4 SUMMARY

A summary of the main findings is given below.

1. Weekly prices fluctuated considerably and for many of the vegetables there was no relation between prices in one year and the next.
2. Many of the time series plots indicated that there was a delay in the response of price to a volume change. This was seen to occur after volume had peaked.
3. The most useful information for growers would be the boxplots of prices and volumes by month. These indicated the general behaviour of prices in a given month and showed what prices have been over a three year period. These were quite useful at picking out seasonal behaviour.
4. The smoothed price series more clearly indicated price trends, and general price behaviour than the original series. Most prices had a very small positive trend.
5. When each smoothed series was split into its component years, and these were superimposed, consistent price patterns were obvious for broccoli, capsicums, celery, silverbeet, kumaras, and tomatoes. The weekly average prices of other vegetables differed considerably for the same week across different years.
6. Month of the year was quite good at predicting price for capsicums, celery, and tomatoes. Volumes were predicted well for brussels sprouts, spring onions, and tomatoes.
7. The principal components analysis extracted five principal components. Varimax was the best method of rotation and produced the following principal components: component 1, which grouped the prices of cabbages, cauliflower, lettuce, and broccoli; component 2, which grouped the prices of kumaras and pumpkins; component 3, which grouped the prices of onions, celery, and mushrooms; component 4, which grouped the prices of tomatoes and capsicums; and component 5, which grouped the prices of garlic and parsnips.

It was concluded that on the whole common variance in prices had been detected and some descriptions of these components were put forward.

Silverbeet prices correlated equally with three of the components and could not be simplified by rotation.

8. The weather variables proved quite good at accounting for variation in marketed quantity for cabbages, capsicums, celery, lettuces, parsnips, spring onions, and tomatoes.

Prices were predicted well for capsicums, celery, kumaras, and tomatoes.

The aridity index was not as good at accounting for variation in volume or price as the original weather variables.

9. The relationship between current week's price and current week's quantity marketed was weak for all vegetables. The largest adjusted r-squared was 44 percent for capsicums.

The transformations used did little to improve this.

10. Lagged prices were used to account for variation in current marketed quantity (supply). Prices were lagged by one week and 52 weeks. Logarithms of current volume and price lagged one week were also used.

In each case the relationship for all vegetables was weak.

11. Price lagged by one week was found to be a poor predictor of current price for all but the stored vegetables. These were celery, kumaras, onions, and pumpkins, and all had values of adjusted r-squared which were 70% or better.

When price lagged by two weeks was introduced there was no improvement in adjusted r-squared for some vegetables and only a marginal improvement for others.

12. Price lagged by 52 weeks was virtually useless at predicting current price.

13. The times of lowest price often do not coincide with the time of greatest supply. Similarly the times of highest price often do not coincide with the times of least supply.

14. Price flexibility coefficients were estimated and indicated that in the immediate run, the percentage price response to a volume change is smaller than the percentage volume change. The coefficients were all negative indicating that an increase in volume results in a decrease in price.

The reliability of these coefficients is questionable since most were estimated for equations with extremely low values of adjusted r-squared.

15. The behaviour of each vegetable is briefly described below. The weeks of highest and lowest prices are indicated on the various plots which have been produced. Chapter 7 gives a clearer indication of these.

1. Broccoli

Prices increased in each year and were more variable than volumes. Highest prices were in October and it was not clear when prices had been lowest. High prices generally corresponded with low supply, and low prices with high supply.

2. Brussels sprouts

Prices were less variable than volumes. Highest prices were received in September and lowest prices in June.

3. Cabbage

Prices were more variable than volumes. Highest prices were received in July and lowest prices in December and January. Sometimes high prices occurred before or after lowest volumes.

4. Capsicums

Prices were less variable than volumes and very clear seasonal behaviour was exhibited. Generally prices were lowest at times of highest supply which was in March. Prices were highest in winter, in July and August.

5. Cauliflower

Neither volumes and prices exhibited a clear seasonal pattern. It appears that there are three supply seasons in each year. Times of low prices and times of high prices varied considerably from year to year.

6. Celery

There was quite large variation in price within a season. One season each year was clearly exhibited. Prices were higher in summer by a considerable amount.

7. Garlic

There was considerable variation in the first of the three years in the price series. Volume did not behave in this manner. Prices were generally highest in the summer.

8. Kumaras

Prices peaked at the end of December and the beginning of January each year, and were lowest in February and March. Prices were more variable than volumes.

9. Leeks

Leeks were not available all year. Prices were highest at the beginning and end of the season. Volume was considerably more variable than price.

10. Lettuces

Price was more variable than volume. Highest prices were received in the middle of winter and the middle of summer.

11. Mushrooms

Prices were least variable of all the vegetables. Volumes and prices were equally variable. However, for a vegetable which is grown indoors, a surprising variation from week to week was exhibited. No seasonal pattern could be detected.

12. Onions

Prices and volumes seem to have indicated cyclical behaviour. In two of the three years prices were lowest in March. There was no consistent time of lowest prices in the series.

13. Parsnips

Prices for parsnips also seemed to indicate cyclical behaviour. The time of highest prices was generally in October with lowest prices being received in July. High prices were often just before or just after lowest supply.

14. Pumpkins

Price was more variable than volume and was generally lowest in summer and highest in winter.

15. Silverbeet

Price was more variable than volume. Two price seasons in each year were found, and prices peaked in mid winter and early summer.

16. Spinach

Prices were highest in July and August and lowest in March. Both price and volume were quite variable.

17. Spring onions

About three price peaks were discovered in each year. These peaks were about three months apart and occurred in March and April, July, and November.

18. Tomatoes

There was one season in each year with some minor peaks which did not occur at the same times from year to year. The major peaks were typically in July and August. Prices were consistently lowest in March.

CHAPTER 5 THE MARKETING SYSTEM FOR FRESH VEGETABLES

A marketing system involves relationships between many variables. It has been suggested that before analysing any of the individual components of a marketing system for a commodity one should propose a model which describes how the system as a whole is believed to function.

The first step in any statistical analysis should be to set up some sort of theoretical model describing how the markets for a commodity work. The model generally starts with a listing of the factors that are believed to affect the supply, demand, and price of the commodity, Waugh (1964b).

In this chapter a description of the behaviour of the marketing system is presented. The chapter is divided into 19 sections as follows:

Section

1. Nature of the commodity traded
2. The nature of growers in New Zealand
3. Supply response
4. Short run supply response
5. Immediate run supply response
6. Which price?
7. Recursive systems
8. The nature of demand
9. Pricing systems
10. Marketing channels
11. The nature of auctions
12. Price formation at a New Zealand auction
13. Market information
14. The nature of buyers
15. The future of auctions
16. Criticisms of auctions
17. Concluding comments
18. Likely causal relationships in this system
19. Summary

1. The nature of the commodity traded

The characteristics of products largely determine the nature of their markets. This is especially true of horticultural products.

A 1970 OECD report (OECD 1970) describes horticultural products as being land and labour intensive; uncertain and of seasonal nature, that is subject to the effects of climate, pests, and diseases; and perishable, so that many vegetables cannot be stored for very long. These characteristics affect trading considerably.

The authors argue that climatic influences are the major determinant of yield for outdoor crops. This leads to uncertainty regarding yields and prevailing prices and thus growers have a difficult time forecasting for a season. They note that inevitably this uncertainty leads to periodic shortages and surpluses. It is also claimed that the

perishable nature of horticultural products leads to difficulty in adapting supply to demand because it is difficult to control output and quality.

Most vegetables are highly perishable. They typically have short shelf lives and in general cannot be stocked for very long. Some exceptions are potatoes, onions, kumaras, pumpkins, parsnips, and garlic. Stock holding costs will affect the extent to which large stocks can be held and in general it will not be worth holding stocks to the time that new season's fresh produce becomes available.

Once ready to be harvested most vegetables cannot be left very long in the soil or they will spoil. A table of the storage characteristics of each vegetable is given in appendix 1.

When most vegetables are ready to be harvested they must either be taken to market or ploughed in.

The OECD report notes that most vegetable production is characterised by three crops. An early crop, which is typically low yield, a main crop the duration of which varies, and can to a small extent be controlled, and a late crop which like the early crop is typified by low yield.

In the past crops have been distinguished as summer or winter crops, according to the season of the year in which they grew. With hybrid seed available this distinction is becoming less important.

Growers may be able to hurry a crop to take advantage of high prices. If prevailing prices are low, (market supply is large relative to demand) a grower may be encouraged to retard the growth of a crop in the expectation of getting better prices later in the season.

Vig (1975) notes that growers may be motivated to extend the harvesting period by season-dependent prices, and he presents several methods by which this might be achieved.

A considerable amount of work has been conducted on growth regulators, see for example Acta Horticulturae no. 134 April 1983.

Hybrid seed adapted to late planting, technological advances in fertiliser and chemical sprays, and methods of weather protection have enabled many vegetables to be grown in a broader range of weather conditions, Vig (op cit p 34).

2. The nature of growers in New Zealand

Carson (1985) asserts that family businesses predominate in the production of vegetables for the fresh market. For most vegetables there are numerous producers who generally act as individuals.

Crowder (1979) asserts that a major characteristic of growers has been their independence.

 Table 3 Number of holdings by size of holding as at 30 June 1982

holdings	size group (hectares)					Total
	< 5	5-19	20-59	60-199	200+	
Market gardening	1632	2499	794	225	35	5185
% of total	31	48	15	4	.7	100
cum %	31	79	94	98	100	100

 Total farming 8031 12447 14444 21603 17400 73925

size as % of
 total farming
 in size group 20 20 5 1 .2 7

source MAF Agricultural statistics 1984

Table 3 indicates that most market gardens are small in size.

 Table 4 Area of holdings by size of holding as at 30 June 1982

	size group (hectares)					Total area
	<5	5-19	20-59	60-199	200+	
Market gardening	4450	23867	24955	21823	11091	86186
% of total	5	28	29	25	13	100
cum %	5	32	61	86	99	100

 size as % of
 total farming
 in size group 18 19 4 .9 .06 .4

source MAF Agricultural statistics 1984

Data were originally from the Department of Statistics, Auckland, and classifications apply to holdings where more than 50 percent of gross farm income is derived from the stated activity.

Tables 3 and 4 refer to the whole of New Zealand as at 30 June 1982. More up to date figures were not available. Both tables indicate that most vegetable producers are small. For instance 94 percent of the 5185 holdings were less than 60 hectares in size, but this represented only 61 percent of the area devoted to market gardening. In terms of farming as a whole, large market gardens represent a very small proportion of large farming enterprises. There is no reason to expect the current situation to be very different to what it was in 1982.

Ridler (1966) noted that in 1966 growers numbered "somewhat less than 3000, with holdings owner operated and on average small."

Table 5 Employment in Market Gardening as at 30 June 1982

	holdings	employees full-time	part-time
Working owners			
leaseholders	4778	4942	2705
paid permanent fulltime employees	1294	3095	
paid permanent part time employees	767		1981
paid casual employees	1495		9412

source: MAF NZ Agricultural statistics 1984

Of 5185 holdings, 92 percent or 4778 were operated by owners or leaseholders, rather than managers.

Most vegetable production is consumed domestically. According to the 1983 Official Yearbook, the largest exports of fresh vegetables by volume are onions and potatoes.

Growers do not necessarily supply only one region. The auctioneers, Arlidge Brothers Limited, estimated that 50 percent of volume traded at their particular market was grown in the Manawatu region.

In general growers have little contact with retail buyers and with the ultimate consumers of their produce, and must rely on their receipts and the auctioneers to aid decision making.

3. Supply response

There is a large literature on farmers' supply response to various factors such as weather, technology, and price.

Most studies of supply response have been restricted to categories of agricultural commodities, such as livestock, grains or vegetables rather than to individual crops.

Heien (1977) comments that most analyses of the crop sector in agriculture have concentrated on supply-acreage considerations.

Ortmann (1982) notes that the short run supply of many agricultural commodities is fixed by the size of the harvest and points out that "supplies to the market are determined in advance of current prices".

Enting et al (1965) report that irregular supply in England had been exaggerated by simultaneous increases in acreage and yields per acre.

According to Lipsey (1980) unplanned changes in supply are not responsible for the regular manner in which price fluctuates in many agricultural markets. These are largely the result of actions taken by agricultural producers.

Working (1958) however points out that a large amount of price fluctuations cannot be explained by fluctuations in supply and demand.

Supply also responds to technological changes. Griliches (1957), for instance, researched the speed at which hybrid seed was adopted by Iowa corn farmers. He found that it took four years for the adoption rate to go from 10 percent to 90 percent. The indication is that seed and other technological improvements are not adopted instantly by all farmers, but eventually will affect supply. Either greater supply will result, or the same yield will result from less inputs. This may liberate other inputs to increase the supply of other produce.

Kemmers (1976) points out that trends in production are caused by technical development and improved crop management.

Daly (1958) notes that yields and total output of crops have been greatly increased by technological developments.

Fox (1953 p 59) writes "Production is assumed to depend chiefly upon weather and upon economic influences prior to harvest."

The effect of weather on production and yields has been researched by Oury (1965), Stallings (1960), Shaw (1964), and Doll (1967).

Abnormal weather conditions may account for a general increase or decrease in supply for a given period and will therefore have some effect on prices. Where weather conditions deviate considerably from the norm, the effect on prices, through a change in volumes, might be large.

For example, weather conditions may cause more to be available at a given time than was planned. A grower who planned to market a large quantity at a time of general low supply may instead be marketing at a time of generally high supply if weather conditions hurried his crop.

Weather may be important from the demand point of view also. For instance consumers may eat less salad vegetables in summer when it rains and replace them with "winter" vegetables.

An additional consideration in supply and price analysis, as pointed out by Waugh (1964a), is that the planned production of one vegetable may be influenced by the prices of other vegetables. If the current price of a production substitute

(A) is relatively high growers may be encouraged to produce more of (A) at the expense of a lower priced substitute crop, (B). Later more volume of (A) will be available and consequently the price of (A), all things being equal, will fall. Substitute crop (B) will now probably be receiving higher prices due to lower volumes and production will then move back to producing (B).

In theory the output of one vegetable may be influenced by the prices of any other competing production or investment possibility. This effect however, is very difficult to identify.

Cochrane (1955) distinguishes two types of supply relationship. One he refers to as a supply relation or supply function and is concerned with a static or ceteris paribus response of output to price changes. The time period is fixed, technology is constant, and all other factors which influence output, except price, are held constant. This might be expressed as $Q = f(P)$.

The second relation is referred to as the supply response relation. This also endeavours to explain how output responds to price changes but the ceteris paribus condition is not applied. This might be expressed as $Q = f(P, a, b, c, \text{etc})$.

Cochrane lists three factors which affect the slope of the supply relation for a commodity. These are the time available for output adjustment, which should be considered in relation to the time required for output to adjust; production alternatives; and how close these alternatives are with regard to the return to factors of production.

If the time frame is very short, the output of products produced by biological processes cannot respond greatly to price changes. Such a time frame means that technological influence will be constant. This recognises that it takes time for a sufficient number of growers to adopt new technology and for this to make an impact on output.

The greater the time available for adjustment, then the more adjustment can take place. We would expect production to be perfectly inelastic with respect to price in the immediate and short run, becoming less inelastic as the length of run is increased.

Cochrane points out that when the adjustment time available is long and a product has close alternatives a small change in its price will result in a large change in the quantity which is supplied. This would be referred to as an elastic supply relation.

He noted that in 1955 few empirical studies of supply relations had been constructed because of the problems of holding various factors constant, and of knowing which factors to hold constant.

4. Short run supply response

Most of the literature deals with supply response in the short run, which is usually defined as changes from year to year.

Bean (1929) found that the price in the preceding season was the main factor influencing acreage changes for potatoes, sweet potatoes, and cabbages. The price two years preceding was also important, especially if it was a low price. He used a weighted average price for the crop year as the price variable.

Fox (1958) reported that the supply or production of many annual crops is mainly determined by prices prevailing at an earlier time rather than at the time of harvest or marketing. He noted that the same state would exist for crops which are produced throughout the year, but that the prior period price would be in a period shorter than a year.

Lipsey (1980) notes that there is evidence pointing out that price fluctuations are a result of planned output changes and that these output changes follow a cyclical pattern.

According to Enting et al (1965), in general, acreage responds to the previous year's prices and tends to move in the same direction. Thus, if prices rise, acreage can be expected to rise in the following year.

Rogers (1970) asserts that short run price fluctuations are largely due to over reactions because of incomplete knowledge. This can be caused by both growers and buyers.

Tweeten and Quance (1969) found that output of agricultural production was more responsive to a once-for-all price increase than to a once-for-all price decrease.

Johnson (1950) describes the output of agriculture under certain conditions as regards the direction of prices. He points out that agricultural supply response is restricted by the ability of factors to respond to price changes.

He notes that the price elasticity of the supply of land is very low in the short run and that the price elasticity of supply of capital assets is very small when prices fall, but is higher when they rise.

Johnson concluded that farmers could not move more land into agricultural production and had few alternative uses for land already committed to agriculture in the short run. So the responsiveness of the factor of production was limited. He also argues that agricultural assets are more productive in agricultural employment than in other employment, even when the prices of agricultural commodities are falling.

Cochrane (1955) comments that elements which are fixed in the short run tend to be the size of the labour force, the land available, the amount and type of machinery and other equipment, and the production related buildings. He

describes short run changes as being those that occur from one planning period to the next.

Tompkin (1958) found that livestock farmers responded to price changes after the new price level had existed for more than a year. Admittedly production lags in livestock are much longer than for crops, but this reasoning might apply in cases where crops require specialised machinery and handling.

Enting et al (p 61) make the following comments about the supply of vegetables in New Zealand:

Fluctuations of prices are caused by either seasonal weather or by over or under supply which is not the result of the weather. The first we have no control over. In the second group over supply generally follows a season of good prices, which cause heavy plantings the following season. The result is a glut, or over supply, which may continue for two or three seasons, until finally some growers stop growing these crops. The fall off in the quantity of crop planted results in the following season being a good one. This is the usual pattern for all field cropping.

Ekeland and Lundahl (1984) found that green house production of tomatoes and cucumbers in Sweden responded inelastically to price changes. The short run elasticities were 0.25 for tomatoes and 0.53 for cucumbers. They noted that the response of supply to price changes was "sluggish".

Furthermore, the authors discovered that output was not closely related to current price changes but there was a close correlation between current quantities and quantities lagged by one year.

Kohls and Paarlberg (1950) researched the hypothesis that farmers change the acreage planted to crops, or intend to change acreage, in response to year to year changes in the relative crop prices.

In many instances, they found the variation in intended acreage or harvested acreage explained by changes in price to be small, and noted that for some of the crops studied, none of the variance in acreage was explained by price.

They also analysed the relationship between current price and last year's price and found it to be weak.

For cabbages, 20 percent of the variation in the current year's price could be explained by the variation in the preceding year's price. The figure was seven percent for onions and three percent for tomatoes. They discovered that the most important factor explaining acreage change for cabbages and onions was the preceding season's price.

For cabbages 54 percent of the variation in harvested acreage was explained by the price in the preceding year. Thirteen percent was explained by the price two years preceding. For

onions 27 percent of the variation in harvested acreage was explained by the preceding year's price and none by the price two years preceding. For tomatoes only 1 percent of the variation in harvested acreage was explained by the preceding year's price.

The authors reported that the results of their study tended to refute the suggestion that when prices are falling farmers will increase production to maintain their incomes. They concluded that year to year changes in the price of a commodity were not very useful at predicting future supply changes.

The supply function "indicates the quantities of a product that will be offered for sale at alternative prices assuming the prices of all inputs and other outputs are combined in the least-cost manner", Tomek and Robinson (1981). The theoretical market supply curve has positive slope. It predicts that growers will produce more when prices rise and less when prices fall.

Any increase in the quantity supplied may be in response to a price increase (static change) which is a short run phenomenon or the result of a shift in the supply curve (a structural change) which is a long run phenomenon.

Structural changes occur as a result of changes in technology and changes in the relative prices of production inputs.

The elasticity of supply is a measure of the responsiveness of quantity supplied to a price change.

It is important to determine the length of run before discussing supply elasticities. Manderscheid (1964) outlines problems in using and interpreting elasticities.

It has been noted that changes in the volume of produce marketed are the major cause of price fluctuation. Agricultural commodities are frequently referred to as being own-price, or simply price, inelastic. This means that a small percentage change in price leads to a smaller percentage change in quantity supplied. For instance, a one percent increase in price would result in less than a one percent increase in quantity supplied. Because of the fixed nature of vegetable production in the immediate run this is what would be expected. In the longer run, supply response should be more elastic.

Considering a static supply model, Cochrane (1955) suggested that for certain vegetable crops such as cabbages, onions, and tomatoes, the short run price elasticity of supply would range from 1.0 to 2.0. Further, he asserted that these would increase as the length of run increased.

For an individual grower, Cochrane observed "most economists are in agreement that the short run supply relation for the typical farm firm is severely inelastic."

Cochrane noted that the elasticity of supply varies depending on the crop. For wheat it is highly inelastic and for some vegetables it is elastic.

Houck (1967) points out that price elasticity of supply is treated less fully in the literature than price elasticity of demand.

Schnittker (1958) comments that calculating elasticities from real price-quantity data may be meaningless because of violated assumptions, but concedes that in the short run, the assumptions do hold and calculating and analysing elasticities is worthwhile.

Manderscheid (1964) outlines some of the problems in using and interpreting elasticities and notes that the procedural decisions taken to measure elasticities affect the measure of elasticity obtained. He defines elasticity as "the percentage change in quantity associated with a 1 per cent change in a causal variable assuming other variables are unchanged." Manderscheid points out that all other things cannot be held equal and that all that can be hoped is that the more important variables are held constant and that changes in any other variables have little influence on the results.

Tweeten and Quance (1969) assert that over a long period of time, farmers have a lot of scope for substituting one commodity for another in production. They found that the response of output to price for crops did not change from 1921 to 1966.

Three approaches were used to calculate the elasticity of farm output with respect to farm prices. The supply elasticity for crops was found to be 0.17 for the short run (2 years) and 1.56 for the long run (many years). A low response of acreage to price was found for both the short run and long run.

Edwards (1959) asserts that the supply response to small price changes is inelastic due to the fixity of farm assets. He reasons that price changes which are large make it worthwhile to change the farm's asset structure and that the response should become more elastic.

Askari and Cummings (1977) also make comments about the comparison of supply elasticities from different studies. They point out that price and output are defined and measured differently, the time period over which observations are collected varies, and the quality of the data also varies.

The authors however, proceed to present a summary of studies of elasticities for various crops in various countries.

1 The short run supply elasticity of brussels sprouts has been found to be .20 in the UK.

2 The short run supply elasticity for cabbage has been found to be from .3 to .36.

3 The short run supply elasticity for capsicums in the USA is reported as .07.

4 The short run supply elasticity for cauliflower is reported as .14 in the USA and .05 in the UK.

5 The short run supply elasticity for celery is reported as .14 for the USA and .10 for the UK.

6 The short run supply elasticity for lettuce has been found to be .03 in the USA.

7 The short run supply elasticity for onions has been found to range from .05 to .59 in absolute value. It has been reported as .34 in the USA and .59 in the UK.

8 The short run supply elasticity for tomatoes is reported as .16 in the USA and .17 in the UK.

9 Vegetables as a whole are reported as having an elasticity of supply of about .30 in the UK.

We would expect the supply response for speculative crops to be much quicker than for staple crops. For instance, Carson (1985) notes that 400 growers grew garlic one year in the Waikato and that in the following year when prices were less than harvesting costs, "there were none of these growers left."

Askari and Cummings (1977) review the literature regarding the estimation of supply response using the Nerlove model which focusses on price expectations and partial area and production adjustments. They note that much of this has been concerned with acreage response to price fluctuation and argue that farmers actually want to adjust output not acreage. They note that in most cases it is asserted that past prices affect planting decisions, and therefore supply.

5. Immediate run supply response

Most of the literature notes that the supply of agricultural produce is in general price inelastic in the immediate and short run.

However, little published research on immediate-run supply response, that is from week to week or day to day, was found. This is probably because supply cannot respond very much in the immediate run, and therefore this analysis would not be seen as of much use for policy purposes.

The authors of the OECD report (op cit p 14) describe the behaviour of price during a season. They assert that in general the shape of the season price curve for horticultural products is saw-toothed.

Early season production is typically sold at a relatively high price, main or full season production is typically characterised by price fluctuations and perhaps a large price drop as the market begins to experience surpluses. Later, as the product becomes increasingly unavailable, prices may rise.

The biological nature of vegetable production means that supply cannot immediately respond to a price change.

In the immediate run, and in the short run, we would expect the overall effect of technological change on supply and price to be small.

Heien (1977) notes that since supply is virtually predetermined in the short run the only variation which can occur in the system is in stocks and prices. Due to their perishable nature, many vegetables have virtually no stockholding potential, and the only variation which can take place is in price.

In considering the immediate run Dahl and Hammond (1977) also point out that nothing can be done to change the supply. The only decision to be made is to harvest or not to harvest. This can of course be tempered by consideration of how much to harvest assuming that some retardation or storage is possible. They comment that it will either be profitable or loss minimising to market the entire crop as long as the price of the crop exceeds harvesting costs.

In the immediate run, which they describe as the marketing day or week, nothing can be done to increase the size of the crop and the supply curve is perfectly inelastic. Graphically this would be depicted as a vertical line, where the y axis represents price and the x axis quantity supplied in the immediate run, or quantity marketed. The position of this line on the x axis would be the daily or weekly quantity marketed.

As long as recent prices are higher than harvesting costs, or perhaps as long as expected prices are higher than harvesting costs, growers will take all mature produce to market. The price moves to clear the market.

Where growers have information concerning prices at other markets the additional decision as to which market to sell in enters the system.

The nature of consignment of produce to the auction floor means that there can be no quantity response to price on a given day. From week to week there is room for a quantity response to take place. Growers may be able to hurry a crop or retard it. Imports from other regions where prices are lower, or exports to other regions where prices are higher are possible.

Within a week there is also room for a quantity response to take place. Growers are probably not able to advance a crop's maturity very much within a week but they can certainly restrict supply. This will probably only occur if prices are lower than marketing costs.

Ortmann (1982) argues that price flexibility coefficients are more relevant for crops than elasticities. He reported the following price flexibilities of supply at the farm level:

Tomatoes	-0.65
Onions	-2.36
Cabbages	-0.45
Pumpkins	-3.75
Sweet potatoes	-1.33

Thus, for example, a 1 percent increase in the quantity supplied of tomatoes resulted in a .65 percent fall in tomato prices at the farm level.

This makes sense if we are concerned with immediate run rather than short run response.

The price flexibility coefficient for a commodity is given as the percentage change in price associated with a one percent change in quantity supplied, *ceteris paribus*. (Tomek and Robinson 1981). They note that the reciprocal of the price flexibility coefficient can be used as an estimate of elasticity but that it is not always a good estimate. This is because different variables are held constant when each is calculated.

An absolute value of the coefficient greater than 1 is generally considered to indicate inelastic demand. A value less than 1 indicates elastic demand.

Colman and Miah (1973) note that the price flexibility coefficient has a different causal meaning to an elasticity. Dahl and Hammond (1977) point out that it is used to study the price changes which result when the quantity marketed changes.

Houck (1966) points out that in the short run the supply of agricultural commodities is fixed and price is all that can adjust.

Tomek and Robinson (1981) comment that demand is also relatively fixed in the short run, and that analysts might be interested in the price response to a small quantity change.

More emphasis has however, been given to elasticities than to flexibilities. This is probably because research has concentrated on short and long run response rather than immediate run response.

For each of four vegetables, Lee (1973) estimated the following supply and demand models:

$$\begin{aligned}S_{Ut} &= f(P_{t-1}, W_{t-2}, T_t, S_t) \\ P_t &= f(T_t', W_t, Q_t)\end{aligned}$$

where S_{Ut} = supply of vegetable to Palmerston North auction market in period t (week)
 P_{t-1} = wholesale price of vegetable 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 demanded at t
 T_t = the time trend variable in years at t
 T_t' = time trend variable in weeks at period t
 S_t = the seasonal dummy variables

The current supply each vegetable was given as depending on its average price in the most recent week, some measure of prevailing weather two weeks ago, the season, and a time trend. The supply equation did not allow for longer adjustment lags than only one week. The current price was given as depending on current quantity demanded, current weather conditions, and a trend variable.

The linear equations which were estimated were

$$\begin{aligned}S_{Ut} &= A_4 + B_1P_{t-1} + B_2W_{t-2} + B_3T_t + A_2S_{2t} + A_3S_{3t} + U_t \\ \text{and } P_t &= C_1 + C_2T_t' + C_3W_t + C_4Q_t + V_t \\ U_t \text{ and } V_t &\text{ are the error terms.}\end{aligned}$$

Values of S_{Ut} were obtained by regression and then were inserted in the demand function since $S_{Ut} = Q_t$ at equilibrium.

Lee reported the following price flexibilities:

cabbages	-1.986
cauliflower	-1.228
lettuce	-0.697
carrots	0.519

Packaging and post harvest handling can also influence price. For instance Hartman (1939) cited in Thompson and Kelly (1957) discovered that the price of cauliflowers at auction on Long Island depended on how closely leaves were trimmed at harvest. He also found that in general, crates which contained a smaller number of heads, received higher prices than those which contained a greater number.

6. Which price?

Most discussions of the price to which farmers respond are in the context of the short and long run rather than the immediate run.

Growers may respond to the average of prices for the past period, or some weighted average of past prices. (Nerlove 1958).

Nerlove (1956) comments that farmers respond to expected prices. He readily admits that expected prices can never be observed and proposes a method for estimating expected prices which geometrically weights past prices.

Tompkin (1958) asserts that a large number of farmers make decisions on average rather than marginal values. The price to which they respond would therefore be an average price over a period of time.

Kohls and Paarlberg (1950) noted that for crops in the USA last year's price was not good at predicting current year's price.

It may be that growers do respond to expected prices. These are not measurable and the analyst is left with the problem of defining expected price. Perhaps growers respond to prices of one, two, or more periods ago. Perhaps growers somehow average, or weight and average prices in their minds and they respond to these prices. The time lapse, or lag, between the production decision and yield makes it difficult to be sure just what price growers respond to.

It is doubtful that growers could actually tell a researcher which prices they respond to unless it is some important event like a maximum price or a minimum price. It may be that their production decisions depend more on a certain cash return from given crops over time, than on prices per se.

This return may be compared with the return for the same crop from the last season and production decisions made on that basis. If this was the case, then the relationship between prices and output would not be as strong as expected. Rather the relationship would be between total revenue and total output for a given period.

Kemmers (1976) asserts that expected income determines production levels and notes that because expected income is influenced by unobservable factors that decisions are mainly based on income or prices from the most recent period.

In the immediate run, the amount that is harvested will depend on the relationship between harvesting and marketing costs and the current price level, as suggested by Enting et al (1965), Tomek and Robinson (1981), and Dahl and Hammond (1977).

Enting et al assert that growers are more concerned with current and next season's market prices than with price trends. The reasons given are that a small long term price trend is of less importance to growers decisions and income than a huge short term price change. This is supposedly due to the fact that many short term price changes may be as much as 100 percent or more. The immediate uncertainty facing the grower concerns next year's price and income, and what he believes they will be will have a large impact on production and finance decisions.

Lee (1973) assumed that the supply of a given vegetable in a given week to the Palmerston North auction markets was determined by the price received for the vegetable in the previous week. He assumed that growers responded to an expected price which was somehow generated by the most recent auction price.

While his results were not very good, price lagged by one week was significant at the 95 percent level for all vegetables except carrots. His model was able to account for 46 percent of the variation in weekly supply of cabbages, 28 percent of the variation in weekly supply of carrots, 48 percent of the variation in weekly supply of cauliflowers, and 68 percent of the variation in weekly supply of lettuces.

Therefore there is some evidence to suggest that marketed quantity depends on the most recent price or prices. This needs to be investigated further.

7. Recursive systems

The pattern of behaviour outlined above, in which current output depends on past prices and other influences rather than current influences, is described as a recursive system in the economic literature and is often referred to as the cobweb theorem.

Lipsey (1980 p 143) comments that the theory provides a "reasonably satisfactory explanation (of) the tendency toward oscillations in many agricultural markets with periods of shortages and high prices alternating with periods of surpluses and low prices for reasons that cannot be blamed on such uncontrollable factors as the weather."

The cyclical behaviour of output and price, can be explained as an unintentional high output which depresses prices causing a low output in the following time period which receives higher prices. These encourage increased output in the subsequent season which leads to lower prices at the following harvest.

In seasons of high price producer incomes will tend to rise. In seasons of low prices, incomes will no doubt fall. This has significant implications for production investment and financing decisions, and according to Enting et al perpetuates price instability.

Moore (1917) cited in Waugh (1964a) was among the first to discuss the notion of recursive systems. Moore described how the current price of cotton depended on the current output and that this in turn was influenced by the price in the previous year.

According to Waugh, a wide range of farm products have exhibited similar patterns of price and quantity behaviour. He comments that the term "cobweb" was coined by Kaldor (1934) in 1934.

There are three basic types of cobweb model, converging, diverging, and continuous or oscillating (Waugh 1964a, Lipsey 1980, Tomek and Robinson 1981).

Suits and Koizumi (1956) assert that the onion market in the USA is very much like a textbook version of the cobweb model.

They developed three equations in logarithms of first differences to describe this system. The model comprised a supply equation, a demand equation, and an unharvested crop equation. The supply equation related the quantity which was available for harvest to the preceding year's prices and costs, the demand equation related onion consumption per capita to farm prices and disposable income per capita, and the unharvested crop equation related current unharvested quantity to current price and current harvesting costs.

First differences were used to avoid the problem of autocorrelated residuals.

Except for the war years their price predictions were quite close to actual prices. The authors report that the price and income elasticity of demand were about $-.4$ and $.6$ respectively.

The past behaviour of the production of vegetables for the fresh market suggests a recursive system not unlike the cobweb. As shown in tables 6, 7, 8, and 9, hectares planted and yield fluctuate from year to year. We also know that quantities taken to market on every day are determined by forces which operated at an earlier time.

Information available to growers is quite sparse and so most of their decisions must be made on the basis of past and expected prices.

 Table 6 Area and yield for selected vegetables under study in the Manawatu/Wanganui region

	Year ended 31 October							
	1979		1980		1981		1982	
	Area (ha)	Yield (t)	Area (ha)	Yield (t)	Area (ha)	Yield (t)	Area (ha)	Yield (t)
Brussels sprouts	34	272	40	320	40	321	40	320
cabbage	80	160	75	160	76	384	76	160
cauliflower	111	2011	123	2248	120	2322	124	2259
celery	19	486	22	551	19	496	21	550
lettuce	94	1452	105	1813	106	1885	105	1813
onions	30	741	46	875	46	1146	46	875
parsnips	98	6554	98	10490	97	4365	98	10490
pumpkin/squash	25	512	34	780	35	700	34	780
tomatoes(outdoor)	6	168	11	294	11	440	11	294

 Source Agriculture statistics 1978-79, 1979-80, 1980-81, 1981-1982.

Note that most vegetables exhibit fluctuation in output. It also appears from these figures that yield fluctuates more than acreage.

Unfortunately auction prices for the corresponding periods were not available.

Nerlove (1958), asserts that acreage (and therefore output) is influenced by prices from recent years including the most recent year. This output response is thus distributed over time and these are referred to as distributed lags. Nerlove notes (p 9) that this concept was developed by Irving Fisher.

Nerlove (1956) discusses expected prices and Working (1958) describes a model of anticipatory prices suggested by Taussig (1921). Both look at the influence of price expectations in price formation. Expected prices are projections of price trends which growers believe continue to operate.

Nerlove and Bachman (1966) note that because production inputs must be committed well before output is realised,

decisions must be based on expected receipts rather than on current or historical receipts.

Nerlove (1956) however cited five studies which assert that farmers respond very little to price when planning acreage. These studies dealt with cotton, corn, and wheat and it would be expected that the factors involved in their production would be highly inelastic in the medium run. He notes, however, that price lagged one year has been identified as the price to which farmers react. Nerlove comments that the forces which generated the most recent prices are expected to be in operation in the near future.

The concept of lagged production response is central to the concept of recursive systems. Lipsey (1980 p140) comments that "all decisions take some time to implement, and some decisions take a very long time."

A supply lag is the time lapse between a decision to produce and the realisation of production. In other words it is the time lag between a decision to produce a certain quantity for supply and the actual supply of the commodity to the auction floor. Clearly supply lags will depend on the nature of the product and the length of the production process. For annual vegetables, the minimum supply lag will be a year. For perennials, the minimum supply lag will be somewhat shorter than a year.

Lipsey (1980) asserts that the major factor which determines the length of the supply lag is the time interval between successive crops.

The particular climatological conditions in a given region, crop management practices, and state of technology will also have a bearing on the length of the supply lag.

Lags are essentially of two kinds. Discrete lags are lagged responses that occur in one adjustment. Distributed lags occur when adjustments are distributed through time, Lipsey (1980).

Griliches (1967) presents a survey of literature about distributed lags and suggests distributed lag models be used with caution.

The length of the supply lag will also depend on the behaviour of growers in response to changes in price. The greater the number of growers responding per time period, or the quicker the response, the shorter the lag. Recursive systems will be more complicated and response more difficult to predict, where lags are distributed.

The simplest lag is the one in which the current year's price has no bearing on the current year's supply. This is what would be expected for annuals. This can also be applied to perennials as well because the current season's supply has nothing to do with the current seasons price.

Most of the literature above agrees that to some extent growers decide how much to plant for the next season on the basis of some price indicators in the current season.

This could be represented as follows:

$$Q_{t+k} = f(P_t) \text{ or analogously } Q_t = f(P_{t-k})$$

where k is the supply lag and Q , P , and t refer to quantity planted, price, and time respectively.

Lipsey (1980 p 140) summarises this as follows, "Output coming onto the market at any time is the result of production decisions taken in the past, while the decisions taken about production in the present will not have their effect on the quantity supplied until some time in the future."

In the 20 years since the Enting study was reported, output and hectares planted have continued to fluctuate. See table 6 above and tables 7, 8, and 9 below.

 Table 7 Net areas of vegetables grown for fresh market
 Limited to vegetables under study
 (hectares)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982

outdoor crops										
Brussels sprouts	142	155	144	166	159	158	108	118	117	131
Cabbage	1133	1254	1115	1146	1119	1209	1257	1289	1313	1238
Capsicum	-	-	-	-	-	29	34	34	37	31
Cauliflower	1174	1305	1139	1118	1105	1318	1248	1301	1227	909
Celery	109	98	92	87	91	125	124	121	109	115
Garlic	-	-	-	-	-	98	139	184	151	241
Kumara	486	623	446	520	534	1001	982	696	666	426
Lettuce	728	854	745	862	746	842	798	827	920	955
Leeks	-	-	-	-	-	64	54	69	73	57
Onions	1133	1267	1415	1445	1688	1820	2047	2222	2065	2514
Parsnips	227	243	224	228	255	275	270	244	226	223
Pumpkin	-	-	-	-	-	880	856	954	1522	1928
Silverbeet	-	-	-	-	-	102	100	103	101	213
Sprouting Broccoli	-	-	-	-	-	94	115	96	113	128
Tomatoes	271	323	351	285	243	314	360	366	340	252

indoor crops										
Mushrooms		36	34	36	46	83	47	134	-	
Tomatoes (indoor)		1011	1335	1448	1165	1112	1216	1218	-	

source: MAF Horticultural statistics 1984, 1982

These figures seem to indicate cyclical acreage behaviour for many of the vegetables. Tomatoes seem to have a 4 year acreage cycle and kumaras a six year cycle.

Other vegetables present no clear cyclical behaviour. For instance, Ridler (1966) noted a two year price cycle for spring cabbages. In table 7 above, cabbage acreage appears to have no clear cyclical pattern.

 Table 8 Production for fresh market
 Limited to vegetables under study
 (tonnes)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982

outdoor crops										
Bruss spts	1829	1094	1820	1960	1832	1880	1250	1382	1693	1158
Cabbage	28448	26148	25464	27111	27434	30588	30885	31072	32186	29922
Capsicum			-	-	-	308	346	315	312	248
Cauli	23368	18243	24043	23111	22397	25504	22918	23201	23230	17405
Celery	4674	3561	3377	3307	3372	4018	3829	4589	4319	4992
Garlic			-	-	-	- 699	1014	1330	962	1346
Kumara	8331	9235	7466	5731	6009	15155	8391	15768	10301	6796
Lettuce	15748	16429	15766	17162	16526	18136	16796	17897	19100	20982
Leeks						1419	1111	1329	1274	1205
Onions	36982	37778	43854	49170	56666	59313	66745	76817	66416	78599
Parsnips	4369	4609	4362	5378	6354	6478	5965	13889	6975	13647
Pumpkin/squash						17676	18282	19753	29237	35633
Silverbeet						1114	1108	1298	1242	1354
Sprouting Broccoli						757	991	712	1083	1239
Tomatoes	22779	23488	28808	17443	27080	24856	23889	27834	27789	-----

indoor crops										
Mushrooms		1209	1204	1290	1146					
Capsicums						33	171	100	66	----

 source: MAF Horticultural statistics 1984, 1982

Table 8 indicates that many of the vegetables have had quite large production changes from year to year, for example garlic, brussels sprouts and kumaras.

The tomato figure includes both indoor and outdoor production. Indoor production has exceeded outdoor production in all years for which statistics have been collected. This information is shown below in table 9.

 Table 9 Glasshouse production of tomatoes
 compared with outdoor production of
 tomatoes

year	area (000 m.squared)		production (tonnes)	
	indoor	outdoor	indoor	outdoor
1976	1335	285	9060	8383
1977	1448	243	21055	6025
1978	1165	314	14864	9992
1979	1112	360	15618	8271
1980	1216	366	18306	9528
1981	1218	340	18266	9523

Nationally about two-thirds of tomato production is from glasshouses. Capsicums are still primarily grown outdoors.

In the study by Enting et al (1965) the authors comment that the duration of a production cycle depends on the time it takes for producers to react to prices and the time required for production plans to be completed.

Some growers may act "outside" of this cycle. They may anticipate the "industry" production response to price and choose to behave in a manner counter to the "industry". The existence of cycles is evidence that growers tend to respond to economic stimuli in the same manner. That is by either increasing or reducing output without considering what the net affect of their individual actions will be.

Discussions with some growers revealed that when price was high for one year less would be planted for the following year because it was expected that the general behaviour would be to increase production. These growers acted outside of the production cycle.

The individual grower's income instability associated with price instability will depend on the relative importance of particular crops to his income. It takes time for a production response to take place. Risk and uncertainty as regards prices of crops which represent an important proportion of total income may dampen the response. Therefore the production response might occur after one, or two or more, good or bad seasons. It is asserted, without evidence, that this is how the majority of growers behave.

Askari and Cummings (1977) note that not much work has been conducted on farmers' reaction to risk.

Farmers of other commodities, such as sheep, beef, dairy cattle, and so on might be blamed for some price instability, in that when vegetable prices are particularly good they may

decide to switch some resources to producing vegetables which are receiving high prices. This would tend to exacerbate any glut in the following season and would force prices down. However, Enting et al (op cit) claim that this was not much of a problem in New Zealand.

Most field crops do not require a lengthy establishment period as, for example is required for asparagus, before producing fruit and it is possible to switch production between crops from one season to the next.

The domestic industry has developed to supply a given population size and this size is fairly static. All quantities are usually sold and it would seem that whatever the quantity the market will be cleared. If prices are so low that they are exceeded by harvesting costs, evidence suggests that a proportion of the crop will remain unharvested. (Enting et al).

If past prices play a large part in future production and therefore supply, they should be invaluable for predicting future prices. If current prices are determined primarily by current volume traded, as suggested by the cobweb theory, then we would be interested in predicting future supply from current price and then future price from predicted supply.

Waugh (1964a p 736) produced the following equations to represent a linear recursive system:

$$\text{price } P_t = -aQ_t$$

$$\text{lagged output } Q_{t+1} = bP_t = -baQ_t$$

He points out that if $(ab)^2 < 1$ the system converges; if $(ab)^2 > 1$ the system diverges; and if $(ab)^2 = 1$, the system oscillates continuously.

The simplest cobweb is where the current year's price does not affect the current year's supply. The adjustment to price in this model happens all at once in the following year.

In summary, Tomek and Robinson (1977) comment that the theory of simultaneous determination of prices and quantities is relevant when there is sufficient time for the apparent interdependence to occur. On the other hand, sequential determination of prices and quantities "may be empirically relevant when time lags between changes in variables are long or when the time unit over which variables are observed is short".

Some lagged relationships are investigated in a subsequent chapter.

8. The nature of demand.

Demand at the farm level or regional market level can be treated as derived demand and is based on consumer demand less marketing costs. (Fox 1953).

Kemmers (1976) points out that fluctuation in demand about the demand trend is caused by "seasonal aspects, weather conditions, and changes in the price of substitutes".

Much of the literature notes that demand for agricultural products is price inelastic.

Tompkin (1958) for instance asserted that agricultural commodities are characterised by an inelastic demand.

Waugh (1964b) found that in the USA food becomes increasingly price inelastic as incomes rise.

Eckstein and Syrquin (1971) report that agricultural products have low elasticity of demand. This they say leads many writers to believe that farmers' incomes will suffer due to supply fluctuations. However, they point out that this depends on the shape of the demand curve for the range over which volume fluctuates. They report that if the demand curve is linear, fluctuations in supply will lead to declining average income.

Kitson (1968) reports price elasticities of demand for 5 vegetables in New Zealand, which indicate that they are different at different retail outlets and in different parts of the country.

	supermarkets	fruiterers	grocers
celery	-1.21	-0.87	-0.36
cabbage	-0.74	-0.44	-0.33
tomatoes	-2.07	-1.62	-2.13
lettuce	-0.58	-0.55	-0.93
onions	-0.56	-0.57	-0.44

	All Auckland	Central North island
celery	-1.11	-0.33
cabbage	-0.65	-0.34
tomatoes	-1.93	-1.04
lettuce	-0.58	-0.63
onions	-0.56	-0.21

Most of the vegetables studied by Kitson had price inelastic demand.

Ortmann (1982) conducted a study to determine the response coefficients for various vegetables and fruits in South Africa. He reported that, based on annual data, onions, tomatoes, cabbages, pumpkins, and sweet potatoes all had price inelastic demand.

Lee (1973) reported that over a three year period at the auction markets in Palmerston North demand for cabbages and cauliflower was price inelastic and demand for lettuces was price elastic.

Nerlove and Addison (1958) conducted a study of the demand for vegetables in the UK from 1921 to 1938 and found that they had price inelastic short run demand. In the same study the authors conducted a dynamic supply analysis for 20 fresh market vegetables in the USA. The period was 1919 to 1955. All vegetables had price inelastic supply in the short run. In the long run, some had inelastic supply and others elastic supply. The short run was defined as one year.

Balestrieri (1983) used daily data to estimate wholesale demand elasticities for tomatoes in Italy for 1976 to 1979. Weeks were substituted for days to reduce variability and separate equations were used to estimate elasticities for spring and summer. The logarithms of weekly quantities were regressed on the logarithms of weekly prices. Balestrieri assumed that the national daily supply of fresh horticultural produce was fixed and does not respond to price. It was implicit also that this applied to a week.

Balestrieri obtained the following estimates of seasonal wholesale demand elasticity for tomatoes:

	Spring elasticity	Sig	R.sq	Summer elasticity	Sig	R.sq
1976	-0.60	.05	.8304	-0.63	.05	.6680
1977	-0.63	.05	.8417	-0.86	.05	.6762
1978	-0.60	.05	.8001	-0.76	.05	.8103
1979	-0.58	.001	.8716	-0.73	.05	.8076

In both seasons and for all years the wholesale demand for fresh tomatoes in Italy was found to be price inelastic.

The elasticity depends on the time period, consumer incomes, tastes and so on. Libero and Nasol (1974) note that in many developing countries where per capita income is relatively low, price and income elasticity of demand is expected to be relatively elastic.

Shuffett (1954) noted that as incomes rise consumers seem to purchase vegetables of higher quality.

9. Pricing systems

Rogers (1970) notes that pricing systems have been researched less than other topics in the marketing of agricultural products.

Heien (1977) summarises agricultural price determination models as follows:

Lagged prices, costs, government programmes, weather, and the carryover determine supply; output and price expectations determine stock levels; the difference between stocks and supply is identically equal to demand; demand is determined by prices and incomes.

According to Bowlen (1955), success in studying farmers' response to price for some commodities, has been achieved by using simple regression models with acreage planted as the dependent variable and some lagged adjusted price as the independent variable.

The demand for vegetables at auction is primarily derived from the consumer demand for fresh vegetables. Restaurants, institutions, and households, account for some of the demand at auction but it is asserted that prices are affectively set by vegetable resellers.

Eckstein and Fromm (1968) point out that in the "classic, competitive market, price responds to the difference between demand and supply". Therefore, the beliefs held by buyers regarding the level of consumer demand to the level of wholesale supply will cause the price to move.

The pricing system which operates is largely dependent on the competitive structure of the industry. If it is fragmented with many producers acting independently, if buying power is not concentrated, the system will closely resemble the pure competition model.

10. Distribution channels for fresh vegetables

There are several marketing channels for fresh vegetables.

- 1 direct to household consumers through roadside, or farm gate sales
- 2 direct sales to supermarkets and other retailers
- 3 direct to institutional users
- 4 indirect to users through wholesale firms via the auction floor
- 5 direct to users through cooperative marketing organisations of growers

Traditionally the auction has been the major outlet for fresh farm produce. Ridler (op cit) for instance, noted that the bulk of produce was sold through auctions.

11. The nature of auctions

Dahl and Hammond (1977) comment that auctions appear to be used most where it is necessary to inspect commodities to ascertain the level of quality. They note that variations of the traditional centralised auction have occurred using modern communications technology.

Ridler (1966) notes that most fresh produce is sold by auction and writes:

"The auction, as the single intermediary between nearly all growers and retailers is thus the key element in the marketing system."

The managing director of Arlidge Brothers Limited, Mr Peter Arlidge, asserts that most of the fresh produce at retail in Palmerston North is distributed via the auction system.

Official statistics concerning the volume of trade conducted by auctions are scarce. A comparison of figures from the 1977-78 census of distribution and that of 1983-84 indicates that in the intervening five years some growth in the number of operations, floor space, and people employed, has taken place.

Table 10 Selected statistics about wholesale traders

	1977-78	1983-84	%change
Number of enterprises	91	92	+1
Ancilliary activity units	5	10	+100
Persons engaged end Feb	2249	2616	+16
Salaries etc \$(000)	10996	26803	+144
Total sales & other income \$(000)	202655	434220	+114
Total floor space (m. sqd)	184000	249520	+36

Ridler (op cit) points out that the efficiency of price formation at auction depends on "aggressive bidding" and "adequate knowledge".

The centralising of produce means that reasonably accurate estimates of supply can be made. Growers typically do not participate in the auction and are therefore not in a position to gauge aggregate demand. They are therefore not in a very strong position to affect prices by individual or collective action.

According to Tomek and Robinson (1981) if certain conditions are met the prices established at auction will approximate equilibrium prices. The conditions are that there is a large volume of transactions; that there are many buyers and sellers so that "manipulation of prices is difficult or impossible"; that "unbiased and complete" market information is available to all participants concerning supply and factors affecting demand; and that prices are above government support levels.

The last of these conditions is not relevant in New Zealand, especially under the current government. The other conditions are discussed later in this chapter.

12. Price formation at a New Zealand auction

The functioning of auctions in general, and the functioning of the auction market in this study, are described below.

Growers bring their produce to a regional market and like vegetables are placed together on the auction floor in order of arrival. Quantities are usually small and mostly undifferentiated.

The term "lot" refers to a particular quantity of a vegetable consigned by a particular grower. A grower may have several lots of the same vegetable distinguished on the basis of quality.

The busiest days are Monday and Thursday, although Wednesday volumes are increasing. The probable reasons for these days being the busiest are that they are convenient for buyers, growers and the auctioneers. Buyers are taking time from being in their stores and cannot afford to spend time every day at an auction and growers must await the maturity of new supplies for market and probably cannot afford to spend more time delivering to the market. Tradition probably plays a part in this as well.

The auction usually starts at about 8.00am and finishes at about 10.00am. Most buyers have a list of their requirements and usually inspect the quality, and determine the quantity, of the produce prior to the commencement of the auction. This is considered important because quality can vary greatly.

Arlidge Brothers may have up to four or five auctioneers calling at any one time so that several different vegetables will be auctioned concurrently. Each auctioneer is responsible for auctioning the same vegetable lines at each sale.

Prices are determined on the basis of competitive bids for each lot. Cassady (1967 p 56) refers to this as the English, or ascending bid auction. He estimated that in 1967 75 percent of all auctions were of this type.

Arlidge Brothers operate at a 20 cent interval such that each successive ascending call is increased by 20 cents.

Cassady lists several other types of auction. The two most prevalent after the ascending auction are the Dutch auction, at which prices descend from a high level, and the Japanese auction, at which all bidders make a simultaneous bid, and the highest bid is accepted without the opportunity for bids to be revised.

The auctioneer makes it clear which lot of produce is being auctioned. He starts the bidding by stating the vegetable and a starting price. Often some comments about the quality of the produce are made, and the name of the grower is often mentioned.

Grower reputation seems to be a very important element in the price which is bid, and produce is labelled with the name of the grower.

Bidding continues until the highest bidder is established. The highest bidder has a contract to buy one case of the lot at the the highest price bid. He may buy the whole lot, or some lesser amount.

The next highest bidder has the right to take all or only one case of any remainder at the highest price.

The third highest bidder has the right to buy all or one case of any of the lot not taken by the second highest bidder. He also must pay the highest price bid for the lot. This process continues until all of the lot is taken. Non-bidders may not participate.

If some of the lot is left over it is auctioned again at a lower price. This process continues until all produce is sold. There is no reserve price so any unsold produce is either removed by the grower, or is stored in the auctioneer's cool store for sale the following day. This seldom occurs.

Cassady notes that competition is at its maximum intensity at this kind of auction and that it is possible for the auctioneer to have a large influence on the outcome.

If there is no bid at a called price the auctioneer lowers his call until bidding begins. This, however, does not always occur. Sometimes the auctioneer may have orders for produce at a certain price, and this often sets the base price.

When the quality of produce is fairly constant from lot to lot the price an individual grower receives can depend on the order of a lot in all lots and on the reputation of the grower. Often the price for the last lot in a line of vegetables will be very much lower than the price for the first lot.

By discussing the availability of produce with growers the auctioneers know what quantity is able to be supplied. Recent volumes sold and prices fetched along with an indication from growers as regards expected volumes will indicate the probable range of prices at the next auction.

Auctioneers know the quantity supplied of a particular vegetable in previous day's trading and what is supplied on a given day.

They know what the current season's supply is likely to be having observed general weather conditions and through their contact with growers. Their guesses will be confirmed or otherwise as produce comes to market.

They will also know what the prices have been recently and will have some idea of the trend in prices.

Auctioneers could start calling bids on the basis of expected retail price less markup since they are in a position to observe retail prices, especially in the larger and more aggressive vegetable retailers such as Foodtown and Woolworths. However, according to Mr Arlidge no notice is taken of prevailing retail prices as these vary considerably from store to store and depend to a large extent on the quality of the produce and whether it is being used as a loss leader.

The market information system operated by Arlidge brothers ensures that the auctioneers know approximately what quantity of all vegetables they can expect to be trading on a given day before that day arrives. This is discussed below.

The specific legal rules applying to sale by auction are described in appendix 6.

According to Cassady (1967) the auctioneer has the task of calling the bids, keeping buyers interested in an auction, and encouraging more bidding. The auctioneer is an agent for the growers and it is his job to maximise the prices bid.

The auctioneers manage the account collection from buyers and disbursements to growers. Arlidges also make deliveries and provide finance to some growers.

The lot number, price bid, and bidder are recorded on a form which is processed by the auctioneer. Goods are uplifted by the buyer and checked by a storeman as they are removed. Buyers are invoiced weekly.

The auctioneers deduct a ten percent commission from the receipts of the goods marketed by each grower.

13. Market information

One of the major criticisms in the 1965 report on the New Zealand vegetable industry (Enting et al 1965 p 83) was a lack of information for decision making. The survey of growers discovered that about a third of growers did not know in which month they had received their highest price and half did not know in which month they had received their lowest prices.

It was found that:

Out of 35 crops, more than half of the growers of 14 crops did not know the month of top prices, and more than half of the growers of 17 crops did not know the month of bottom prices.

In many cases the months growers claimed to have received the lowest or highest prices were not in fact the months of lowest or highest prices.

The authors concluded that many growers did not keep records of prices received for their crops.

The panel recommended that a system for reporting prices be set up. The Commercial Grower, the official publication of the New Zealand Vegetable Growers Federation was proposed as one of the media for this purpose. A review of several editions of this published in the subsequent 20 years revealed no reported prices.

The official journal of the New Zealand Fruit and Produce Merchants and Auctioneers' Federation, the New Zealand Fruit and Produce Journal, which is published every two months, does not report wholesale prices either. It does have a section in which current growing conditions in various regions are described. At times this might suggest to some growers that a surplus or shortage in other regions is likely and they may make different production and marketing plans as a result of this. This is probably unlikely, however, due to the lack of timeliness of this information.

Radio New Zealand makes reports about vegetable supply and prices each Thursday morning but not in enough detail to help growers to make decisions. These reports are primarily directed at household buyers.

The local Manawatu newspaper, The Evening Standard, has published a small section about the market in the past. It contained comments by the auctioneers but was primarily aimed at consumers rather than at growers. An extract of one of these reports is in appendix 7.

Arlidge Brothers operate what Mr Peter Arlidge calls a "market information system." This system is a key element in the behaviour of the market. In the afternoon of each major trading day, many local growers are contacted by telephone and told what prices their produce was sold for that morning.

For example a grower may be told that he sold 15 cases of cabbages at \$2.00 and 5 at \$4.00.

Growers are then asked to estimate the volume they expect to be supplying for the following trading day. Not all growers benefit from this system since all are not a party to it.

Auctioneers in different regions communicate regarding the supply situation and arrange for goods to be moved from market to market on a regional basis to alleviate shortages.

14. The nature of buyers

Consumer demand and incomes play the final part in determining prices, and these are reflected at auction by the retail bidders.

It was observed that most of the bidders at the market represented food retailers. Other buyers were either buying for restaurant or household use. Ridler (op cit) noted that the majority of buyers at auction were retailers.

According to Alvisi (1984), vegetable retailers approximate the equilibrium retail price by simply marking up a planned turnover margin on the purchase price.

He notes that buying at the retail level has to be cautious because of the nature of vegetables. The variation in quality and quantity of vegetables and their perishability leads to large and sudden fluctuations in wholesale prices.

He asserts that wholesale prices depend on what is believed will happen to retail prices.

Alvisi points out that wholesalers want to get rid of all produce to make room for deliveries for the following trading day.

Buyers have a notion regarding how much of a particular line they can sell and at what price at certain times of the year. By assessing the quantity available on the floor in relation to their needs they are in a position to make bids. The buyers are aware of current demand for various vegetables, and with their markups and promotion policies in mind, are able to set an upper bid level. Some buyers can exert more influence on prices by virtue of their size.

Ridler (1966) notes that most buyers are small retailers and purchase to satisfy short term requirements. He also asserts that aggregate retail demand is probably inelastic due to the need for retailers to carry a full range of produce to be competitive.

All produce is displayed on the floor and this gives the buyers the advantage of knowing the supply in relation to what they believe the demand to be before the auction commences. When the market is short prices will rise and when supplies are abundant prices will fall.

Buyers know what recent retail prices have been. Most modern supermarkets have cool stores where decay of vegetables can be slowed, but the retail price must be set so as to clear the quantity available for sale within a couple of days.

It may be that buyers, in some unsophisticated fashion, estimate the requirements of their competitors and relate this estimate and their own requirements to the quantity available on the floor. The bidding will reflect the perceived scarcity or abundance of produce in relation to the requirements of individual buyers and their beliefs about the requirements of other buyers.

It is asserted that some of the variation in prices will be due to the errors made by buyers in estimating this relation. This is probably one reason why daily prices for some vegetables often exhibit quite large variance.

The grower has nothing to do with this process other than to supply a quantity of produce to the floor. From the growers point of view, the system works best when there are many buyers and somewhat of a shortage.

Some buyers may be able to influence prices more than others. Lee (1973) reported that the structure of retailing fresh vegetables in New Zealand has "significantly changed", and asserted that larger stores are gaining a greater proportion of sales. These stores can presumably influence prices considerably by bidding high when the market is short, or by refraining when produce is plentiful.

15. The future of auctions

While an increasing proportion of produce is being sold direct to large supermarket chains such as Woolworths and Foodtown, most produce is still sold by auction.

Crowder (1979) asserts that the auction system has helped to perpetuate grower independence and that growers are increasingly moving away from the auction system.

In the 1964 survey of the industry (Enting et al 1965 p 90) it was found that the majority of produce was sold through the auction system. The following table is taken from table 6-1 in Enting et al and contains information derived from the 1964 survey.

Table 11 Percentage of crop sold by wholesale auction 1964

	100% of crop	less than 100%	less than 50%
Onions	57	43	21
Tomatoes	73	27	13
Lettuce	76	24	15
Cauliflower	78	22	15
Cabbage	80	20	11

For the crops listed considerably more than 50 percent of growers sold all produce through auctions.

However, it was reported in Enting et al that the number of growers selling direct to supermarkets was increasing. At the time this was estimated to be about 6% of growers.

A study by Kitson (1968) reported that direct purchases were more prevalent in Auckland than in Christchurch, but that purchases at auction accounted for the majority of purchased volume in both cities.

Bourke (1971) found that only the bulk lines such as cabbages, carrots, tomatoes, and onions were bought direct in any great quantity. He estimated that in Auckland less than ten percent of sales were direct, in Christchurch about six percent were direct, and in Wellington about five percent of sales were direct.

Direct selling has been influenced by auction markets. Carson (1985) writes that direct sellers use prices based on the outcome of auctions. He asserts that auctions remain in existence because buyers and sellers can pull out of direct arrangements when the auction price is sufficiently higher or lower than the contract price.

Bourke (op cit) found that prices and quantities when buying direct were established on the basis of auction prices. He contended that the decline in auction volumes would depend on the degree to which auctions were able to meet the requirements of the larger retailers. Arlidge Brothers provide office space, market information, and arrange direct sales from time to time to meet the needs of the larger retailers. Mr Arlidge commented that in his opinion there was less direct buying in Palmerston North than in the past. No evidence is available in this study by which this assertion can be tested.

16. Criticisms of auctions as price setting mechanisms

Enting et al (1965) describe some of the criticisms of auctions. These tend to centre on the number of buyers present, the existence of rings, and on the wild fluctuation of prices.

If many participants are present it is believed that no one buyer or seller can unduly influence the price.

When the number of participants at auction is small, bidders will get to know each other and the level of bidding power each can exert. This may cause prices to be lower than when bidders are unknown to each other. A bidder with small resources might be unlikely to engage in protracted bidding against a bidder known to have large resources. This would tend to depress prices.

Ridler (1966) asserts that frequently only a small number of buyers attend a given auction. He contends that this is because the ratio of retailers to auctions is small, so that buying power is concentrated, and the existence of competing auction markets with several auctions occurring at once further fragments the number of buyers.

Cassidy (1967) asserts that the size and composition of the group of bidders will affect prices. He points out that when there are not many buyers and they know each other, a certain amount of price restraint can be expected.

Lee (1973) asserted that large bidders may hold back from bidding and in so doing let the smaller bidders establish a lower price than would otherwise be the case. Due to the smaller requirements of the smaller bidders produce will be left unsold. This would then be auctioned again at a lower price. Lee asserts that this practice will depress prices.

The second criticism concerns buying rings. A ring is an organisation amongst buyers whereby they agree not to compete with each other and thereby gain some control over auction prices. Cassidy asserts that a lower bid than otherwise is entered and that later the goods are split between the members of the ring. This practice may depress prices considerably.

A similar effect is claimed to be caused the procedure of breaking up lots. Buyers do collude in the sense that the second highest bidder will often ask the highest bidder (or vice versa) what quantity he requires. If the requirements of both can be satisfied the bidding stops.

Enting et al (op cit) make the following comments about this practice:

It is certain that, from the grower's point of view, the practice of allowing lots to be allocated between several buyers by the final bidder with the assistance of the auctioneer, is an unsound practice, which is probably a symptom of ring buying, and can only tend to depress auction prices.

Ridler (op cit) points out that the breaking up of lots is "an invitation not to bid". Bidders will get to know that a given bidder will only be able to take part of a lot, and will refrain from bidding.

The third major criticism concerns unstable prices. These are a characteristic of auctions because of uncertainty regarding volumes. In direct selling arrangements both parties can specify quantities and prices and therefore avoid a lot of uncertainty and instability. Tomek and Robinson (1981) assert that the auction system is subject to large price fluctuations because of rumours and "mass psychology".

Other criticisms relate to the cost of the system and disadvantages of the ascending type of auction.

Tomek and Robinson (1981) comment that a disadvantage of the auction system over other systems is that all vegetables must be assembled at a central location. They assert that this makes auction selling more time consuming and more costly than direct selling.

Cassady points out that ascending bid auctions may result in prices which are lower than for descending auctions. The lower bidders might not force the highest bidder to bid as high as he was prepared to.

One condition for the system to work well is that a large volume of produce passes through the auction, (Tomek and Robinson 1981). This is to maintain competitive bidding.

Another condition, that both buyers and sellers have access to good information about supply and demand, is not being satisfied. Growers in general know much less about demand than buyers know about supply.

17. Concluding comments about the marketing system

Tomek and Robinson (1981 p 95) claim that the market structure for the price behaviour of agricultural products is often pure or perfect competition in nature.

Ridler (op cit) refers to the market form as imperfect competition.

If the assumptions underlying the efficient operation of an auction were upheld then the market for fresh vegetables at auction could be described as perfectly competitive. There would be many producers of standard undifferentiated products and many buyers. All participants would act independently, and each would have perfect knowledge about quantities available and quantities demanded. No individual would be able to influence prices.

Growers are price takers on any day and generally do not make themselves aware of current and potential demand by observing the bidding. Local growers have their own prices and quantities sold reported but are not aware of the overall level of demand.

Working (1958) points out that a lot of time and expertise would be required to deal with any detailed market information and that therefore growers can never have perfect information.

The ability that individual firms have to influence prices is not very great but it does exist. For vegetables differentiation occurs in the form of quality, branding, and secondary packaging. There is often quite marked quality differences between the produce of some growers.

It has already been noted that current volume can not be influenced greatly by current price. However, because of the market information system which operates, marketed volume is likely to be related to expected price, and this expected price is probably based on the prices received in the most recent day or week as reported by the auctioneers. The relationship between marketed quantity and lagged price is investigated in a later chapter.

Growers are not of the same size, buyers are not of the same size, and prices can be influenced. Furthermore the number of bidders is often small, which is believed to depress prices.

The individual grower will typically sell all of his production of a specific line at one price on the day. In effect, the individual grower faces a perfectly elastic demand curve in the immediate run. The demand curve faced by all growers will also be highly inelastic in the immediate run.

18. The likely causal relationships in this system

The foregoing discussion suggests several relationships. Supply is fixed in the immediate run and the amount that is available to be marketed depends on influences in the past and some current influences.

It is asserted that the quantity marketed in a given week is identical to the quantity harvested and that this depends on:

- 1 the season
- 2 weather conditions -currently, during harvest, and during growth
- 3 the price per case of the same vegetable received in recent weeks and anticipated prices
- 4 the quantity grown
- 5 stocks (for stored vegetables)
- 6 the quantity at maturity
- 7 the cost of harvesting and marketing

The planned quantity grown depends on

- 1 returns for the same vegetable in the most recent season
- 2 growing costs and other costs (eg cost of capital)
- 3 quantities grown by others
- 4 weather conditions at time of planting and expected weather conditions
- 5 prices of substitutes

Immediate run wholesale demand, like immediate run supply is also relatively fixed. (Tomek and Robinson 1981).

This is because retailers can only stock and sell so much in a week, and freshness and quality considerations will be important. The immediate run quantity consumed is set by the population size.

The demand function is the relationship between the quantity demanded of each product and the variables affecting the demand for each product. The general form is given by for example Douglas (1983), Lipsey (1980), Leftwich (1979), and Tomek and Robinson (1981).

The demand function for fresh vegetables will be something like:

$$Q_x = f(P_x, P_s, P_c, K_x, A_x, O_x, Y, T, E, N, S)$$

where:

- Q_x quantity demanded in units of vegetable x
- P_x price of vegetable x
- P_s average price of substitutes for x
- P_c average price of complementary vegetables
- K_x quality of x
- O_x number of distribution outlets for x
- Y index of consumers disposable income levels
- T index of consumers tastes and preference patterns
- E expectations of future prices, availability, and nature of x
- N total market population
- S season
- A_x amount of money spent advertising x

One might speculate that the weekly average wholesale price of a vegetable depends on

- 1 the quantity supplied in the week
- 2 the average prices of substitute vegetables for the week
- 3 the prices of complementary vegetables
- 4 the average quality of the produce compared with other weeks
- 5 the number of buyers present at the auction
- 6 expectations about quantities available the following week
- 7 prevailing weather
- 8 consumer disposable incomes
- 9 population size

We see that part of what influences current prices is attributable to past decisions made by growers and part is attributable to the current beliefs of buyers.

Some of these relationships will be investigated in subsequent chapters of this report.

19. Summary

The marketing system and supply response have been described in detail. Some characteristics of growers and buyers have been noted and some behavioural hypotheses advanced.

Several deviations from the theory of pure competition were noted. Some growers are larger than others and may therefore receive better market information and may influence auction prices by market chasing.

Sometimes there are few buyers bidding for a particular line. It is recognised that not all produce is sold by auction. Buyers know each other and are aware of the buying power each can exert. These factors may lead to prices being depressed.

Information is not perfect and buyers know more about current demand than suppliers.

Because of the fragmented nature of the "industry" and their lack of information, growers are unable to coordinate production and marketing. They seem to lack information which will aid them to make short run and immediate run decisions.

Not all growers are party to the information system and those that are do not act in concert.

All of these undermine the competitive nature of auctions, and it is clear that price can be influenced.

In terms of supply response, it is clear from previous studies, that biological production constraints, the effect of weather, the fixity of farm resources, and uncertainty regarding prices and demand, dictate that the supply and prices of crops will be uncertain.

The effects of price uncertainty on production planning, on the adoption of technology, and on farm incomes have been briefly outlined.

Supply was shown to be more responsive in the short and long run than in the immediate run.

Supply from week to week can be altered by growers supplying other markets and by crop management practices. To be able to do this, growers need information regarding prices and volumes during the year.

It has been shown that to some extent the events of the current season will influence growers future production decisions. These were described as characteristics of a recursive system.

~~It has been pointed out that current production available for marketing depends on prices which prevailed at an earlier time. Marketed quantity in the immediate is considered to depend in part on prices at some earlier time, in part on the relationship of current prices to harvesting costs, in part on non-economic influences such as the weather during growth.~~

Finally, the fixed nature of supply in the immediate run means that the supply curve is perfectly inelastic and that price and revenue for the immediate run, are determined by the demand curve.

Auctioneers were described as eager to clear the floor for the arrival of produce for the next trading day. This behaviour may also depress prices.

The main conclusions are:

1. The supply of agricultural products in general and vegetables in particular is price inelastic in the short run.
2. In the immediate run the quantity marketed is fixed and price moves to clear the market.
3. Production is planned in response to past prices.
4. Yield is a result of cultivar and weather conditions during growth.
5. The quantity harvested is in response to recent prices, anticipated prices, current weather conditions, and harvesting and marketing costs.
6. Growers are many relative to buyers, and most have small holdings. Entry to the industry is relatively easy. Growers act independently. It is asserted that the majority of growers react in the same way without considering the overall effect of many growers behaving in the same way. The only way in which most growers influence price is by improving and maintaining quality.
7. Price levels are set by consumer disposable incomes and bear no relation to production costs in the short run.
8. Vegetables generally perish quickly so that in the immediate run growers must harvest or abandon. If they harvest they have a few options as to which market to sell in.
9. It has been suggested that growers keep poor records and that most are not clear as to the times of highest and lowest prices.

CHAPTER 6 BIOLOGICAL, PRICE, AND VOLUME CHARACTERISTICS OF
EIGHTEEN SELECTED VEGETABLES

1. Introduction

The produce chosen for this analysis were described as vegetables in respect to the way in which they are used rather than with reference to specific biological characteristics. Technically, tomatoes are considered a fruit; however they are primarily eaten as a vegetable. Root vegetables, leaf vegetables, and salad vegetables were represented in the study.

Vegetables are not supplied only from the market's immediate vicinity.

Crowder (1979) notes that over 50 percent of vegetables produced for the fresh market are produced in the Pukekohe district near Auckland. He points out that crop specialisation is quite prevalent in the Auckland region due to the population density and weather conditions in that area. In other parts of the country, where the climate is not as good, crop specialisation is not quite as prevalent.

According to the 1983 Official New Zealand Yearbook 85 percent of onion production is in the North Island, mostly in the Pukekohe district.

Crowder reports that the main crops for the fresh market by volume and acreage are potatoes, onions, cabbages, cauliflower, carrots, and lettuces.

From the demand point of view, expenditure on fresh vegetables has remained a reasonably constant proportion of total weekly household expenditure on vegetables. In each of the years 1980 to 1985 inclusive, the proportion of vegetable expenditure on fresh vegetables has been about 75 percent. Furthermore these vegetables represent about 50 percent of weekly household expenditure on all fresh vegetables.

This information was extracted from Household expenditure surveys for the period and is shown in table 12.

Table 12 shows how expenditure allocated to the vegetables under study has changed over the three years under study.

A three year period is not sufficient to be confident about enduring changes in diet but it is interesting to note that some of the newer vegetables at auction, broccoli and spinach for example, have increased their share of the consumer's vegetable dollar while the share of cabbage, for instance, has declined. This may be partly due to relative price differences between various vegetables at retail and partly to changes in preferences.

 Table 12 Expenditure on vegetables under study as a percentage of weekly expenditure on all fresh vegetables

	Year		
	82-83	83-84	84-85
broccoli	1.37	1.40	1.88
brussels sprouts	1.25	1.39	1.22
cabbage	4.46	4.39	3.72
cauliflower	4.30	4.33	4.16
celery	1.93	1.95	2.05
garlic	0.32	0.24	0.33
kumara	2.97	3.31	2.79
leeks	0.48	0.55	0.46
lettuce	4.57	4.56	5.40
mushrooms	3.28	3.69	4.35
onions	4.25	3.63	6.65
parsnips	1.02	0.99	0.87
capsicums	0.81	0.79	0.92
pumpkin	3.14	3.85	2.80
silverbeet	0.72	0.68	0.74
spinach	0.29	0.32	0.35
spring onions	0.66	0.56	0.68
tomatoes	16.43	15.93	16.39
TOTAL	52.25	52.56	55.76

 Source: Household expenditure surveys 1982-83, 83-84, 84-85.

2. Description of the behaviour of vegetables at auction

The behaviour of each vegetable was analysed using EDA techniques and a summary for each follows.

The original series, the smoothed series, and the boxplots give a different indication of the behaviour of prices and volumes.

In chapter 7 letter plots (Lplot) are used to explore changes in weekly prices from year to year.

Boxplots have been used extensively. They display the dispersion of values about the median value in a batch of numbers. A batch for instance, might be all of the weekly prices for capsicums in January. The significance of the median is that it is unaffected by the magnitude of outliers and indicates the value below (and above) which 50 percent of the values were observed. If the median is quite low it means that half of the time low values were observed.

The first four observations in each series were dropped and the weekly observations were amalgamated into months. The median is indicated by the + symbol. An indication of how the median monthly prices and volumes change from month to month during a calendar year is given.

This gives quite a good indication of seasonality. Each year was included in this display.

The width of the boxplots indicate the range of prices received and volumes marketed in each month. The number of observations per month is quite small, about 12, so the distributions are not very precise.

Boxplots of median weekly price, volume, and turnover were produced for each separate year. The year period was taken as 1 April to 31 March which is the auctioneer's financial year.

These indicated how the median values and range of values of these variables changed from year to year. Descriptive statistics utilising the more familiar mean were also produced and are given at the end of this chapter in tables 13, 14, and 15.

It was noted that there is no standard convention in deciding what constitutes a season. Turning points are described as points which have both points either side higher or lower. In a series of weekly observations adopting a rule of thumb which gives a season as the observations between two peaks or two troughs would lead to misleading conclusions because there are so many peaks and troughs.

Smoothing of the series however, may help detect the "true" turning points.

Each smoothed series was considered for classical time series decomposition. However, the pattern of short term price behaviour was such that without exception searching for a seasonal pattern based on weekly observations alone proved difficult. The number of weeks comprising what were thought to be seasons varied considerably throughout the series for most of the vegetables. This meant that it was difficult to choose a moving average to model seasonal behaviour. If the weekly observations were aggregated into months or quarters this problem would be reduced.

An indication of the trend in prices was established by applying first order exponential smoothing model to each price series. (Mendenhall and Reinmuth 1982). It was calculated for the vegetables with complete series as follows:

$$Tx_t = (P_t * 0.001) + (Tx_{t-1} * 0.999); \text{ and } Tx_1 = Px_1$$

This smoother was very heavy handed and has the advantage that recent observations are weighted more highly in the current smoothed values than past observations.

Five values of the smoothing constant were used, each successive value being closer to zero. For most of the vegetables a value of 0.001 had to be employed to smooth out the variation substantially. The equation produced when the trend values were plotted against week are given below.

 Table 16 Trend lines for vegetable prices

Vegetable	constant	coefficient	rsq	se(T)	sig
broccoli	5.67	.001	.89	.020	.000
cabbage	6.16	-.001	.88	.020	.000
capsicums	2.80	.008	.98	.058	.000
cauliflower	4.69	.002	.96	.020	.000
celery	6.96	.002	.86	.042	.000
garlic	low r-squared, cycle indicated				
kumaras	11.90	.007	.92	.102	.000
lettuce	1.62	.004	.99	.020	.000
mushrooms	12.68	-.001	.77	.022	.000
onions	low r-squared, cycle indicated				
parsnips	10.41	.005	.97	.035	.000
pumpkins	3.15	.004	.88	.071	.000
silverbeet	5.97	-.0001	.95	.002	.000
spring onions	1.09	.002	.99	.005	.000
tomatoes	3.25	.01	.99	.050	.000

An indication of the trend in prices is given above. The only vegetables with negative trends were cabbages, mushrooms, and silverbeet.

The coefficient of variation was calculated as follows:

$$COV = (\text{standard deviation} / \text{mean}) * 100\%$$

This gives an indication as to which variable, price or quantity, had the greatest variance since they are measured in different units.

This coefficient can be compared for different vegetables to determine which have greater or lesser variation in prices and quantities.

The rest of this chapter is divided into 20 sections; one section for each vegetable, a summary of descriptive statistics, and a chapter summary as follows:

section

1. Broccoli
2. Brussels sprouts
3. Cabbage
4. Capsicum
5. Cauliflower
6. Celery
7. Garlic
8. Kumara
9. Leeks
10. Lettuce
11. Mushrooms
12. Onions
13. Parsnips
14. Pumpkins
15. Silverbeet
16. Spinach
17. Spring onions
18. Tomatoes
19. Descriptive statistics
20. Summary

1 BROCCOLI

Broccoli is grown in the Manawatu, Auckland, and Hawkes Bay regions and is available in winter and summer. It is often started under glass then later transplanted to fields. This vegetable is sensitive to frost and requires protection from frost at spring planting.

According to Ballinger (1980) the best time to grow broccoli is in the cooler months. Seed is sown from November to the end of summer so that broccoli can be harvested in autumn and winter. Some cultivars can be started under glass in winter and transplanted later to give an early summer crop.

Carson (1985) asserts that broccoli is one of the newly emerging vegetables as far as consumer demand goes.

Broccoli is not as sensitive to hot weather as cauliflower. However if the weather is hot during harvest time two problems can occur. Head development is quickened which makes harvesting at the proper time difficult and heads can become leafy which reduces the value of the crop. (Thompson and Kelly 1957).

Tannock (1914) writes that plants should be set out at the beginning of the new year.

According to the Yates seed catalogue broccoli is sensitive to variations in the weather and maturity takes longer in autumn and winter than in spring and summer. There are different varieties which mature at different times so that supply to fresh market is possible all year.

As far as consumption is concerned broccoli is primarily a winter vegetable.

1 The expected behaviour of prices

We would expect prices to rise in the hotter months because broccoli grows better in cool conditions. Volume would be expected to be lower in January, February, and March and highest from May to September.

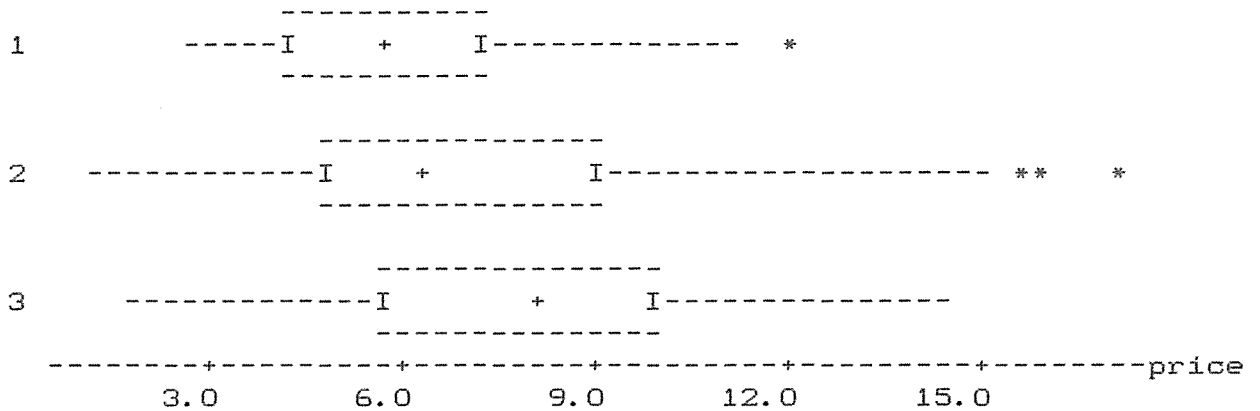
2 The behaviour of broccoli at auction

Broccoli was supplied for the full period under study.

The mean weekly price for broccoli rose in each successive year. See table 13.

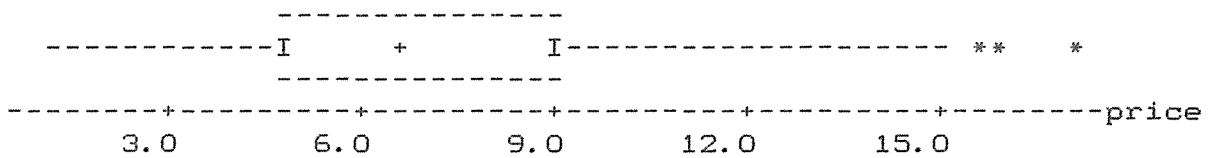
The following boxplots illustrate the increase in median price for each of the three years under study.

Year



Prices were more variable in year 2 than in years 1 and 3. This can also be seen in the plot of the smoothed price series which follows.

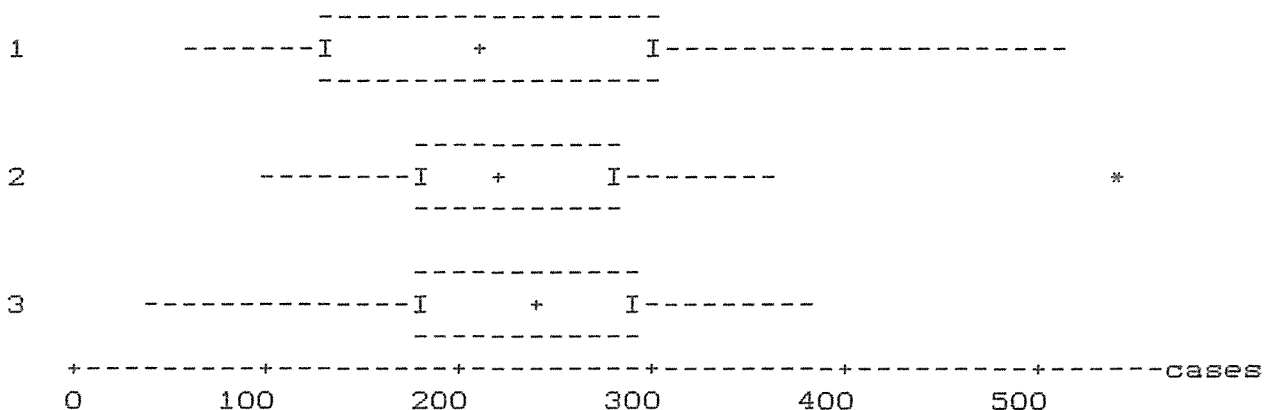
For the entire series, weekly price was slightly left skewed about a median of \$6.61 and ranged from a low of \$1.10 to a high of \$17.20.



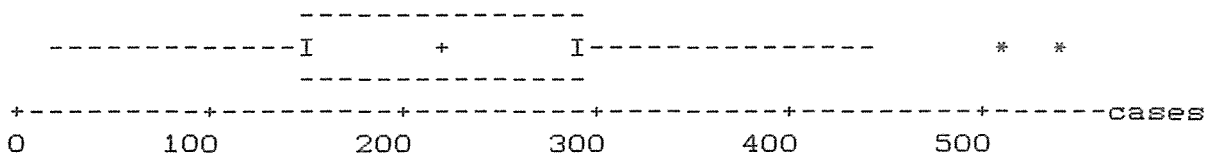
Total yearly volume increased by almost 5% in year 2, and by about 1% in year 3. See table 14.

Weekly volume has risen in each successive year, and the range of weekly volume while being extreme for year 1, was quite similar for years 2 and 3.

Year



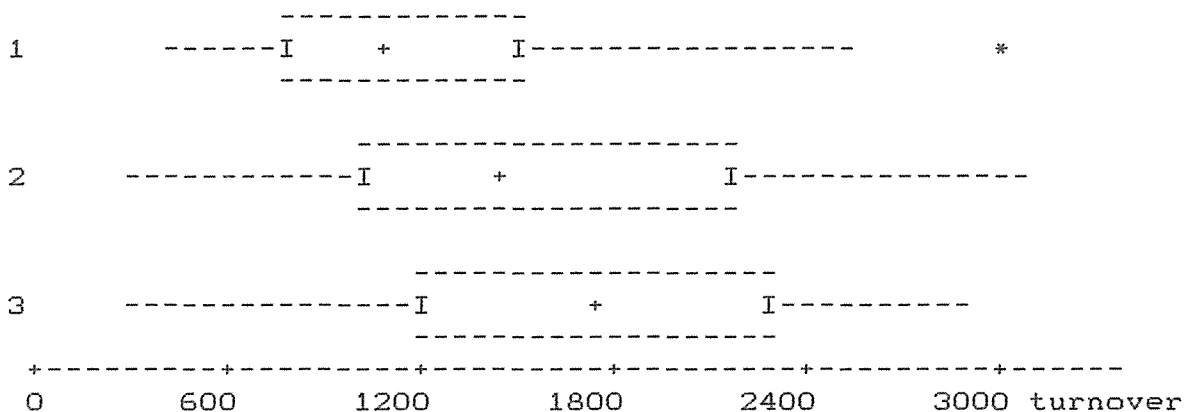
For the full series, weekly volume was symmetrically distributed about a median of 221 cases with a minimum volume of 19 cases and a maximum of 537 cases.



Yearly turnover increased considerably more in percentage terms than volume in the three years. The increases were about 29% in year 2, and about 11% in year 3. See table 15.

In each year median weekly turnover has risen.

Year

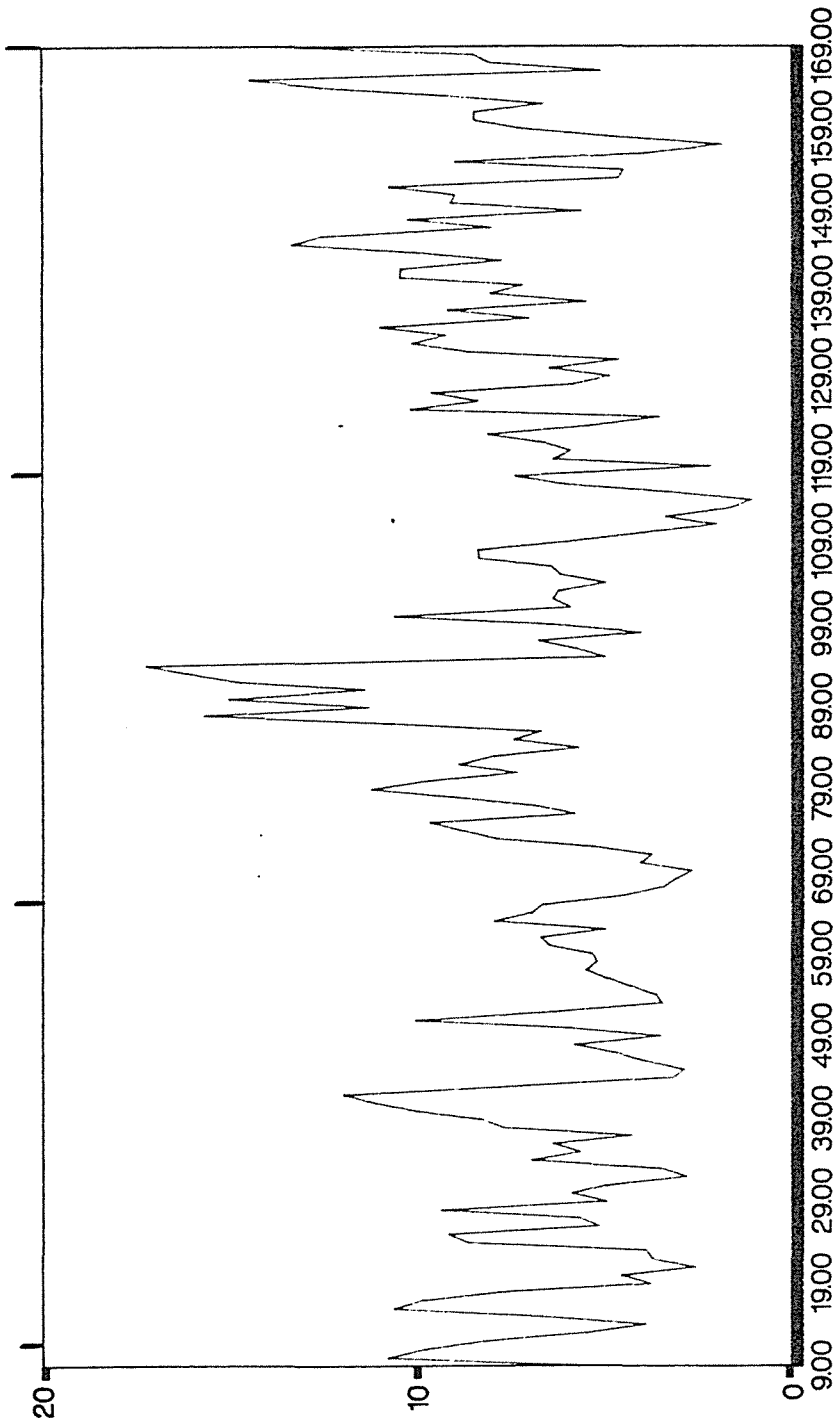


29/3/85

30/3/84

25/3/83

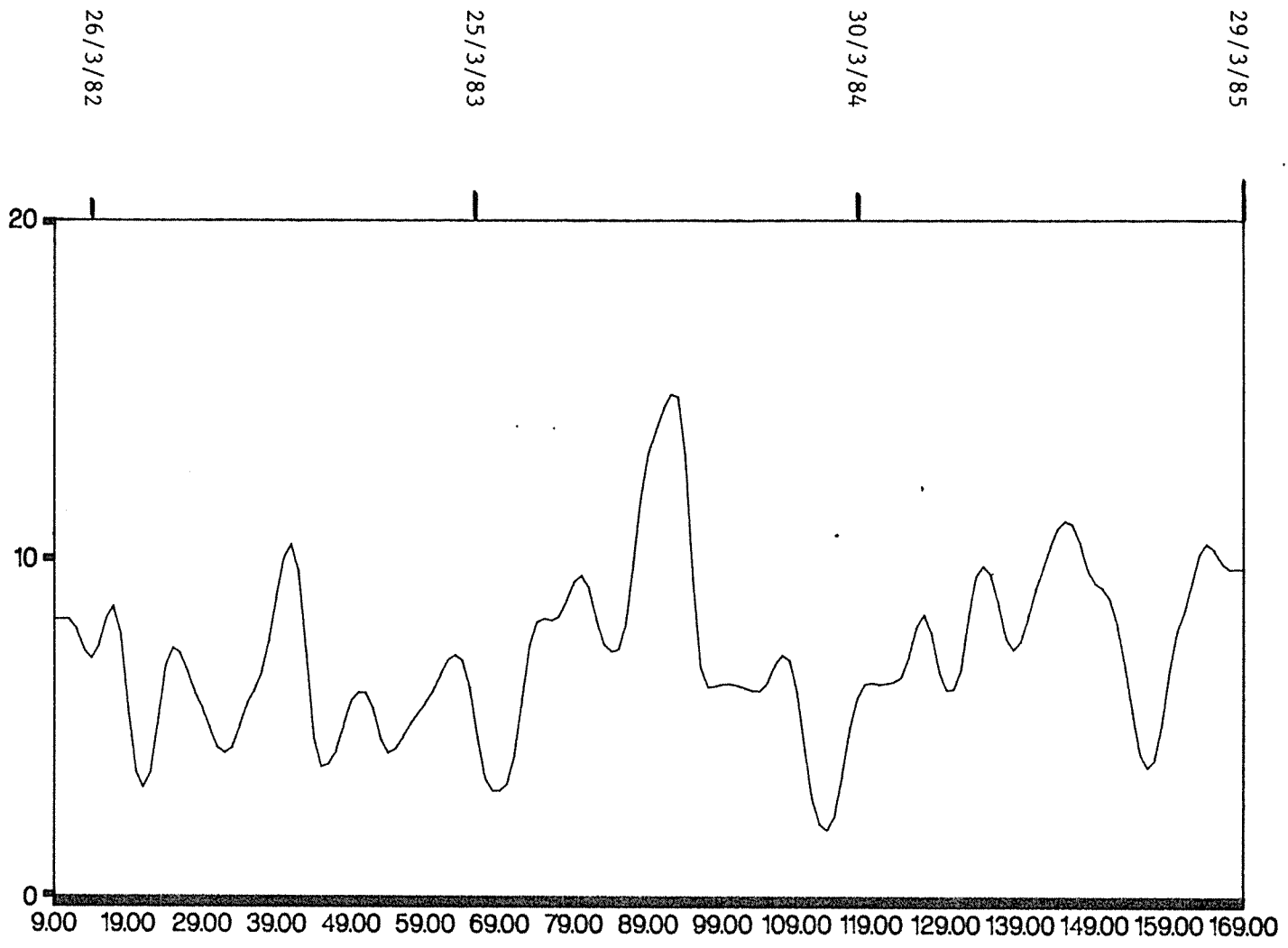
26/3/82



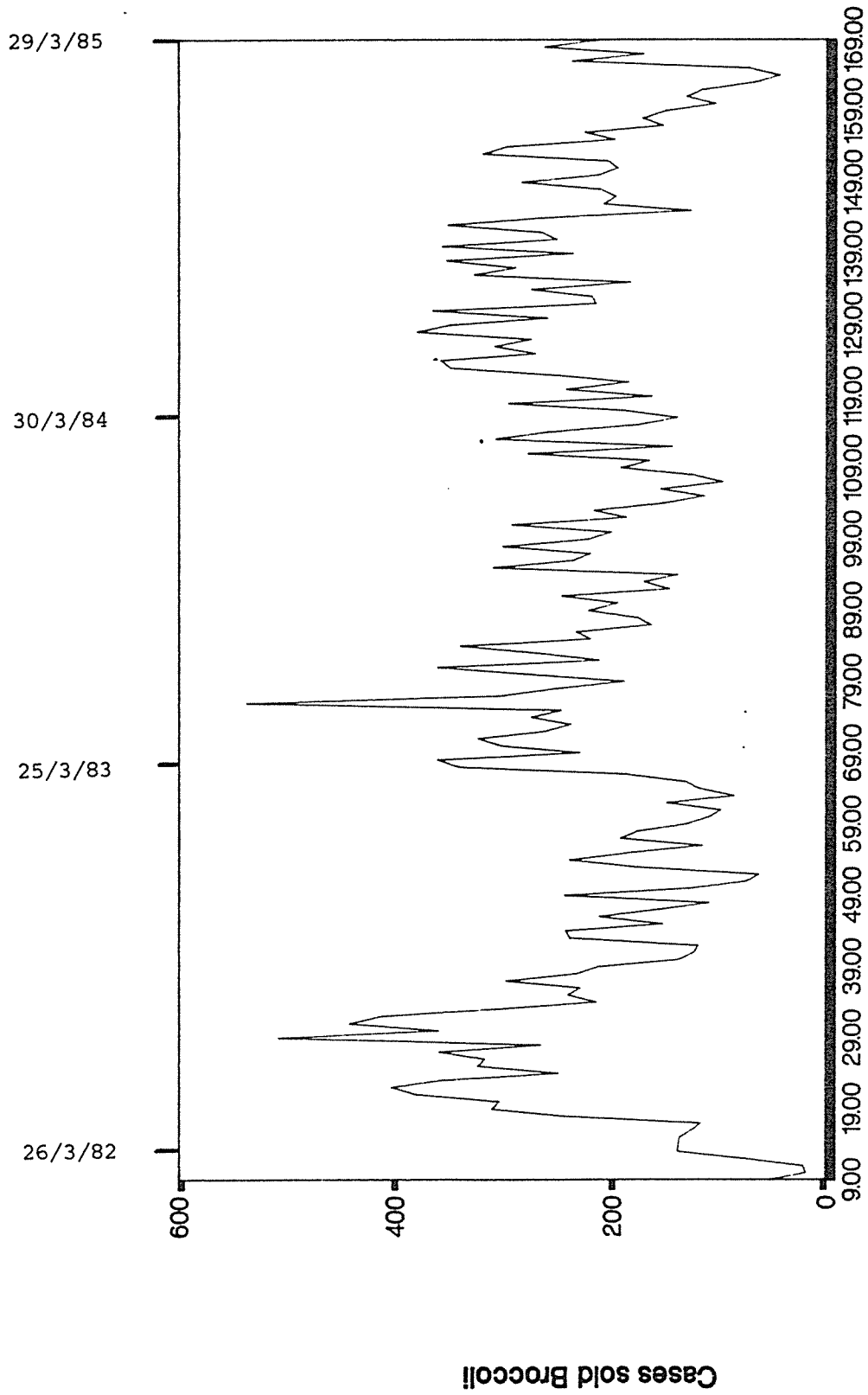
900 1900 2900 3900 4900 5900 6900 7900 8900 9900 10900 11900 12900 13900 14900 15900 16900

week rank from 1.182 to 29.385

smoothed price of broccoli



week rank in period 1-1-82 to 29-3-85



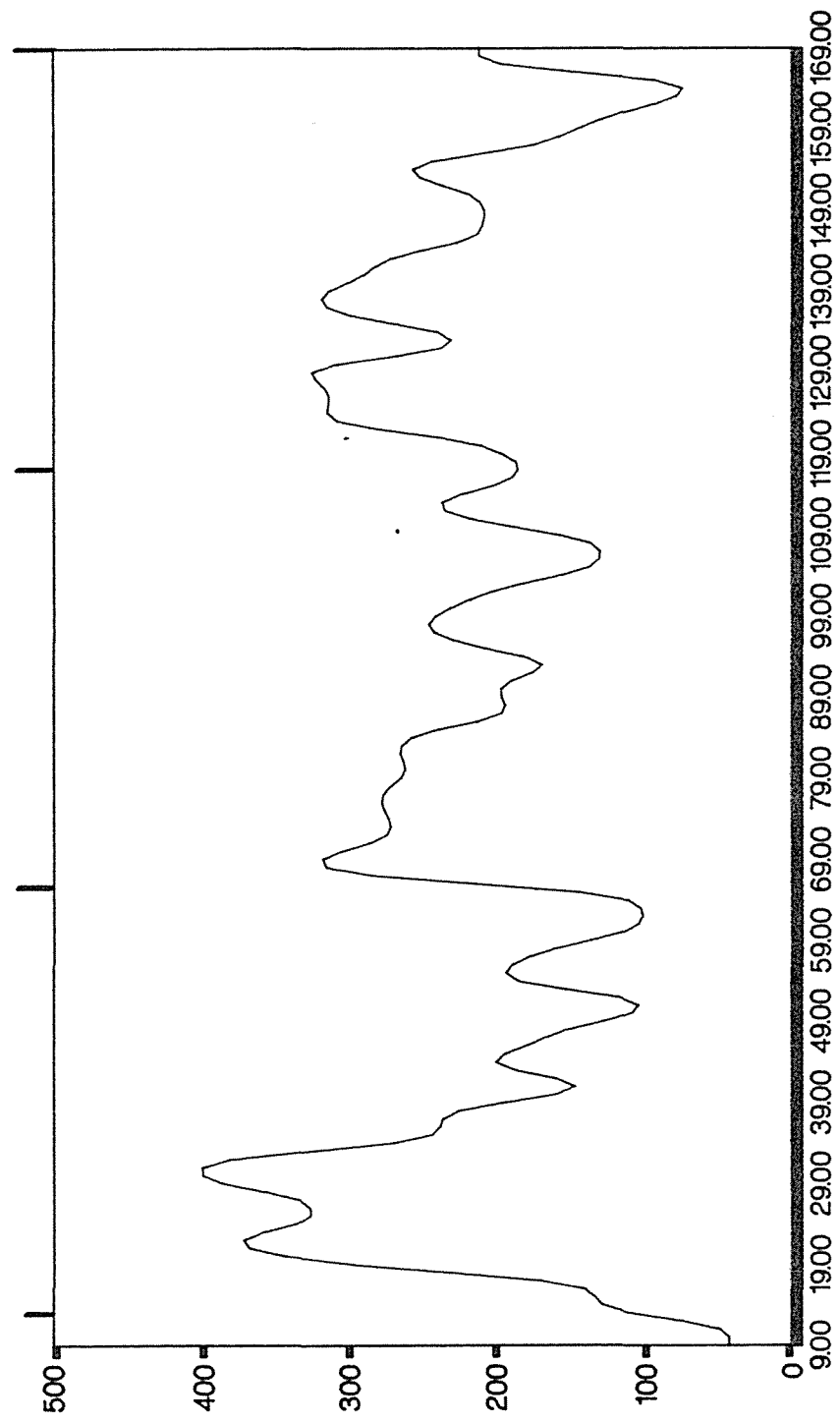
week rank from 1.182 to 29.3.85

29/3/85

30/3/84

25/3/83

26/3/82



smoothed volume of broccoli

week rank in period 1-1-82 to 29-3-85

The original price series shows times of large variation in prices from week to week.

The plot of smoothed prices has 24 turning points. There are ten in year 1, seven in year 2, and seven in year 3.

The year 1 and year 3 parts of the series have similar variation, but year 2 exhibited one very high spike in early October followed by one very low spike in May.

The particular smoother chosen was not able to clearly detect a seasonal pattern. It appears that over all, prices peaked in mid October.

The time of lowest price differed from year to year.

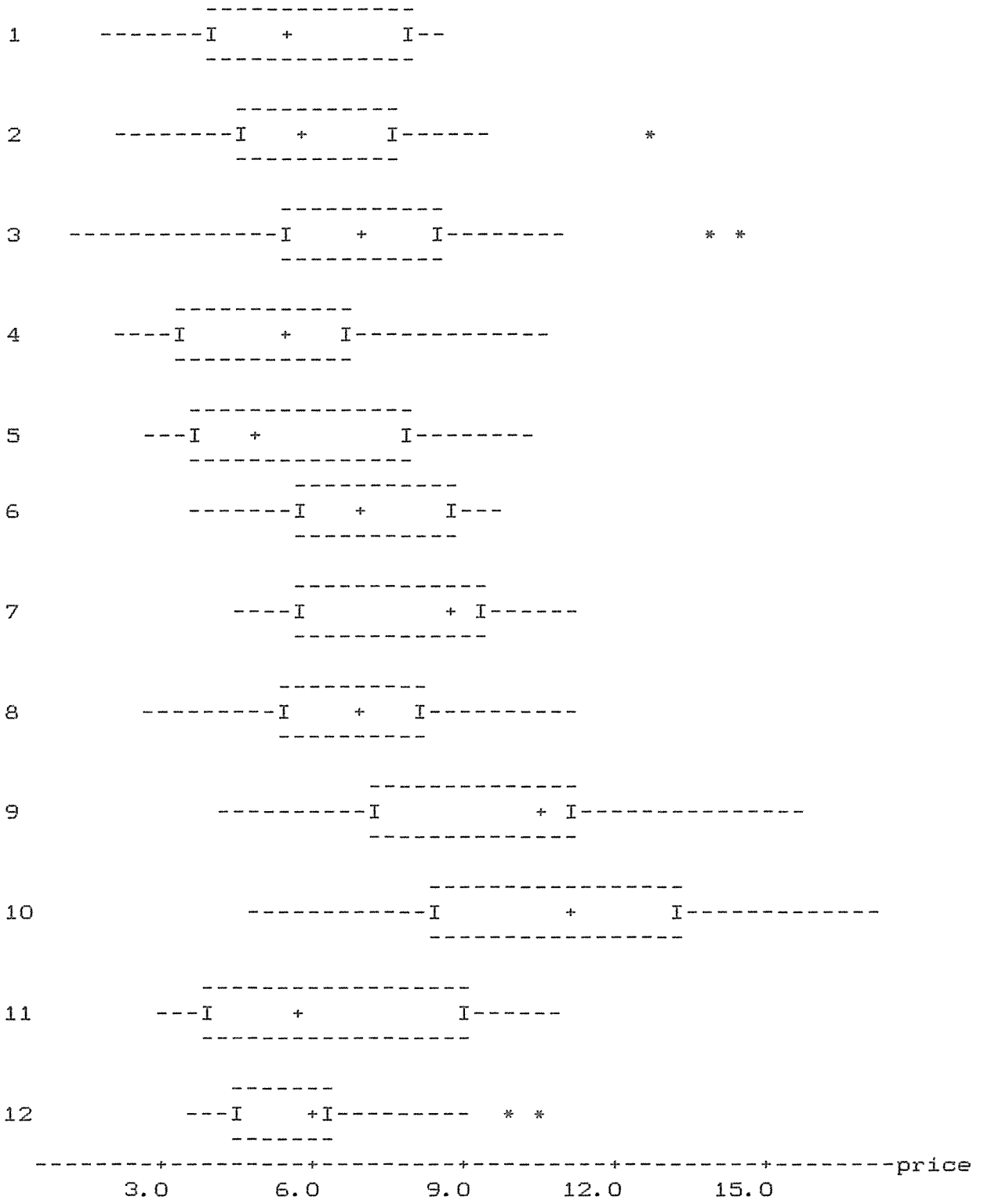
Volumes were highest in June and July, and lowest in January and February. The smoothed series indicate that in general the volume peaks correspond to the price troughs and the volume troughs correspond to the price peaks.

Over the three years prices were slightly more variable than volume.

	Coefficient of variation
price	.44
volume	.42
turnover	.49

The following boxplots display prices and volumes for the full three years in the study.

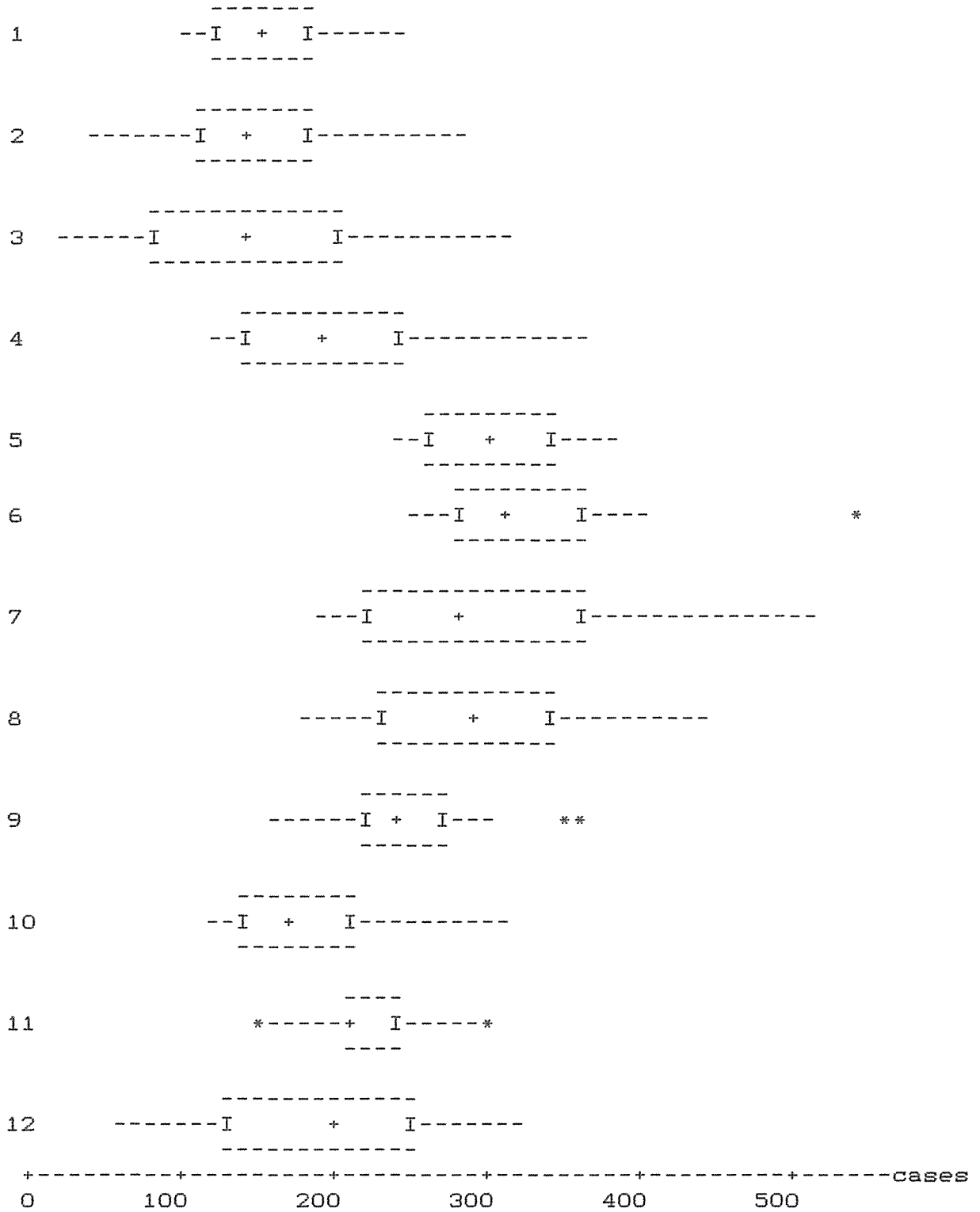
Month



From the above boxplots it can be seen that in general price rose in September and October and was fairly constant from November to May.

Median volume increased from its lowest in February and March to be highest in June.

Month



2 BRUSSELS SPROUTS

According to Ballinger (1980) brussels sprouts grow best in cool conditions. Plants are transplanted to the field in mid December and harvesting can take place from autumn.

The edible part is the buds or heads.

According to Thompson and Kelly (1957) brussels sprouts require similar treatment to cauliflower and thrive in cool and moist conditions.

The Yates seed catalogue notes that brussels sprouts are suited best to colder regions.

1 The behaviour of brussels sprouts at auction

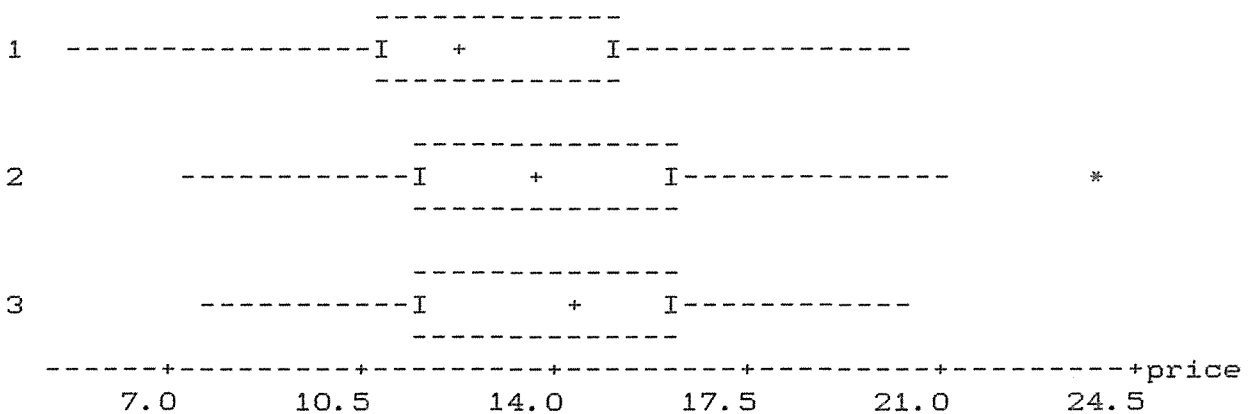
Brussels sprouts were not supplied continuously. There were three periods in the 3 years when no brussels sprouts were supplied. These times were the beginning of October 1982 to 14 February 1983, 23 September 1983 to 20 January 1984, and 28 September 1984 to 29 December 1984.

That is, the end of supply was at the end of September, and the first supplies were from the end of December to the middle of February.

Mean weekly price rose by about 11% in year 2 and then by 0.5% in year 3. See table 13.

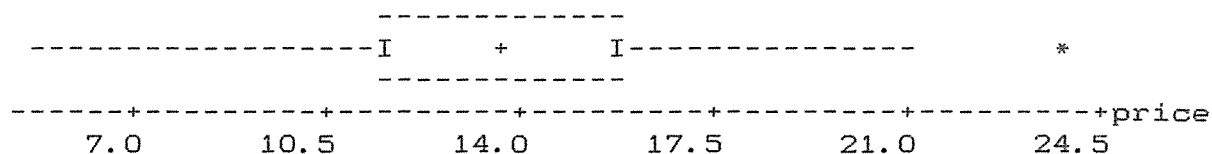
The range of prices has fallen in succeeding years while the median has risen. The range of prices received in year 3 was about the same as for year 2.

Year



For the entire three years price was quite symmetric about a median of \$13.76 except for one outlier occurring for week 89, ending 16 September 1983, which was for the last of the season's production.

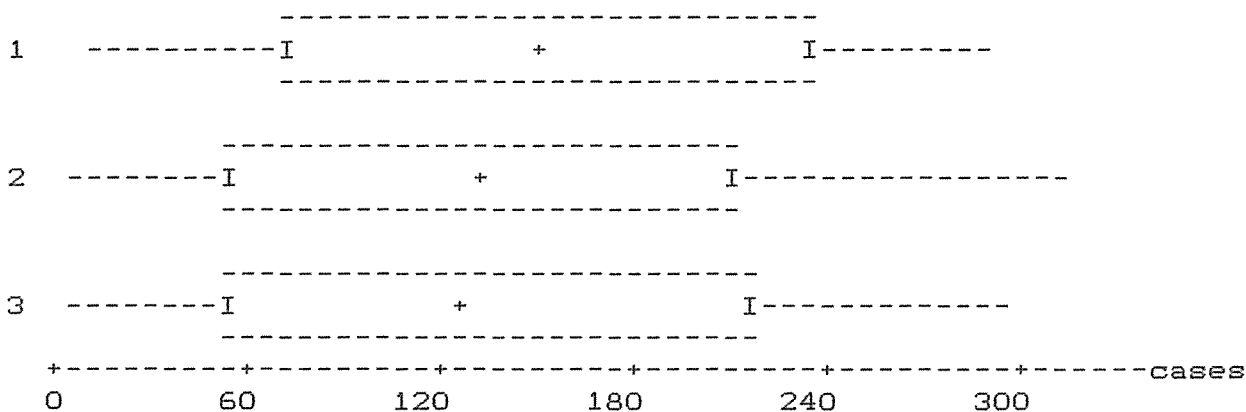
There is no other evidence to suggest that prices rise at the end of, or in anticipation of, the end of the season.



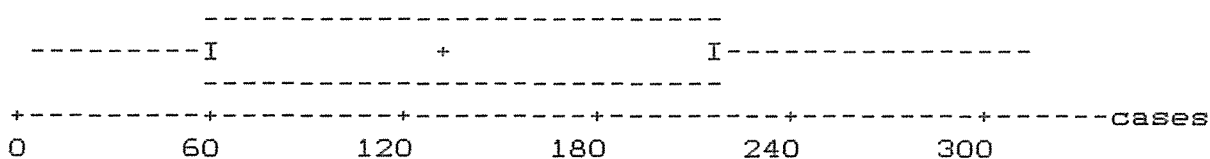
Volume fell by about 16% in year 2 rising again in year 3 by about 8%. The year 3 volume was less than the year 1 volume. See table 14.

In each succeeding year median weekly volume has fallen.

Year



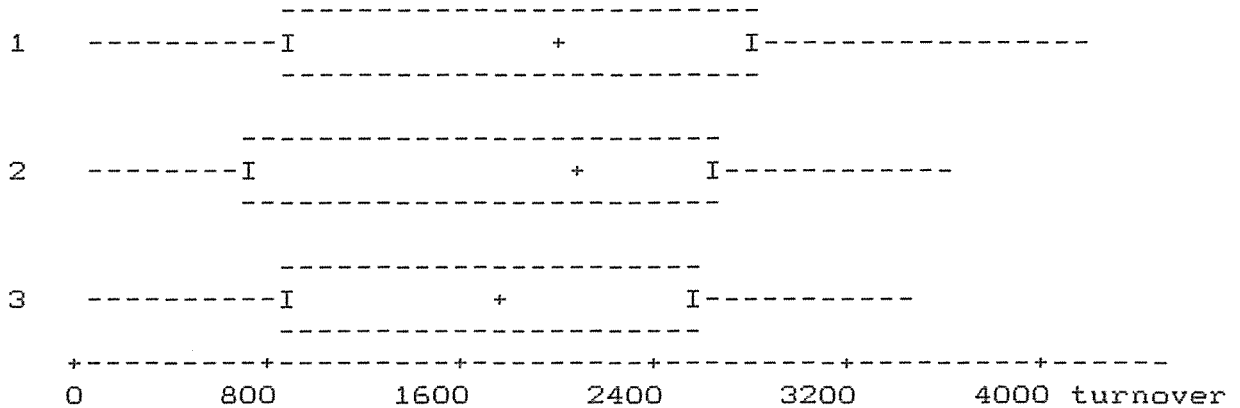
For the entire series volume ranged from 3 cases to 314 cases and was symmetrically distributed about a median of 131 cases.



Annual turnover fell in the second year by about 13% and increased in the third year by about 8%. It did not reach the same level as the first year. See table 15.

~~Both the range of weekly turnover and median turnover per week have fallen.~~

Year



At the beginning of the season few cases are supplied. Peak supply occurred in about weeks 19, 79 and 129. This was mostly towards the middle of winter. Supply lasted for about 30 weeks, ending sometime after the end of August but before the beginning of October. The beginning of the season was late January and early February.

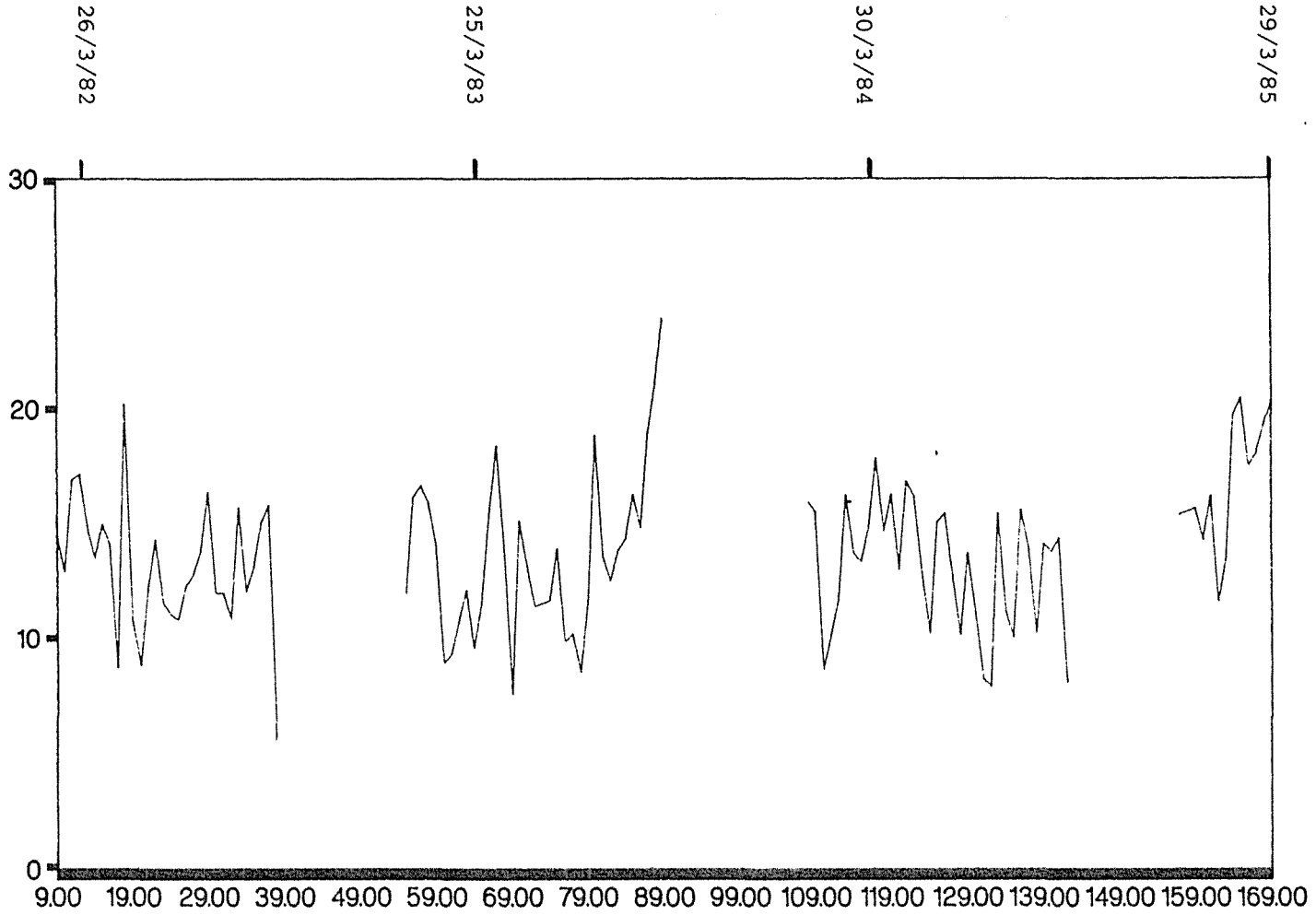
The price series indicates that prices have not varied as much from week to week as for some of the other vegetables.

Volume was more variable than price for the period.

	coefficient of variation
price	.24
volume	.63
turnover	.59

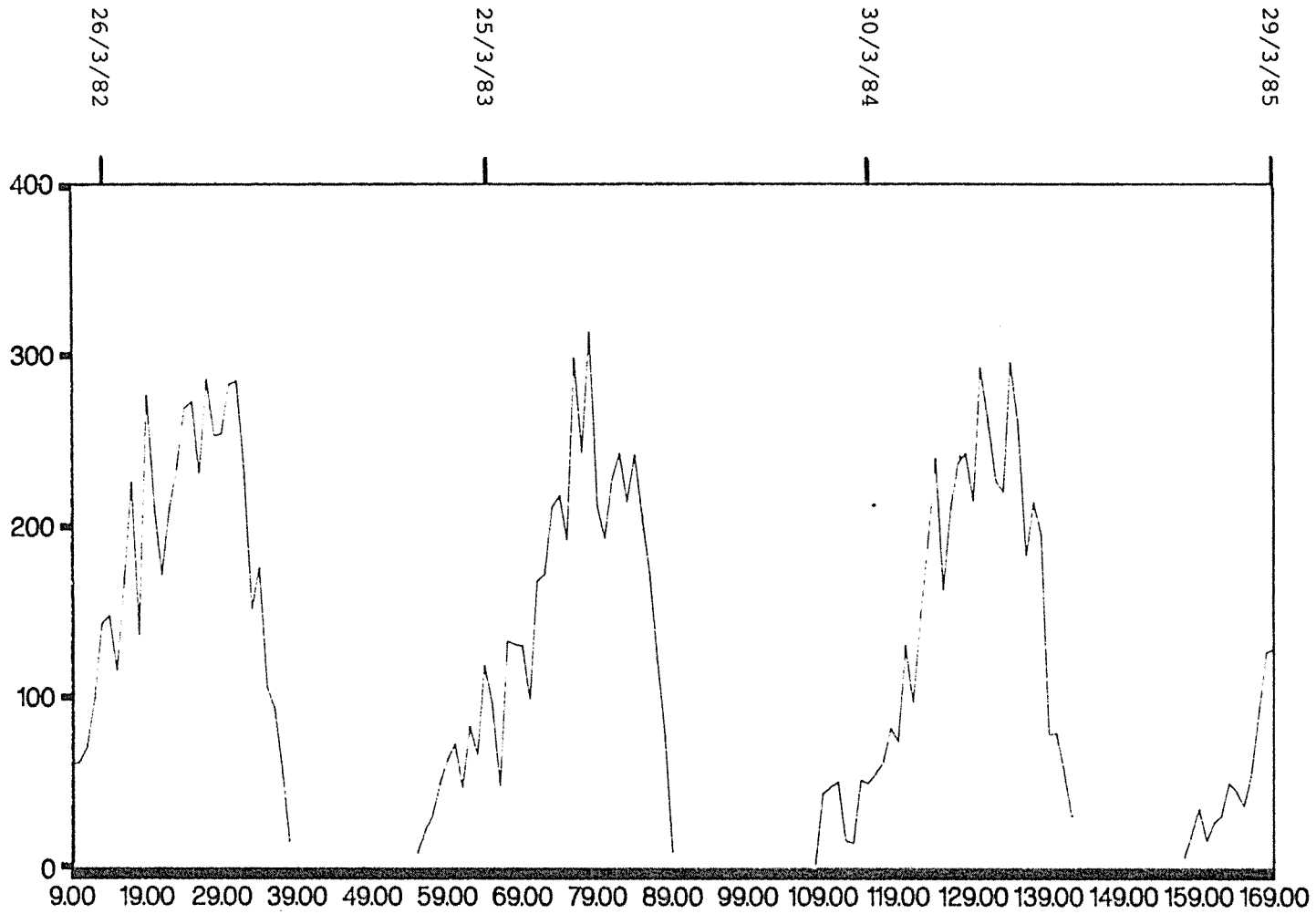
Note: smoothed plots were not produced for brussels sprouts.

price per case of Brussel Sprouts



week rank from 1.82 to 29.3.85

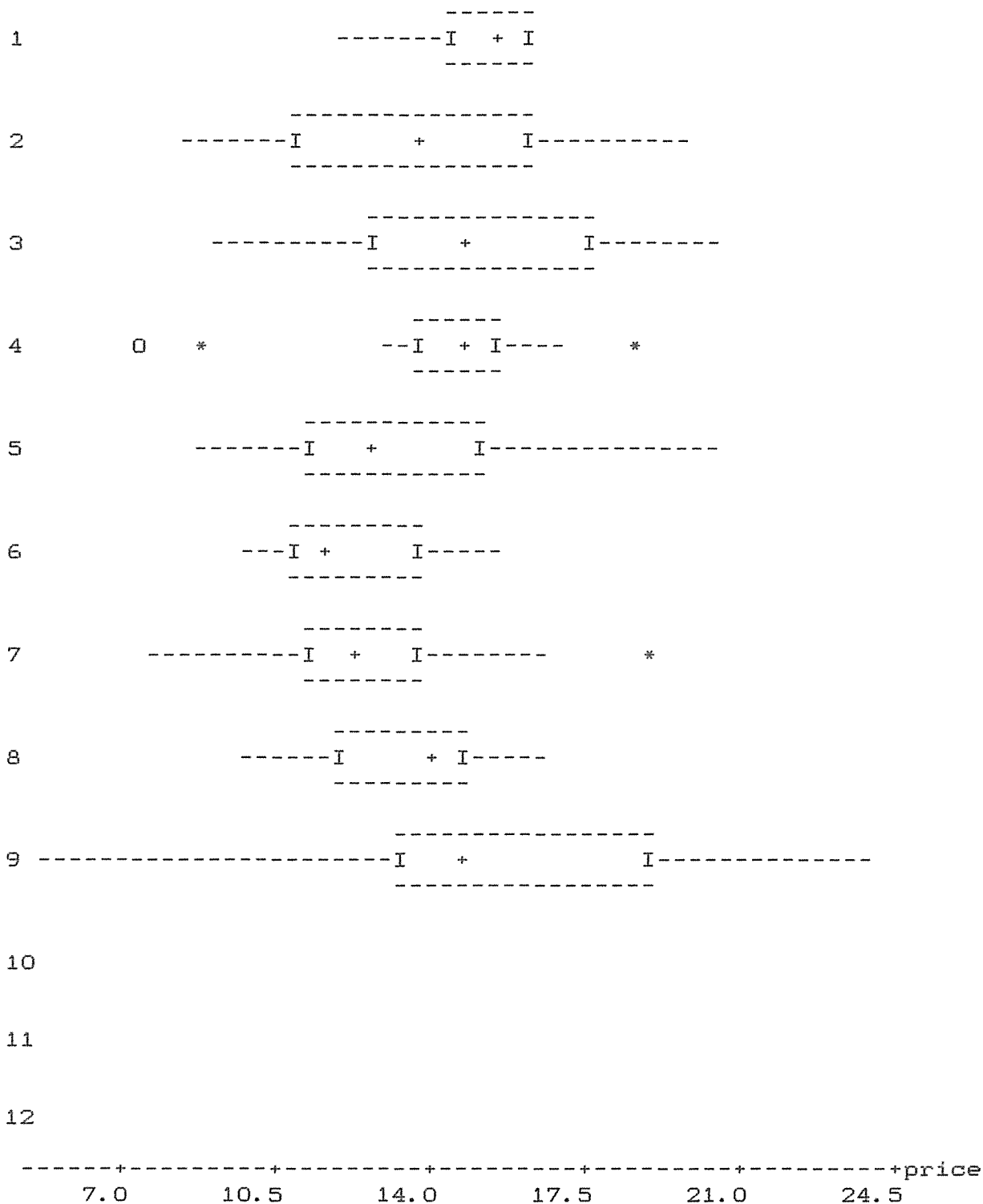
Cases sold Brussel Sprouts



week rank from 1.1.82 to 29.3.85

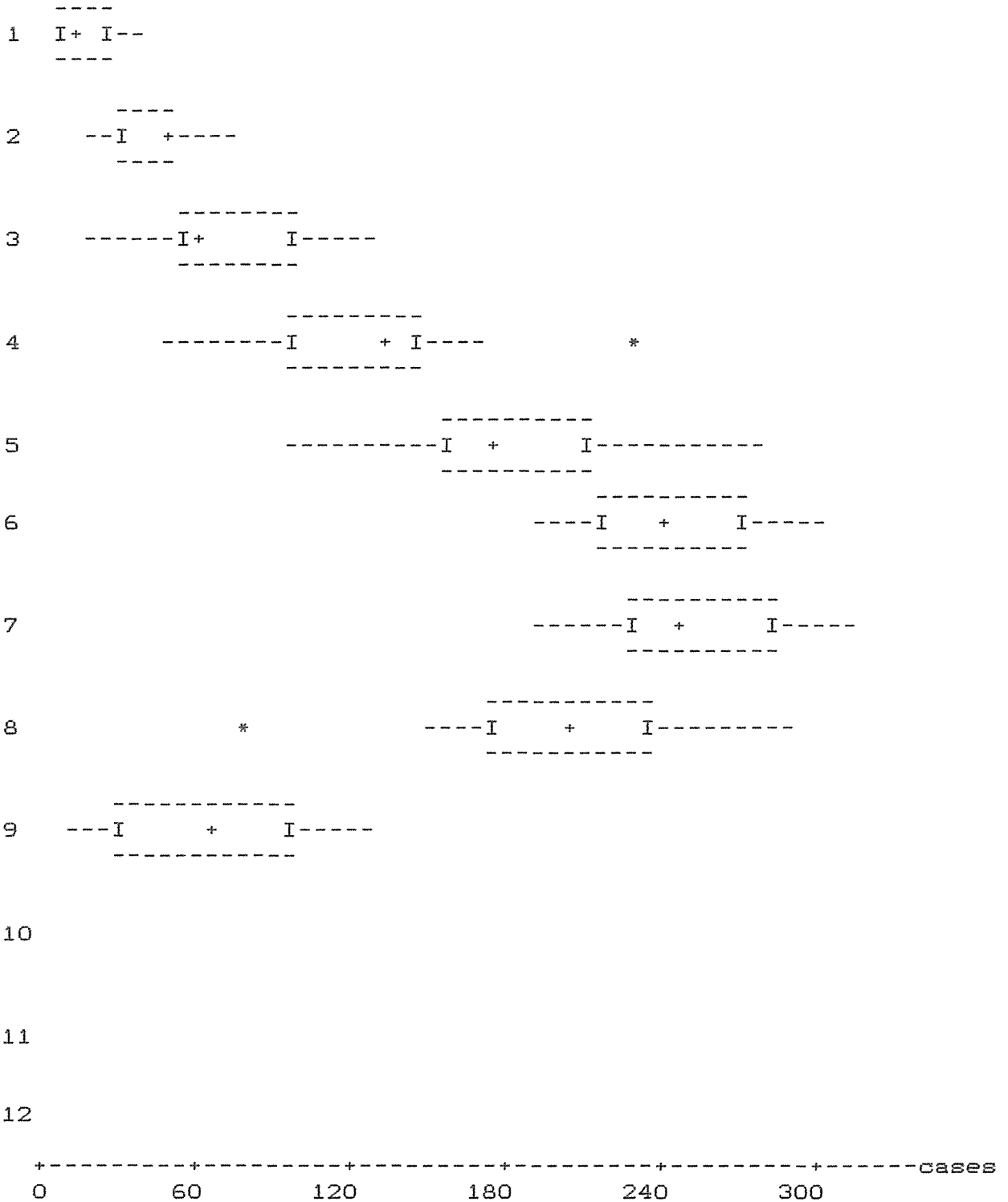
The following boxplots illustrate that in general prices were lowest in June and highest in September which is the end of the season. No volume was supplied in October, November, or December. Prices are also quite high in January, which is the beginning of the season. Median weekly price for January was about the same as median weekly price for September.

Month



Supply to the market began in January and rose steeply to peak in July. It then fell with nothing available in October, November, and December.

Month



3 CABBAGE

Cabbages are grown throughout the year in the Manawatu, Auckland, and Hawkes Bay regions.

According to Ballinger (1980) the many cultivars make it possible to have a supply all year. The length of time taken to reach maturity depends on the cultivar and the time of year.

days to maturity

spring	100-160
summer	70
autumn	80
winter	80 -110

The planting times depend on the cultivar and the weather conditions in a particular region.

According to the Yates seed catalogue cabbages are not sensitive to cold until they pass the seed bed stage of development. Once past this stage if subjected to extended cool periods yields may be effected. There are sufficient varieties so that cabbages can be planted and harvested in all seasons.

1 The expected behaviour of prices

There are many different varieties of cabbage and it is available all year. The vegetable does prefer cooler conditions so we would expect volumes to be higher in the winter months than in the summer months. Consequently we would expect prices to be higher in summer than in winter. Cabbage is used as a salad vegetable and so the reduction in its summer demand might not be as high as for, for example, cauliflower. Therefore we might find cabbage prices varying a little more than cauliflower prices.

Even though cabbage is available all year we would expect volumes to be highest at the end of winter.

2 The behaviour of cabbages at auction

Cabbages were supplied continuously for the full period under study.

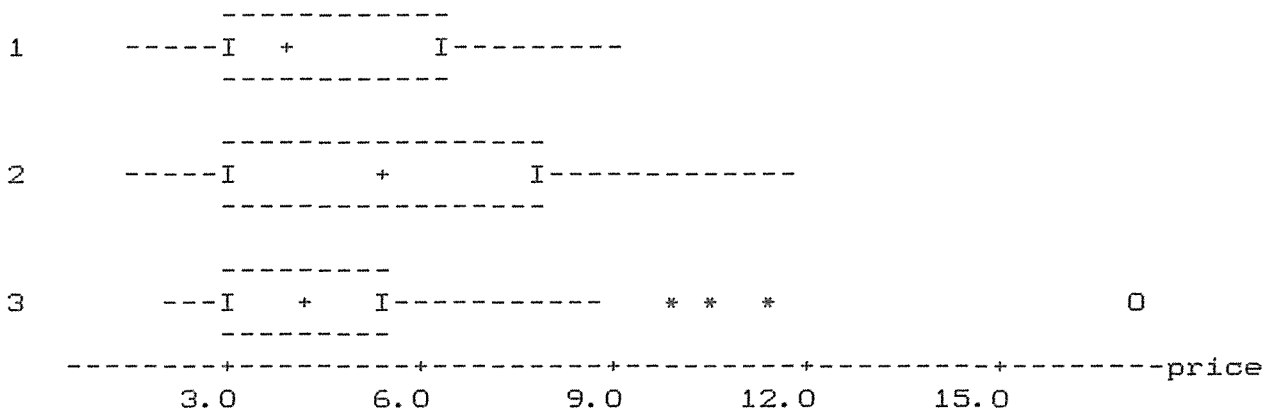
The mean weekly price for cabbages rose and then fell in successive years. See table 13. For the years ended March 1983, March 1984, and March 1985 it was \$4.49, \$5.62, and \$5.10 respectively.

Weekly price exhibited more variation in the year to 31 March 1984 than in the March 1983 and March 1985 years. The price for cabbage has in general remained at much the same level after three years.

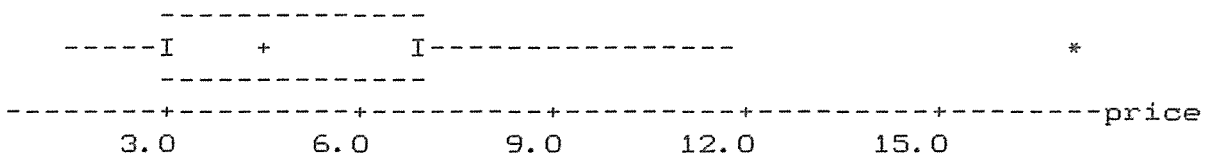
Most prices are concentrated about \$4.00 with quite a long tail; at times prices in excess of \$9.00 were received.

The median price in year 3 was about the same as for year 1. However, in year 3 there were four occasions when relatively high prices were received. The price hinge-spread has decreased in year 3 also indicating that in general lower prices were received in year 3.

Year

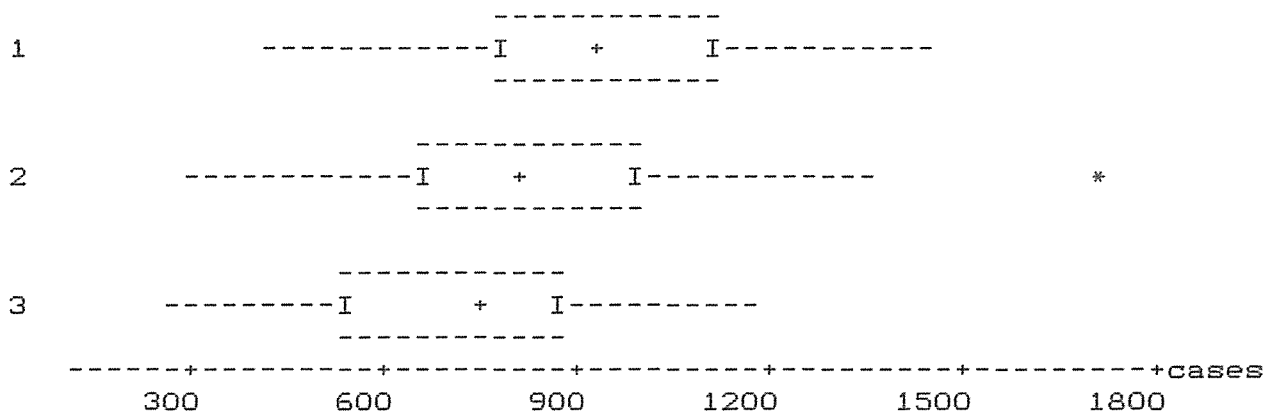


For the entire series, weekly price was left skewed about a median of \$4.42 a case with a minimum price of \$1.52 and a maximum price of \$17.16.



The total number of cases sold has fallen each year.

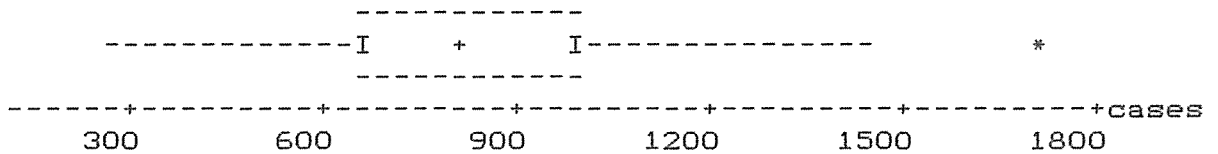
Year



~~In 1984 volume had fallen by about 12% and in 1985 by about 13%.
See table 14.~~

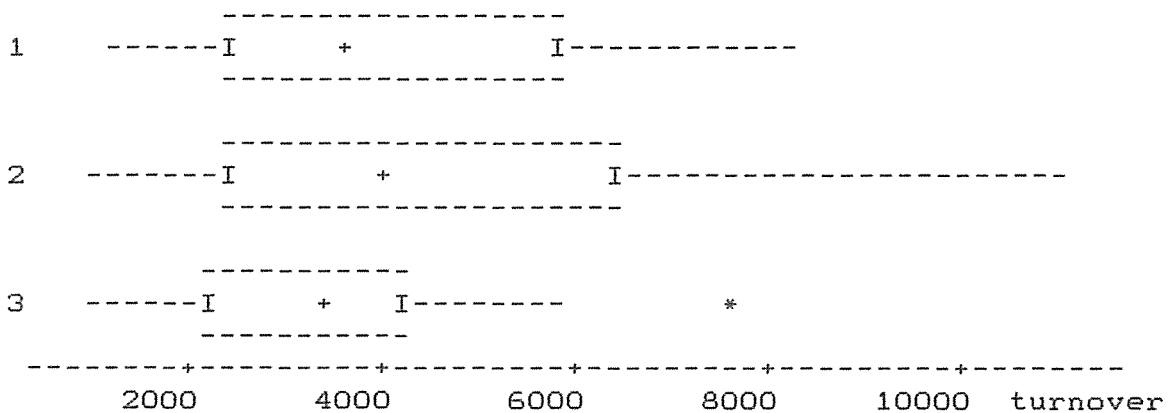
The increase in turnover of 6.6% in the year to March 1984 caused that year's average (mean and median) price to rise above the previous year's price by 25%. In the following year however, turnover, volume, and price fell by 24.6%, 13.1%, and 9.1% respectively. Not only was there less sold, but it was sold at a lower price.

For the entire series weekly volume ranged from a low of 274 cases to a high of 1701 cases, and was symmetrically distributed about a median of 819 cases.

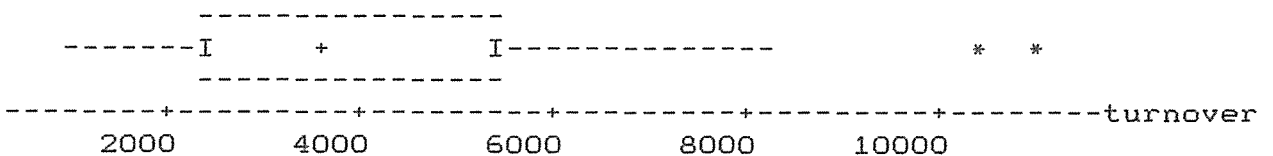


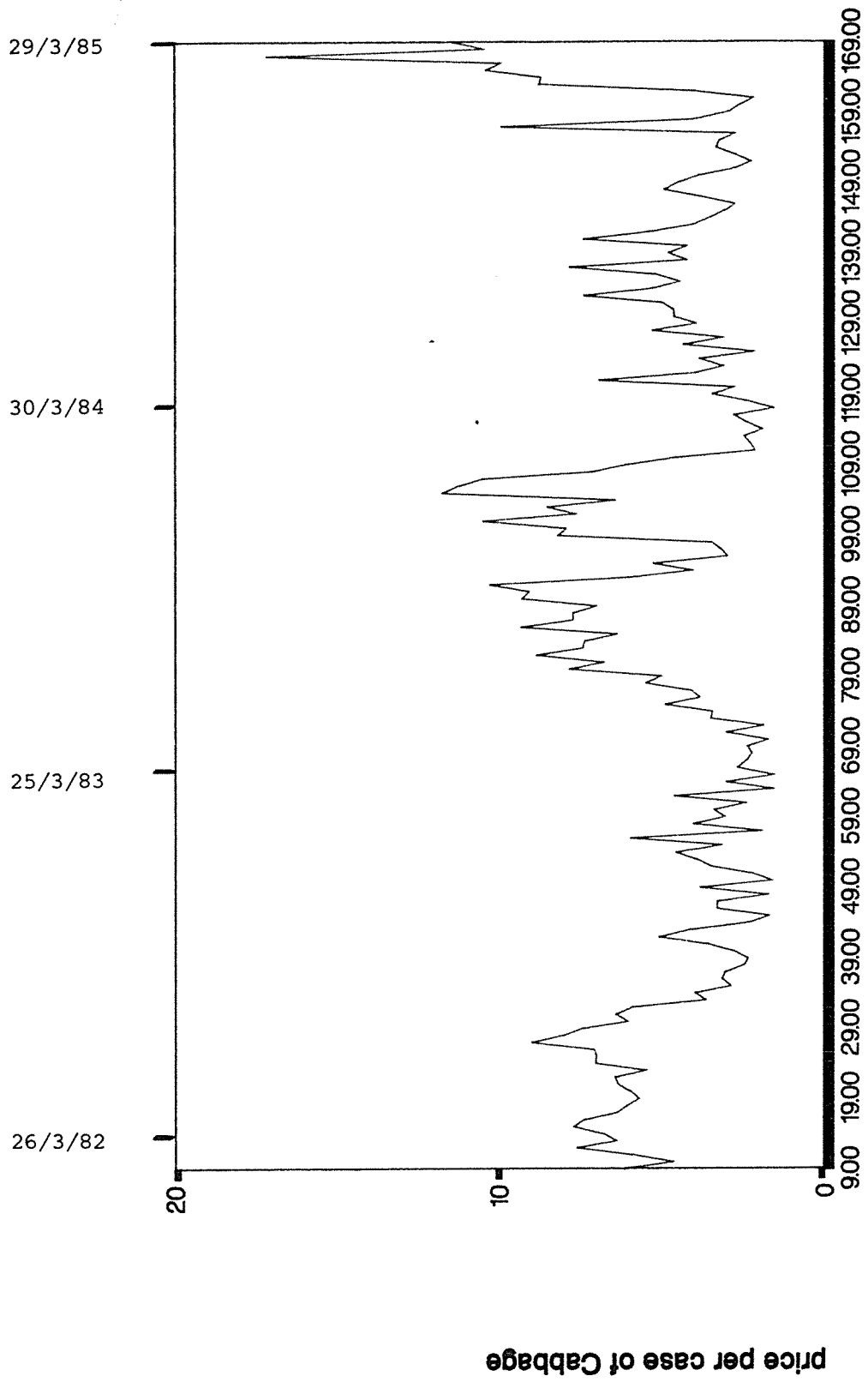
Annual turnover increased by about 7% in year 2 and then fell by almost 25% in year 3. See appendix table 15.

Weekly turnover for each year is displayed below. In year 3, not only was median turnover lower, but the variation in turnover had decreased dramatically.



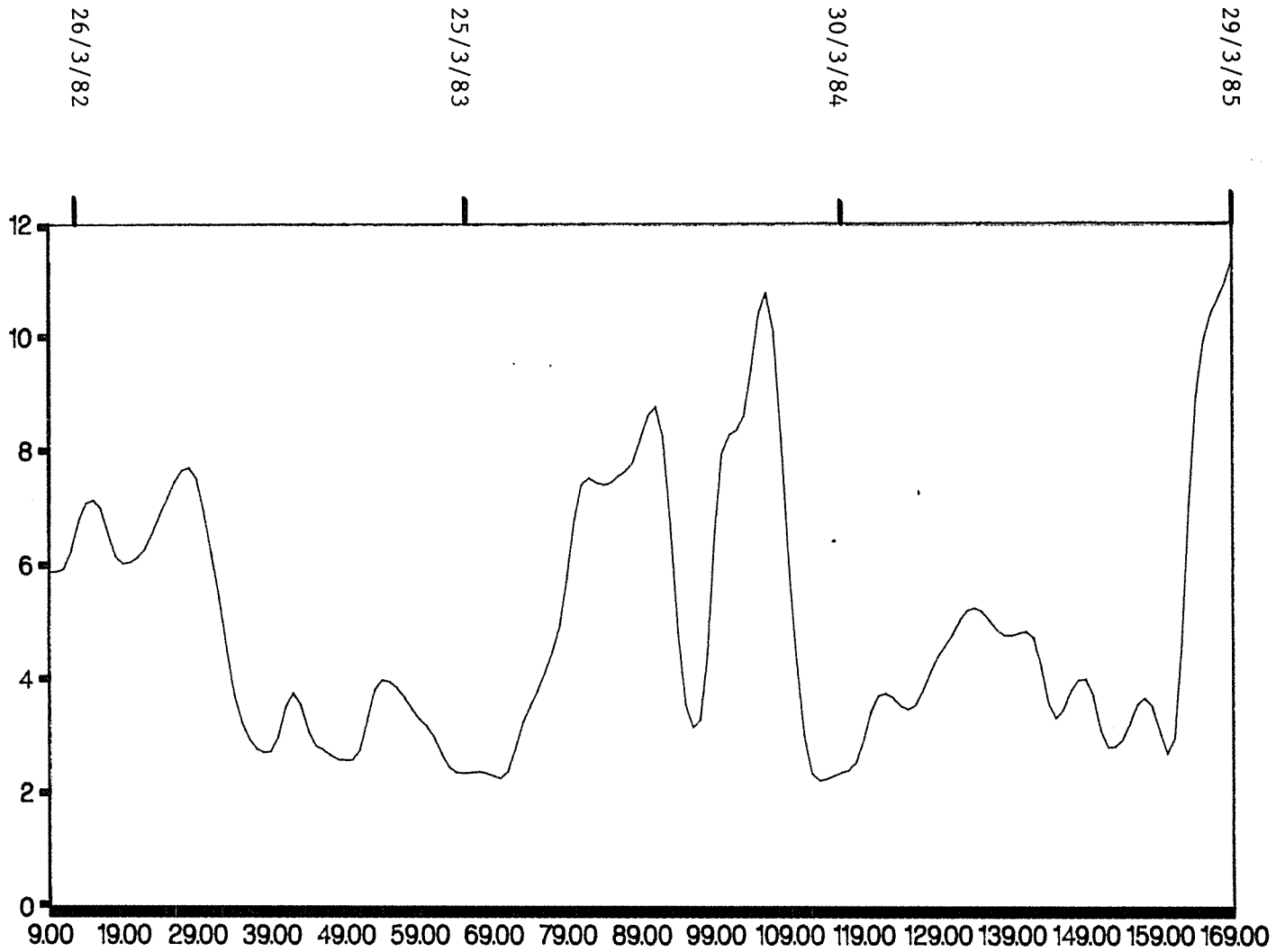
For the complete series weekly turnover was right skewed about a median of \$3644.00 and ranged from \$912.00 to \$11034.00.



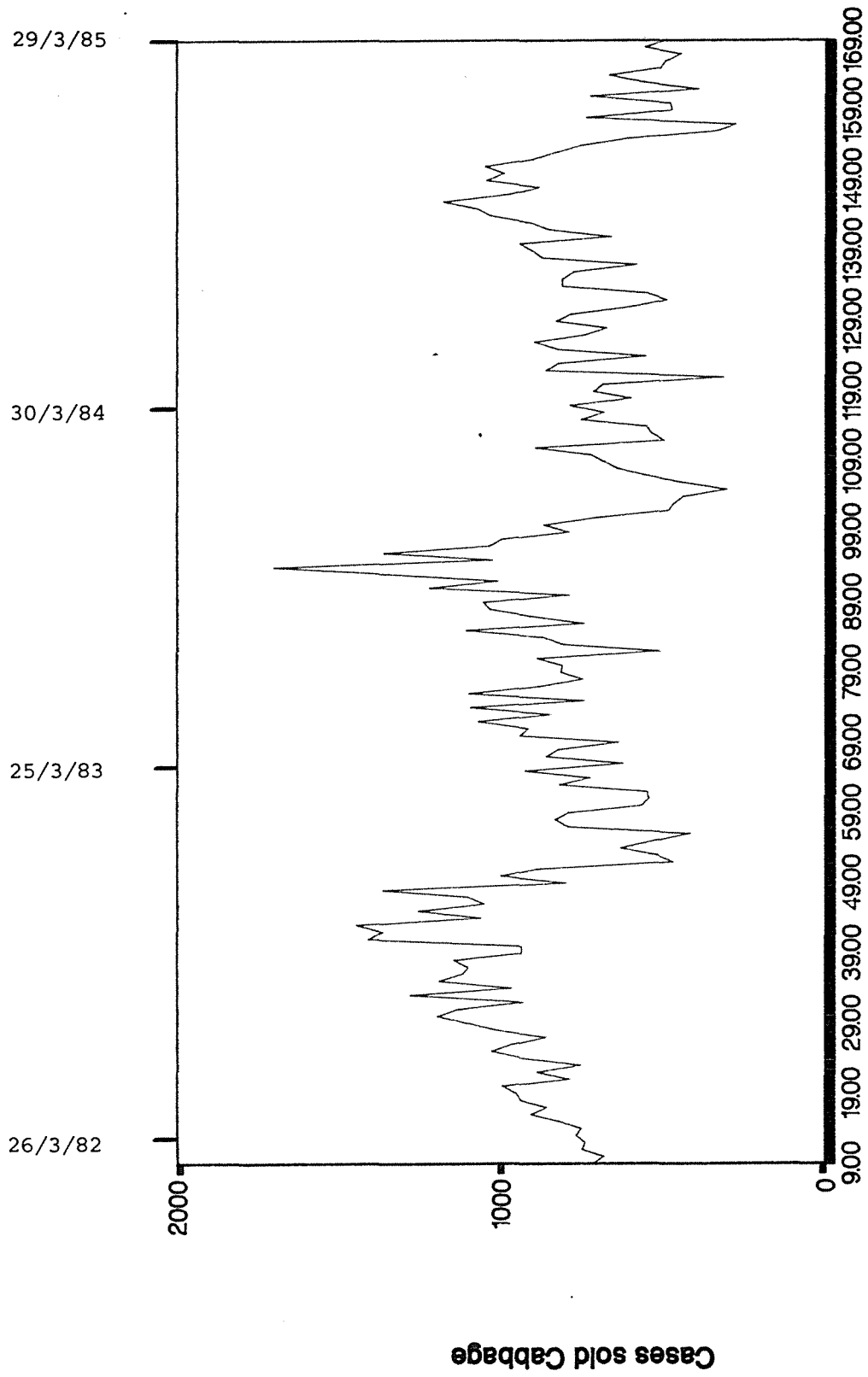


week rank from 1.182 to 29.3.85

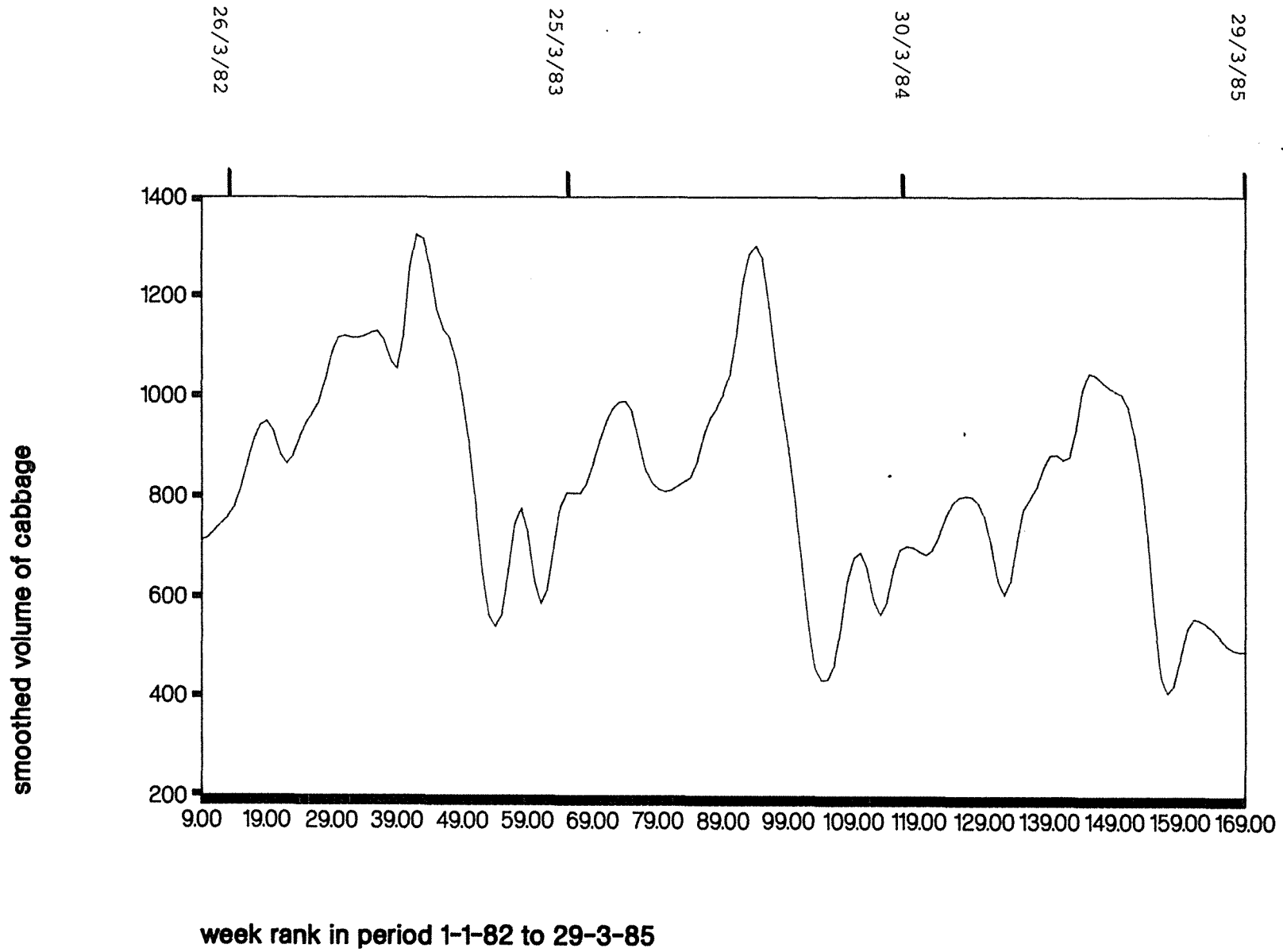
smoothed price of cabbage



week rank in period 1-1-82 to 29-3-85



week rank from 1.182 to 29.3.85



Apart from July which features twice as a period of high prices, the periodicity between corresponding high prices, and between corresponding low prices is not constant. January features as a month in which the series has both peaks and troughs.

Weekly cabbage prices were quite variable and did not exhibit very much seasonality. For the first two years they low in March and April, but by March in the third year they were peaking.

Prices were consistently high in July.

Volumes exhibited a reasonably constant pattern being lowest in December and January and highest in October.

About a third of the time highest weekly prices and lowest weekly volumes did not coincide, price often peaking after lowest supply.

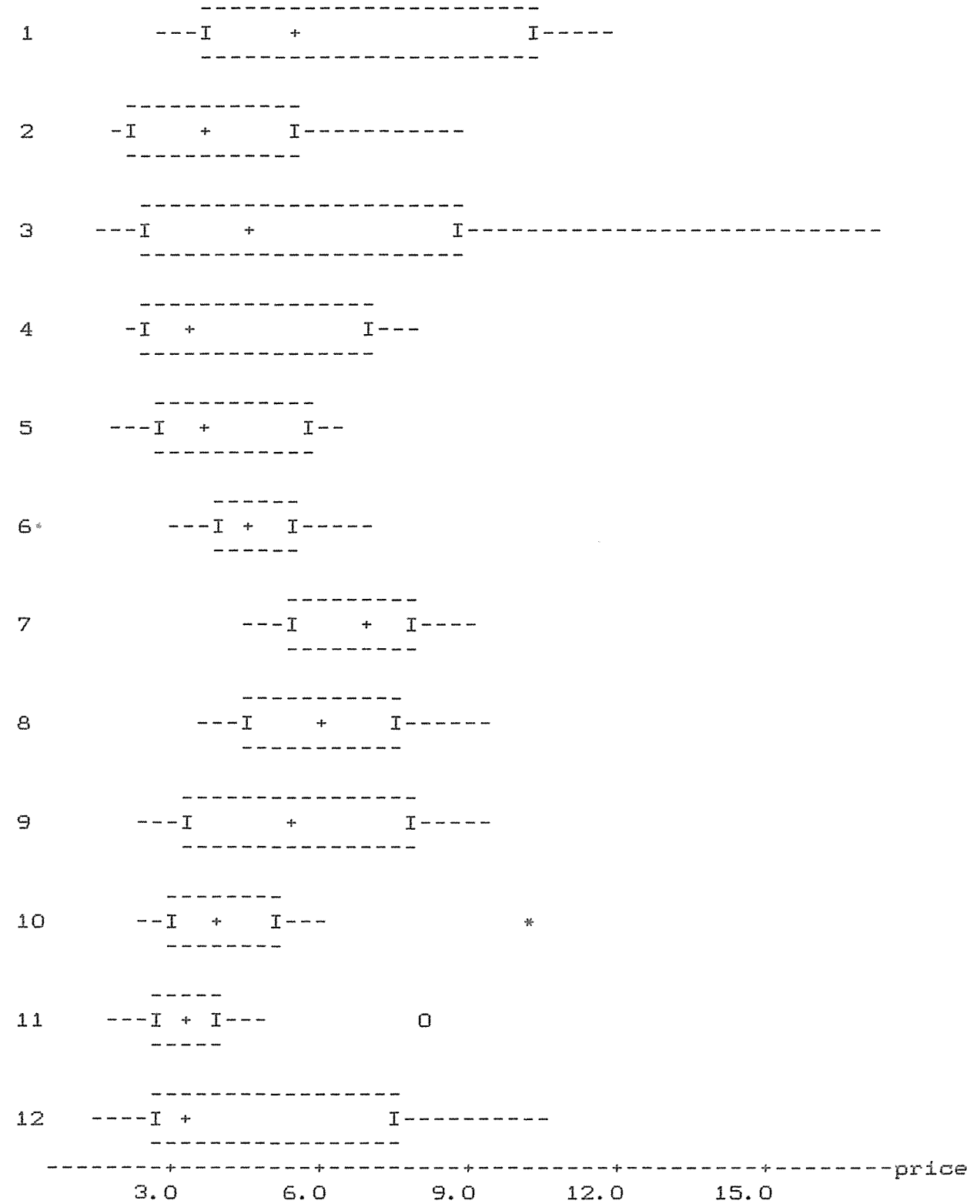
Price was considerably more variable than volume.

coefficient of variation

price	.52
volume	.31
turnover	.51

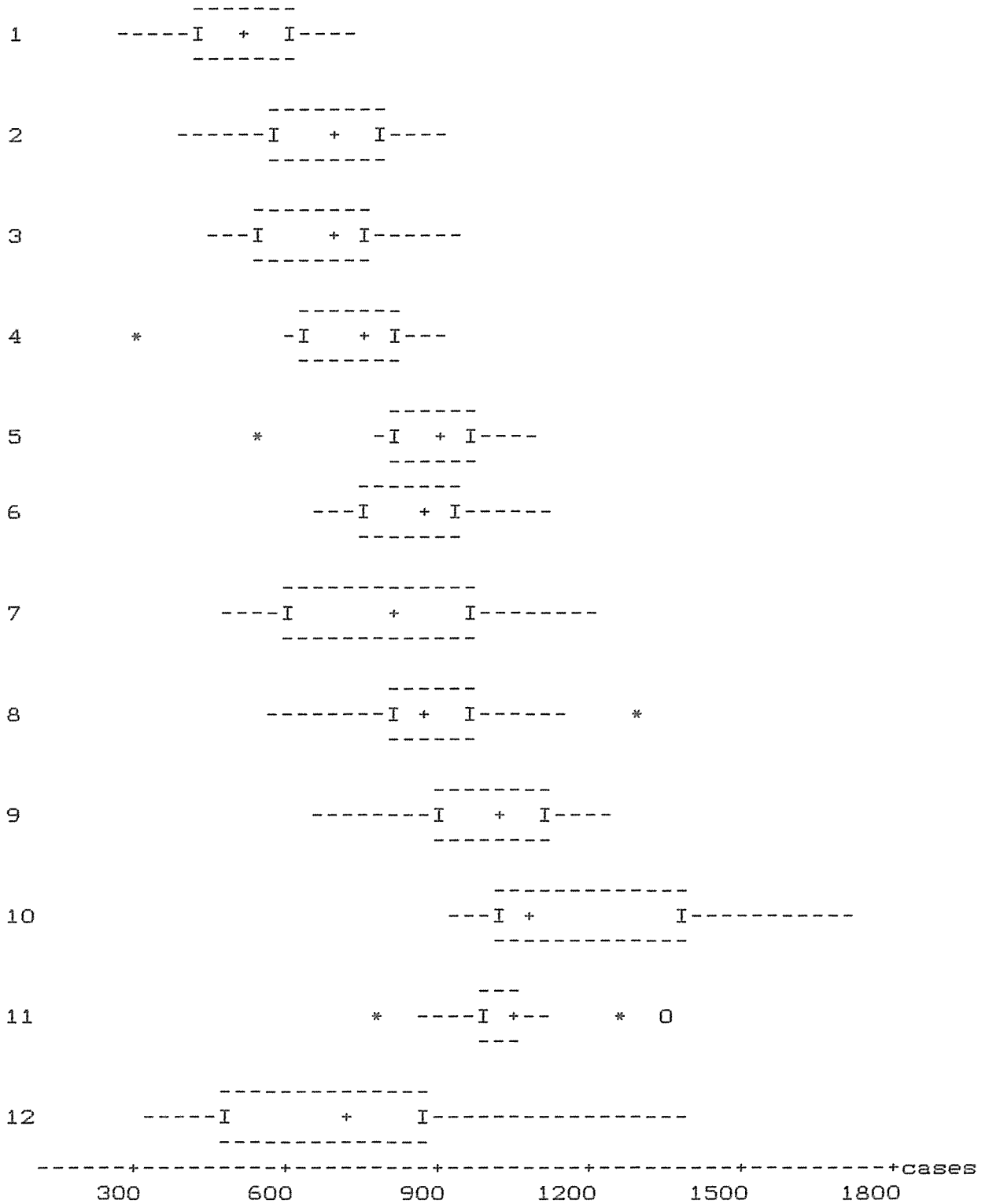
~~It is difficult to discern a clear pattern in the boxplots below.~~
 Median price is highest in mid winter and low in autumn and the beginning of summer. There is one turning point in July with perhaps another one in November.

Month



Volume rose smoothly to peak in October and then declined and was lowest in January. Turning points appear to be in January and October.

Month



4 CAPSICUMS

Capsicums are grown throughout the year, but are primarily a summer crop. They are grown outdoors in the summer months and indoors in the winter months. A large difference usually occurs between summer and winter quantities supplied and this is reflected in the price. Capsicums are grown in all three North island regions.

Capsicums are very sensitive to frost and are treated like tomatoes (Ballinger 1980, Thompson and Kelly 1957).

Ballinger notes that seedlings are planted in October and November, when the likelihood of a frost is small. It takes about 90 days for the vegetables to mature. During the colder months the market is supplied with glasshouse capsicums.

The Yates seed catalogue says that maximum yield is achieved if the growing period is long and warm. However yields will be adversely affected by extreme temperatures and insufficient water.

1 The expected behaviour of prices

We would expect volumes to be highest in summer and lower and probably constant during winter. Prices in winter should be higher than in summer, perhaps considerably so. Production in winter is limited by available greenhouse space which can alternatively be used for tomatoes.

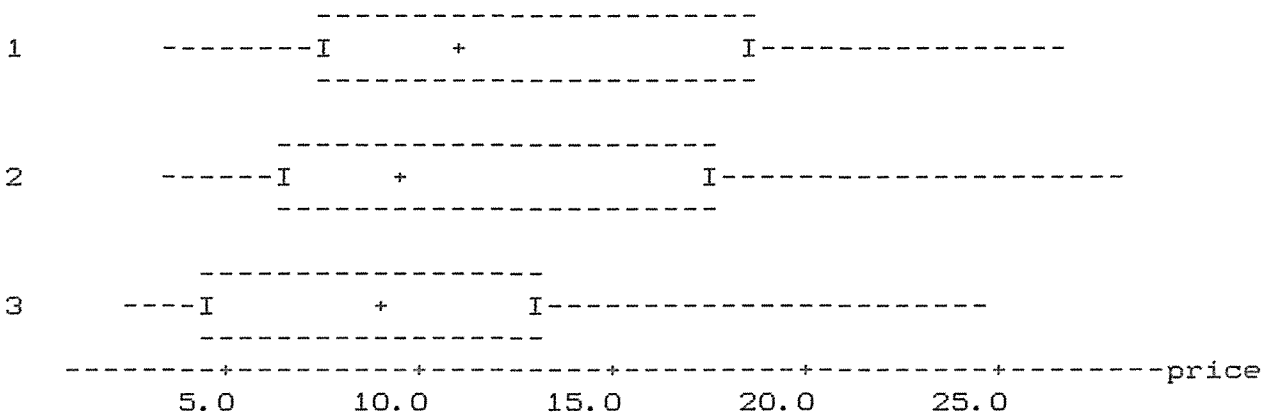
2 The behaviour of capsicums at auction

Capsicums were supplied for the full period under study.

The mean weekly price for capsicums declined by 8% in year 2 and by 20% in year 3. See table 13.

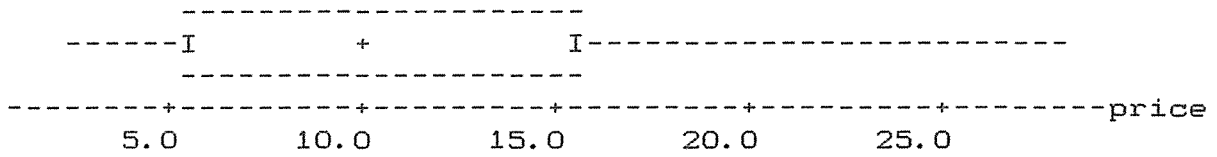
As can be seen from the following boxplots, the price per case of capsicums is highly variable ranging from below \$5.00 to above \$25.00 in the same year.

Year



The median has fallen from about \$11.00 a case to about \$9.00 a case.

For the entire series, weekly price was right skewed about a median of \$10.00 a case, and ranged from \$2.33 to \$27.77.

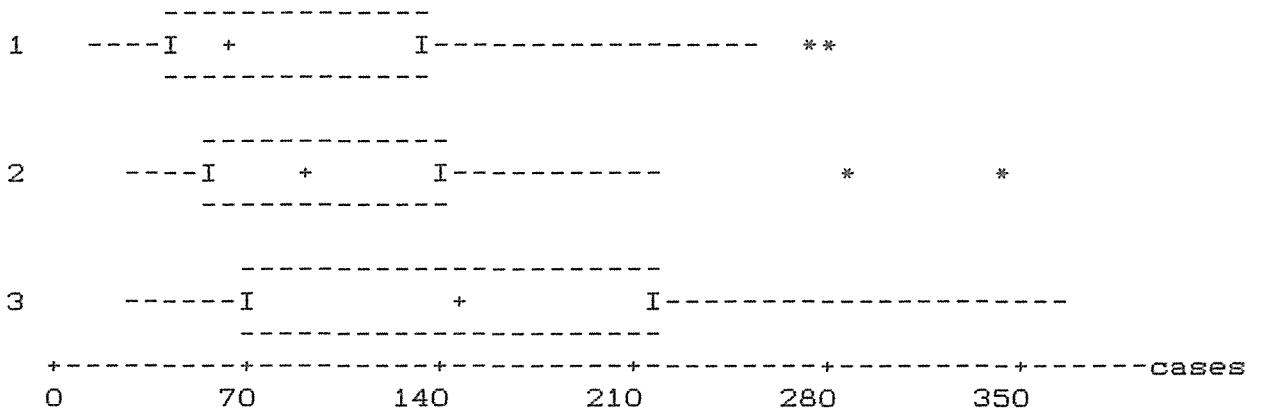


For the three financial years under study the total number of cases sold has increased, by 11.5% from 1983 to 1984, and a huge 44% from 1984 to 1985. See table 14.

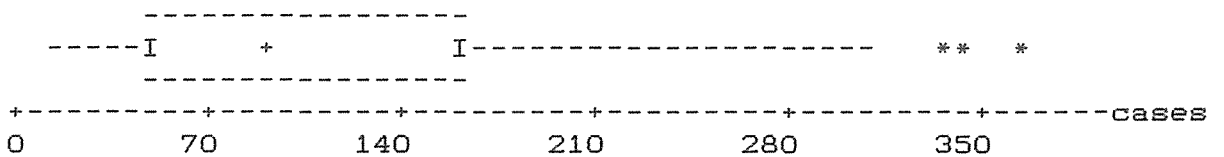
Capsicums seem to be becoming less of an exotic vegetable as reflected in the increase in volumes.

Median weekly volume sold has increased for each of the three years.

Year



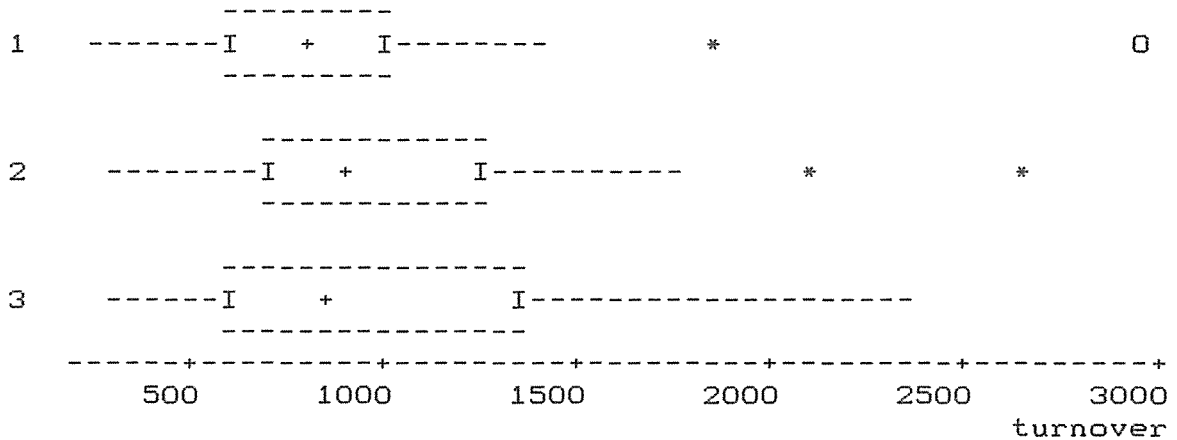
For the entire series weekly volume was right skewed about a median of 89 cases. Volume ranged from a low of about 10 cases to a high of about 360 cases.



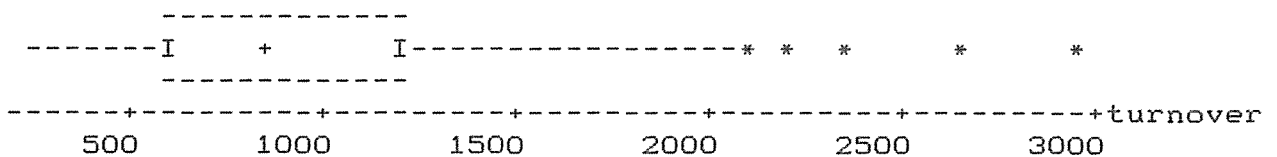
More capsicums are being brought to market and the price is falling.

~~This review is completed by considering weekly turnover. This has risen but not at the same rate as the quantity brought to market and sold. In year 2 turnover increased by about 13% and in year 3 turnover increased by about 4%. See table 15.~~

Median weekly turnover rose in 1984 and fell back to about the same level as 1983 in 1985.

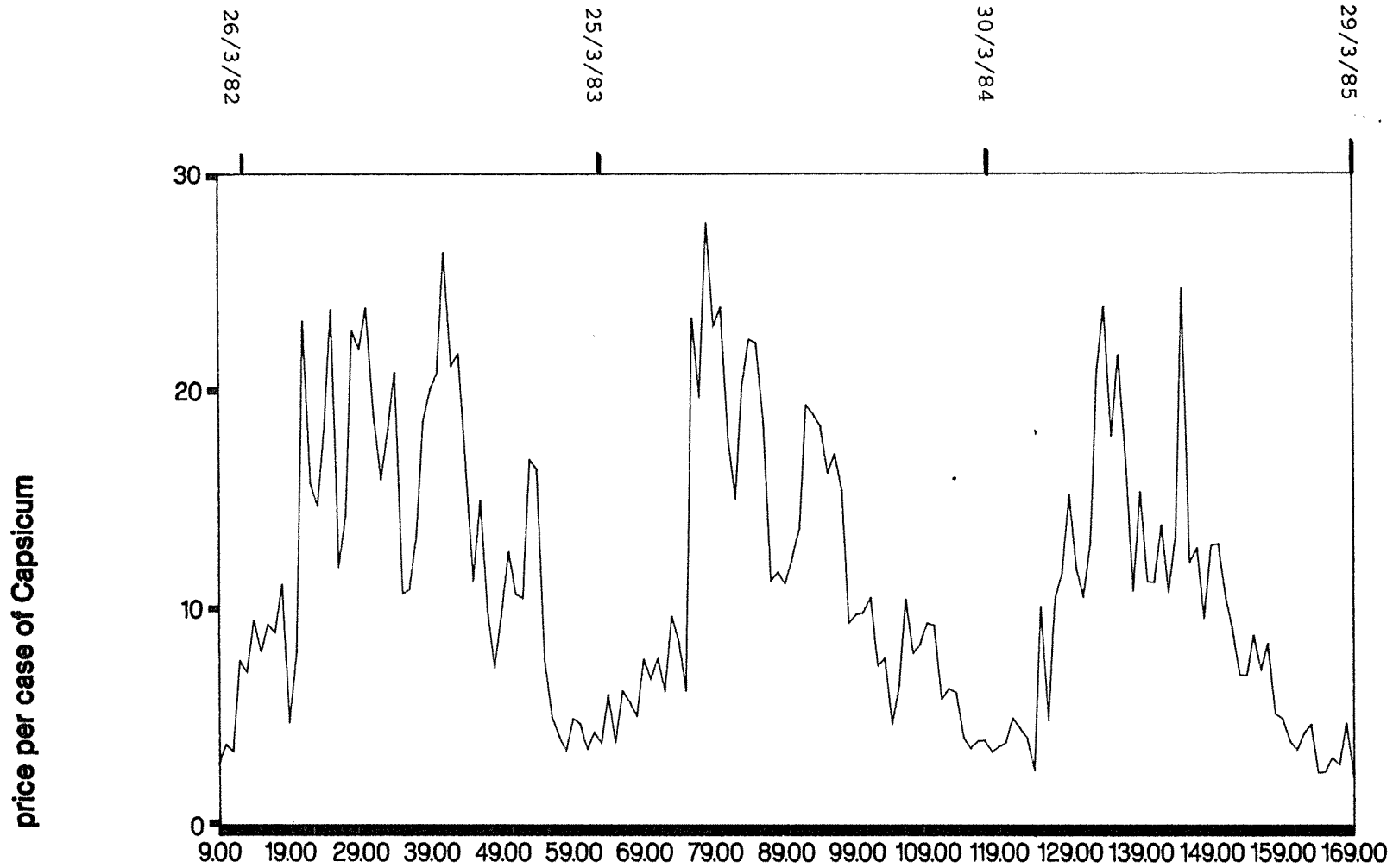


For the entire series weekly turnover was right skewed about a median of \$865.00. Weekly turnover ranged from \$249.00 to \$2941.00.



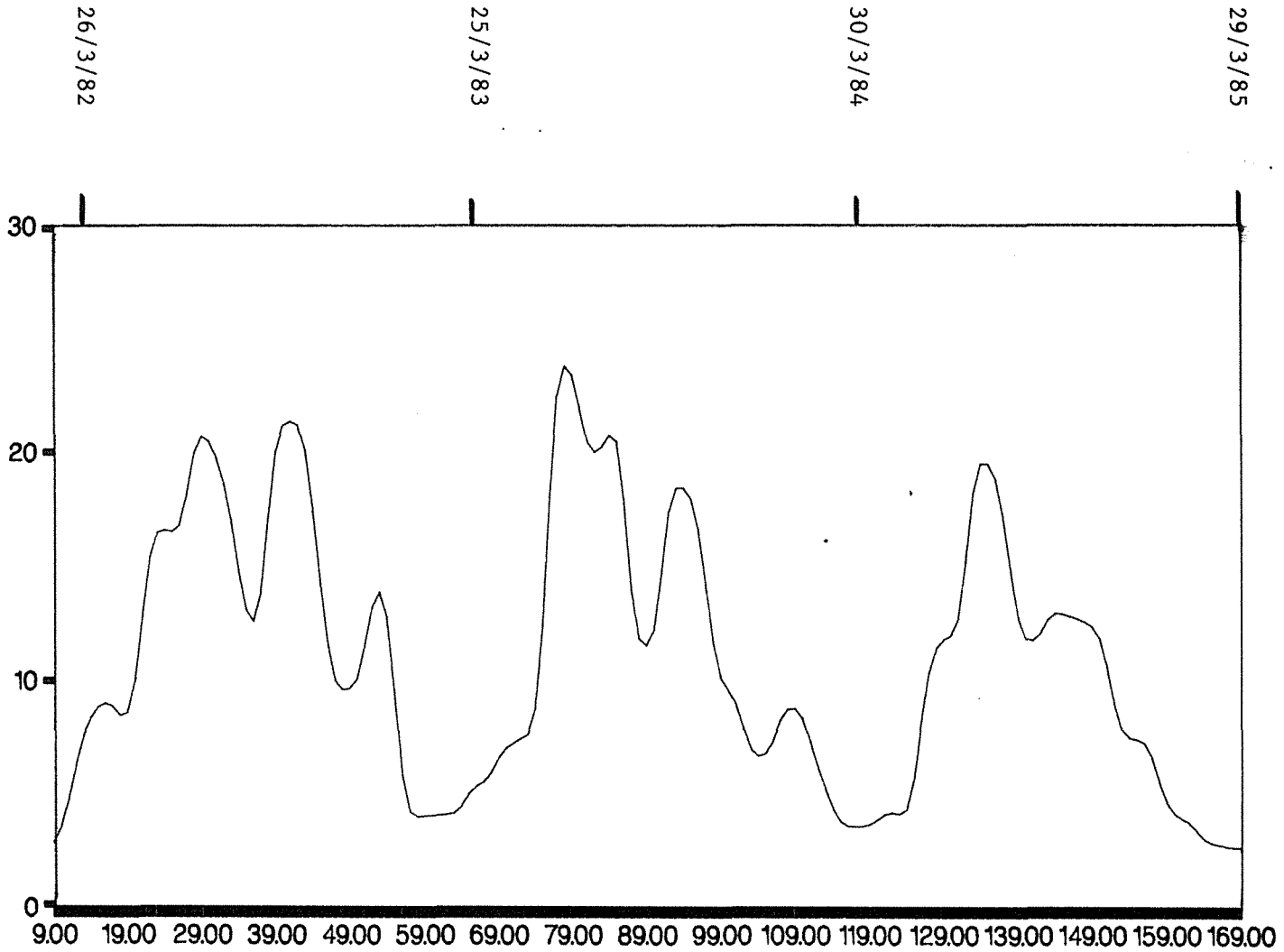
Both prices and volumes were highly variable with volume being more variable than price.

	coefficient of variation
price	.57
volume	.69
turnover	.50

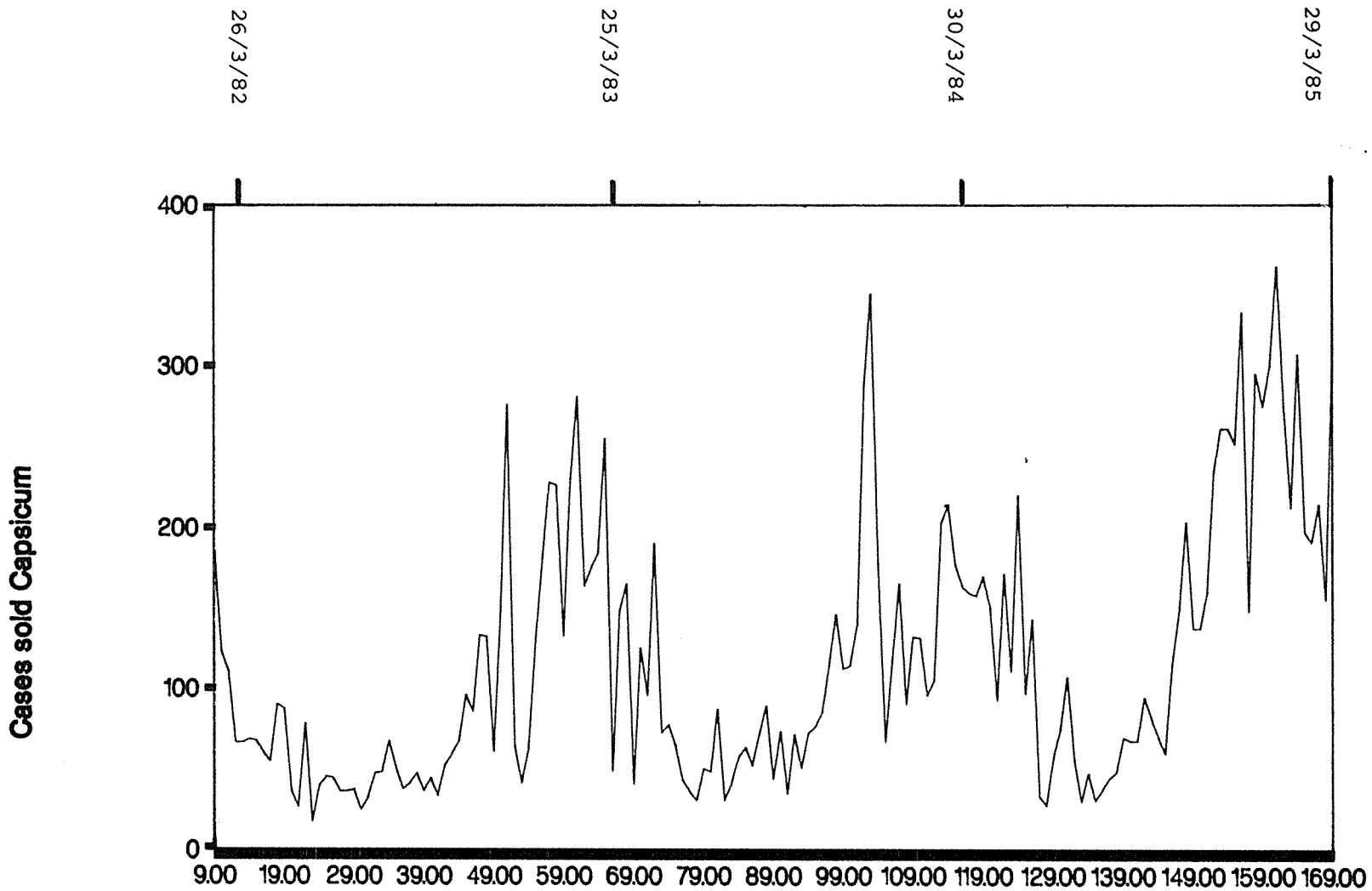


week rank from 1.182 to 29.385

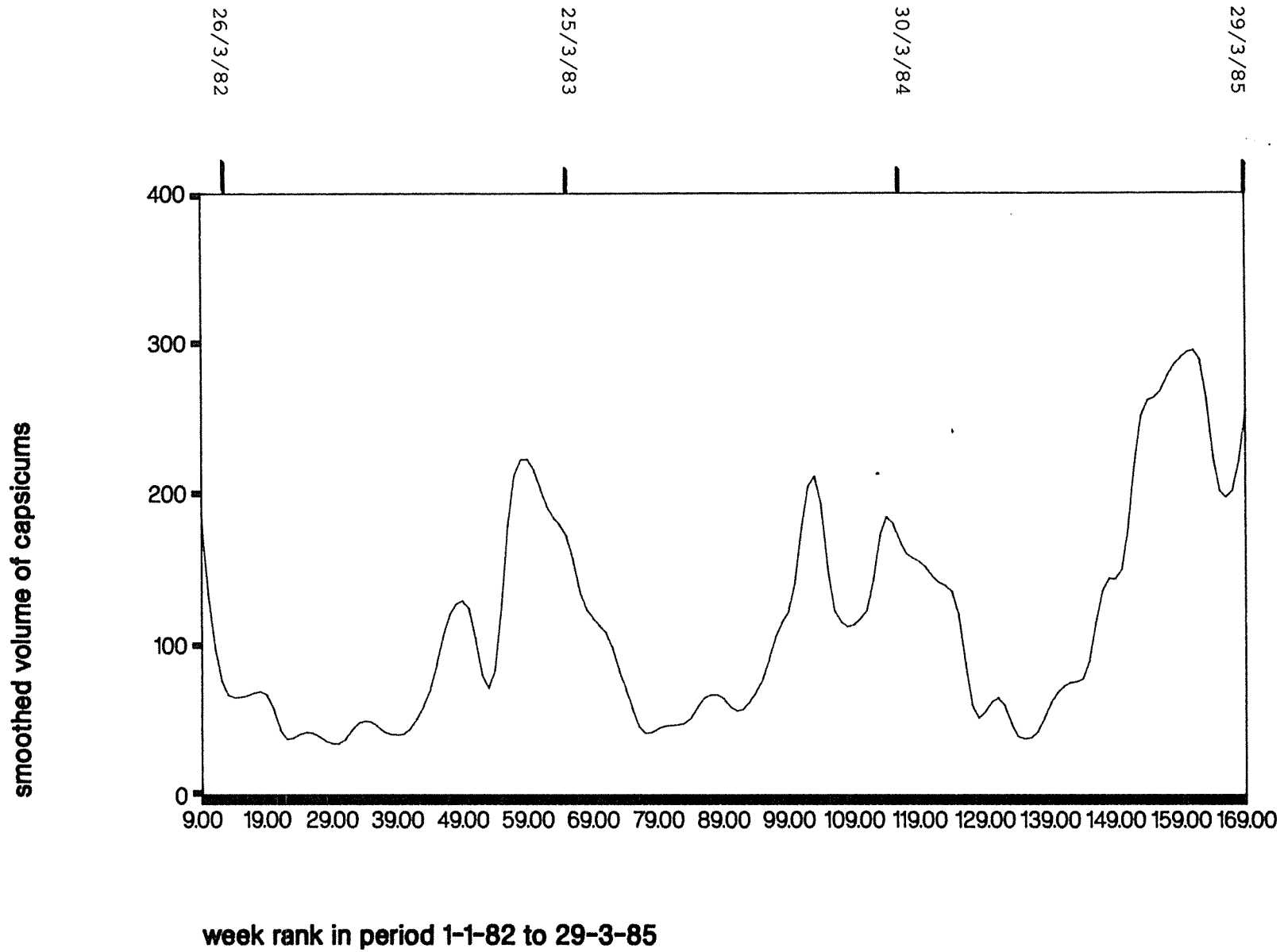
smoothed price of capsicum



week rank in period 1-1-82 to 29-3-85



week rank from 1.82 to 29.3.85



~~There are about seven peaks in the smoothed price series. The first 52 week period is characterised by three very distinct peaks.~~

There are two distinct peaks, and one minor peak in the second 52 week period.

Finally, there is one distinct peak in the last 52 week period.

It can be seen from the smoothed series that the period between peaks or troughs is about 10 weeks, although this varies.

If the smaller variations are ignored, in general it can be seen that prices rise to a peak in the winter months, especially July, and fall to their lowest in March and April. There is one clear season for capsicums.

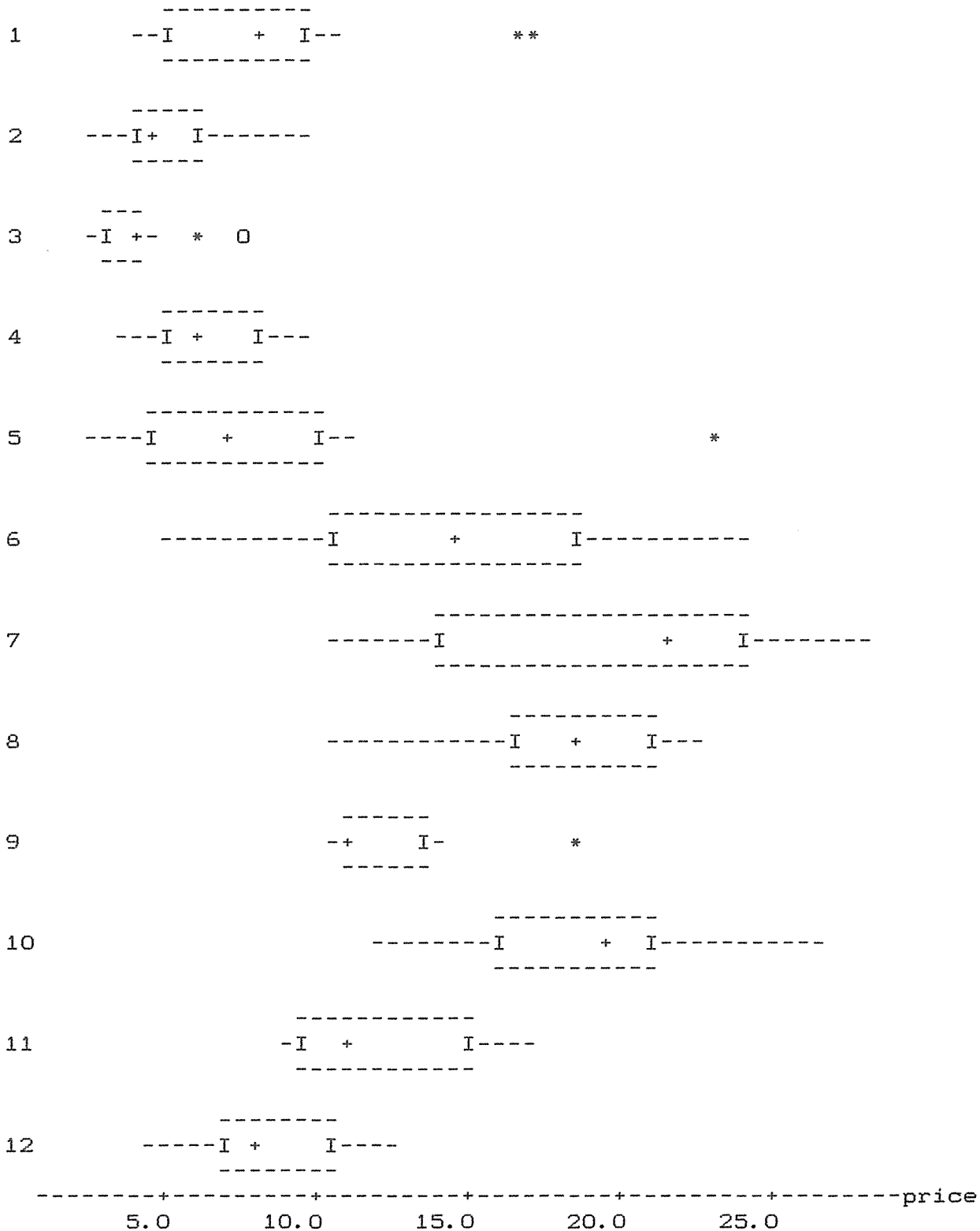
This pattern is seen more clearly with the smoothed volume plot. Volumes are relatively low from early to mid June until the middle of October. From the middle of October volumes rise, peaking from about the beginning of February to the middle of March.

Times of high prices were associated with times of low volume and times of low prices were associated with times of high volume.

The seasonality of prices and volumes is shown in the boxplots below.

Prices are clearly highest in the middle of winter and lowest in the warmer months, particularly at the end of summer.

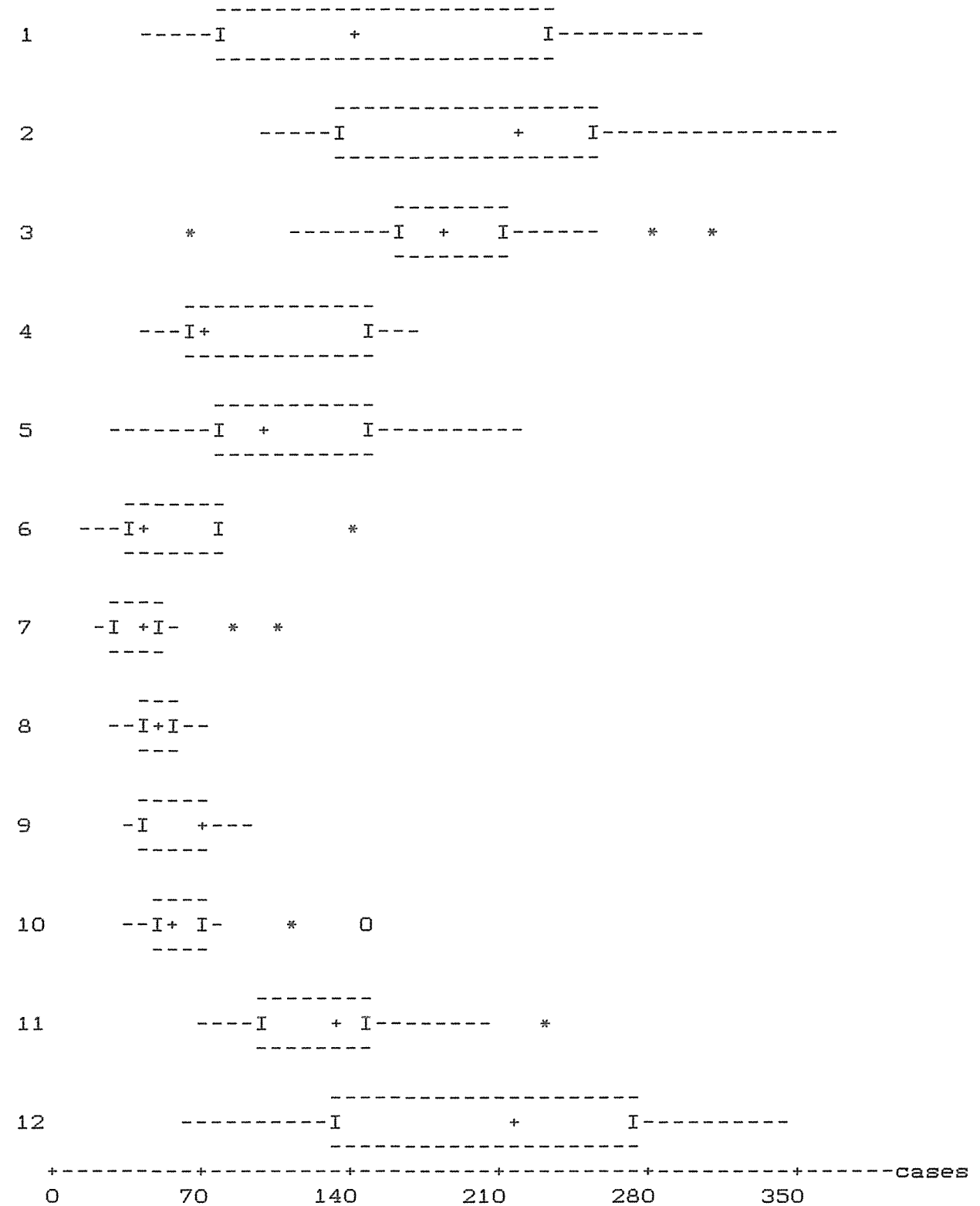
Month



Volumes are highest over the summer, in particular in December and February. The December peak is probably due to christmas. The normal seasonal peak is probably in February, which is when

most plants are producing maximum mature yield. The lowest supply is in July and August.

Month



Highest prices were generally in periods of lowest supply.

5 CAULIFLOWER

Cauliflower is one of the more significant vegetables in terms of turnover. See table 15. It is grown in both winter and summer in the Auckland, Manawatu, and Hawkes Bay regions.

The Yates seed catalogue lists many varieties of cauliflower which enable the market to be supplied all year.

Cauliflower grows better in cooler conditions but there are summer and winter cultivars. According to Ballinger (1980) there is a large range of sowing and planting dates for cauliflowers. He comments that winter cultivars are generally sown in November, transferred to the field in January or February, and mature in about 120 to 180 days. Summer cultivars mature in about 100 days.

There is only a small number of summer yielding varieties and cauliflower is probably a vegetable consumed mostly in the cooler times of the year. It would be expected that production would be lower in the warmer months than in the cooler months. This means that prices are probably higher in summer than in winter.

Tannock (1914) notes that the curd is damaged by wet conditions and by frosts, so volumes might be expected to fall in the wetter and colder months. Consequently, prices may be higher at these times.

Thompson and Kelly (1957) note that cauliflower is grown in much the same way as cabbage; that it grows best in conditions which are cool and moist; and that the heads do not develop well when the weather is hot. For these reasons it is mostly grown in autumn and winter.

1 The expected behaviour of prices

We would expect cauliflower prices to remain fairly stable because it is grown throughout the year. However, we would expect lower yields in the hotter months, because cauliflower prefers a cooler climate, and the very cold months. So prices can be expected to be a little higher in summer than in winter. Furthermore, cauliflower is primarily consumed in the cooler months so we could expect demand to fall which might reduce the price effect of smaller volume.

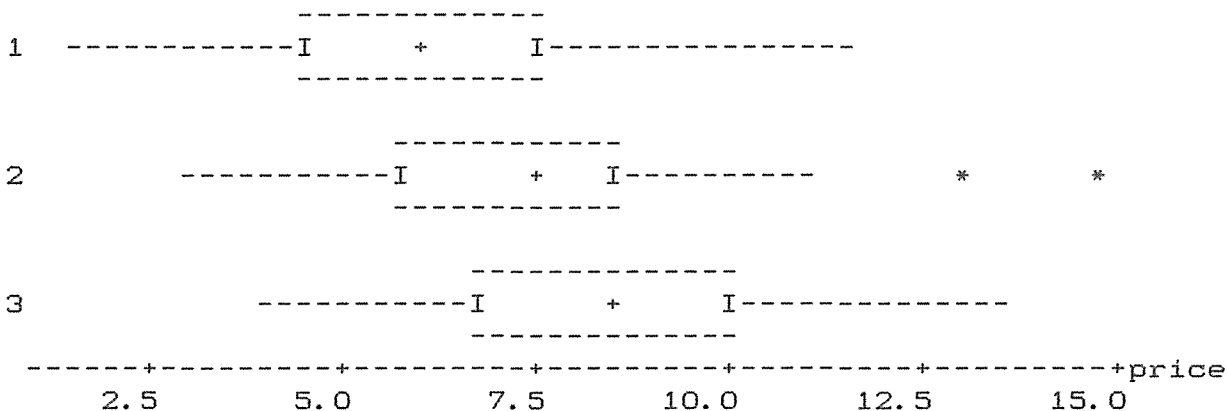
2 The behaviour of cauliflower at auction

Cauliflower was supplied to the market every week for the full period under study.

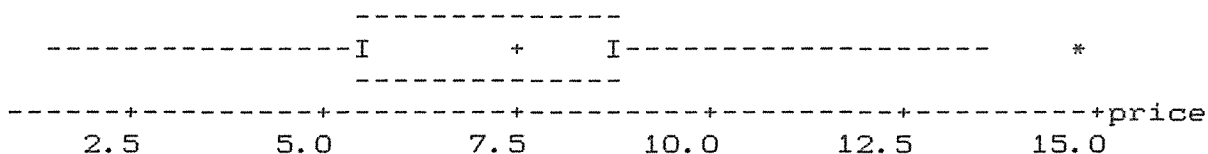
Cauliflower prices increased in successive years remaining almost at the same level of variability in each year. In year 2 prices increased by about 24% and in year 3 by about 11%. See table 13.

In each year median price rose while having about the same variance for each year.

Year



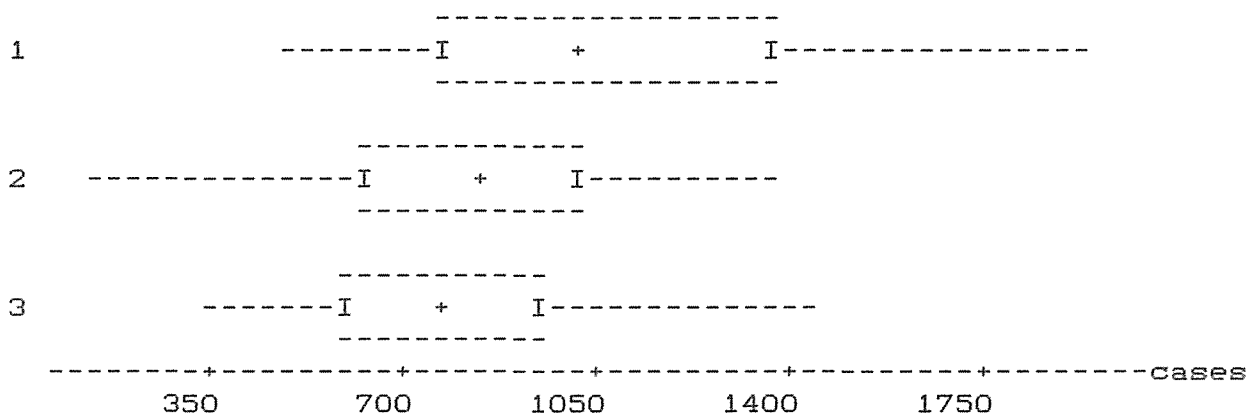
For the entire series weekly price ranged from \$1.62 to \$14.82 about a median of \$7.39.



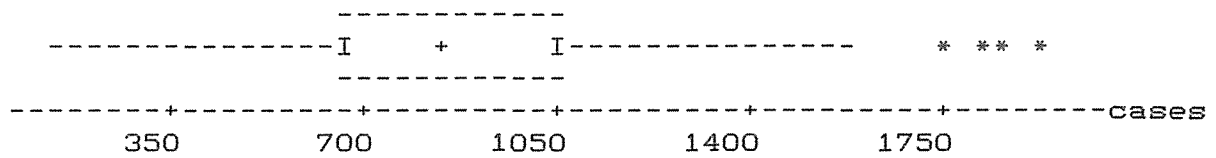
Annual volume fell by 23% in year 2 and then fell by about 9% in year 3. See table 14.

Median weekly volume has fallen in each of the three years.

Year



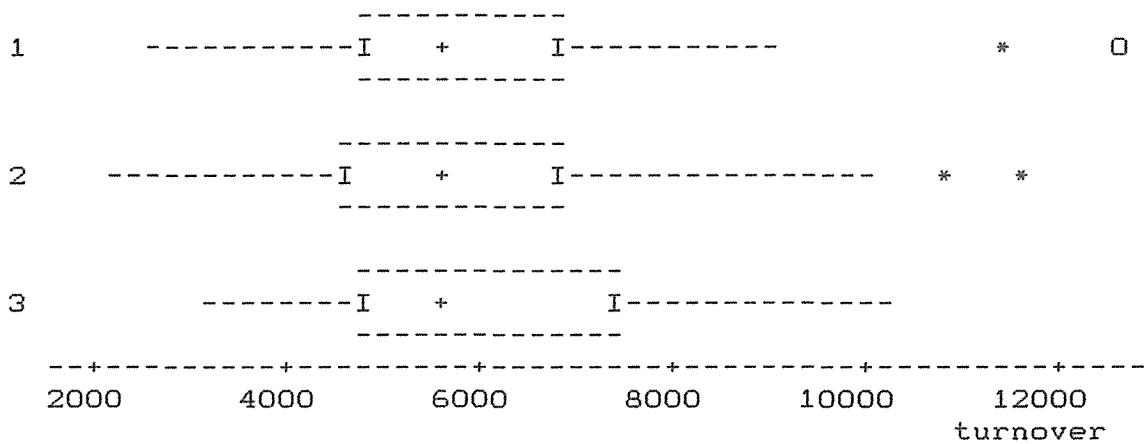
For the entire series volume was quite symmetrically distributed about a median of 850 cases. Values ranged from 153 cases to 1926 cases.



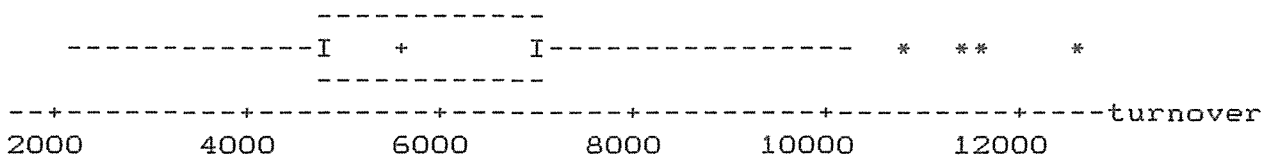
Annual turnover fell by about 1% in year 2 and then increased by about 2% in year 3. See table 15.

Median weekly turnover was about the same for each of the three years.

Year



For the entire series weekly turnover was right skewed about a median of \$5536.00. Values ranged from \$2268.00 to \$12648.00.



29/3/85

30/3/84

25/3/83

26/3/82

20

10

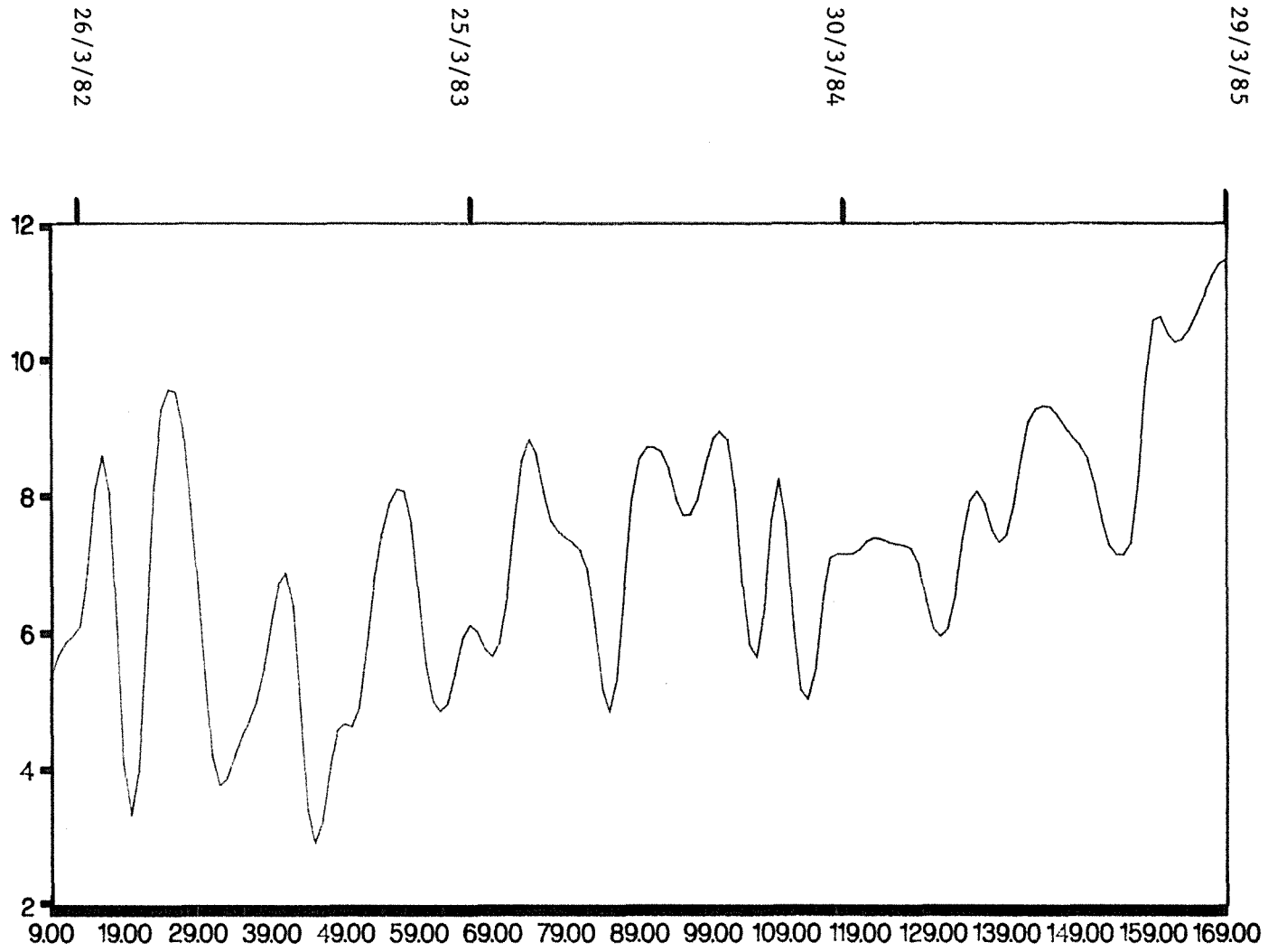
0

price per case of Cauliflower

9.00 19.00 29.00 39.00 49.00 59.00 69.00 79.00 89.00 99.00 109.00 119.00 129.00 139.00 149.00 159.00 169.00

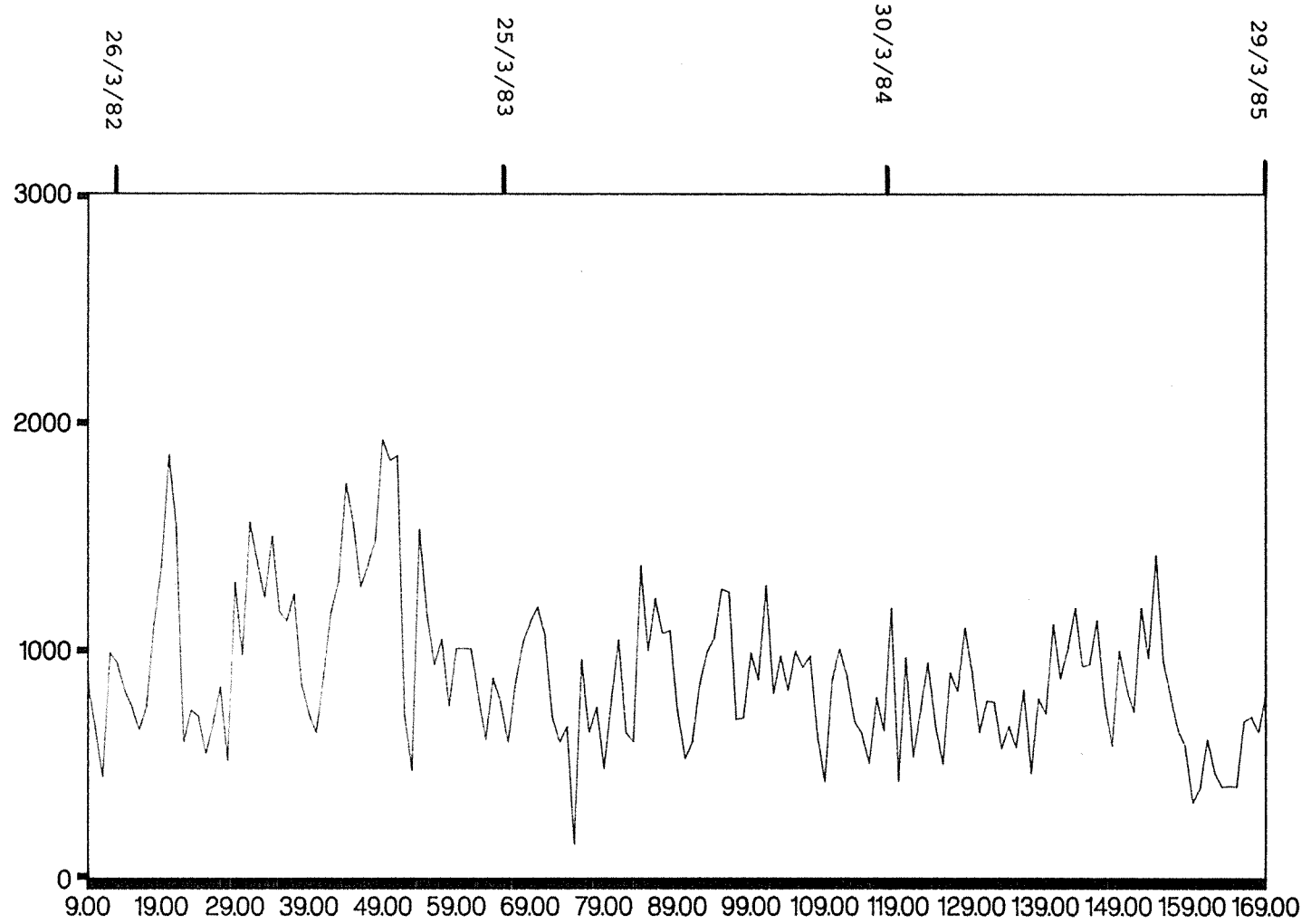
week rank from 1.82 to 29.85

smoothed price of cauliflower



week rank in period 1-1-82 to 29-3-85

Cases sold Cauliflower



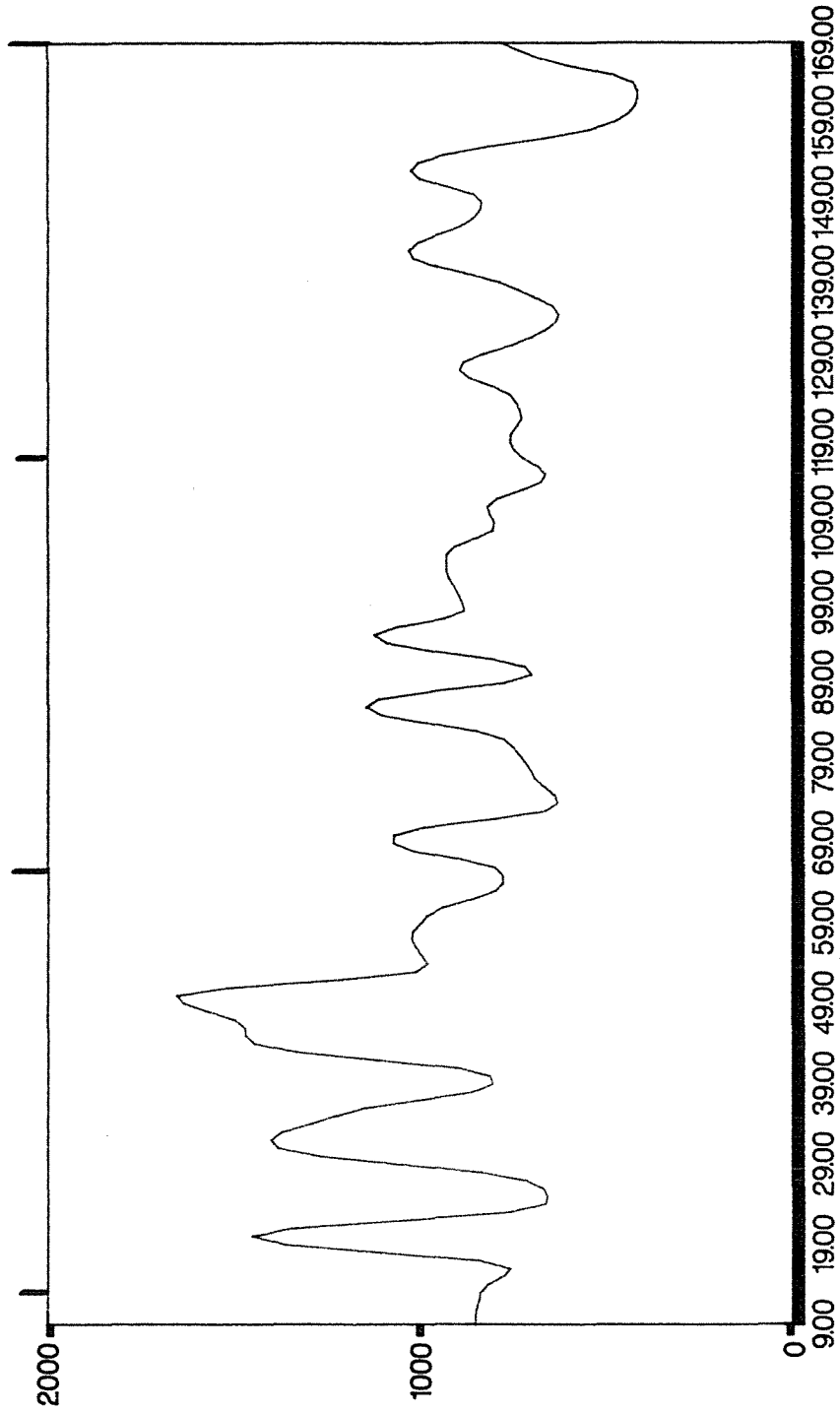
week rank from 1.182 to 29.3.85

29/3/85

30/3/84

25/3/83

26/3/82



smoothed volume of cauliflower

week rank in period 1-1-82 to 29-3-85

The original price series shows frequent price changes from week to week.

There are about 25 turning points in the smoothed price series.

April, June, October, and January are the most common peaks in the three year series.

The smoothed price series indicates an upward trend in price while the smoothed volume series indicates a downward trend in volume.

The smoothed plot of cases sold has about three peaks in each year. These do not occur at the same time and they are not of consistent amplitude. April/May, August, and December were times of high volume and June/July and March were times of low volume. These observations indicate that it may be very difficult to predict future volumes and prices.

Lowest prices correspond to times of highest prices and highest prices to lowest volumes. However this has not always occurred in the same week and suggests that bidders lack information about supply.

Weekly price was slightly less variable than weekly volume for the three years under review.

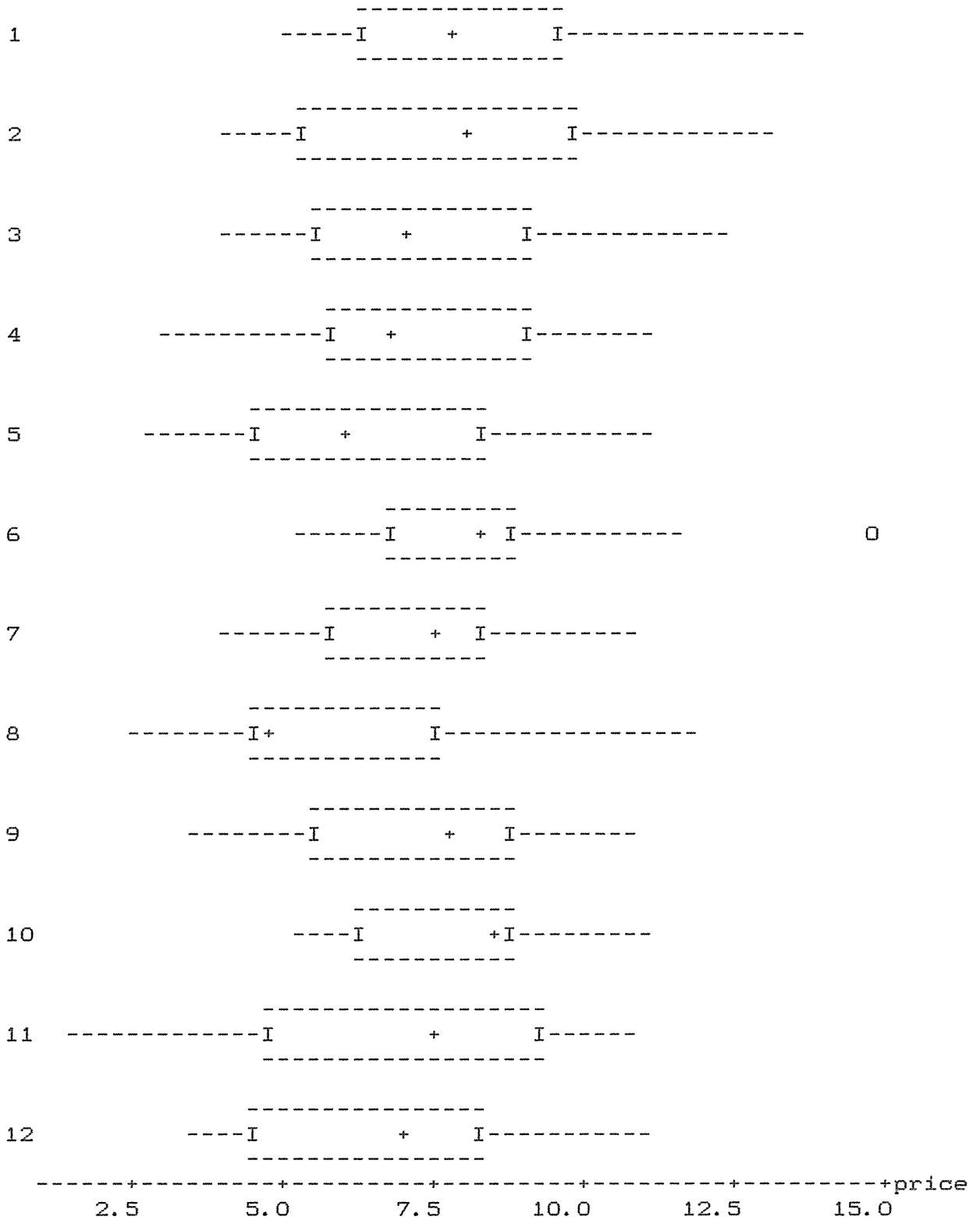
coefficient of variation

price	.34
volume	.37
turnover	.32

The boxplots below also indicate that it is difficult to detect seasonality in prices and volumes.

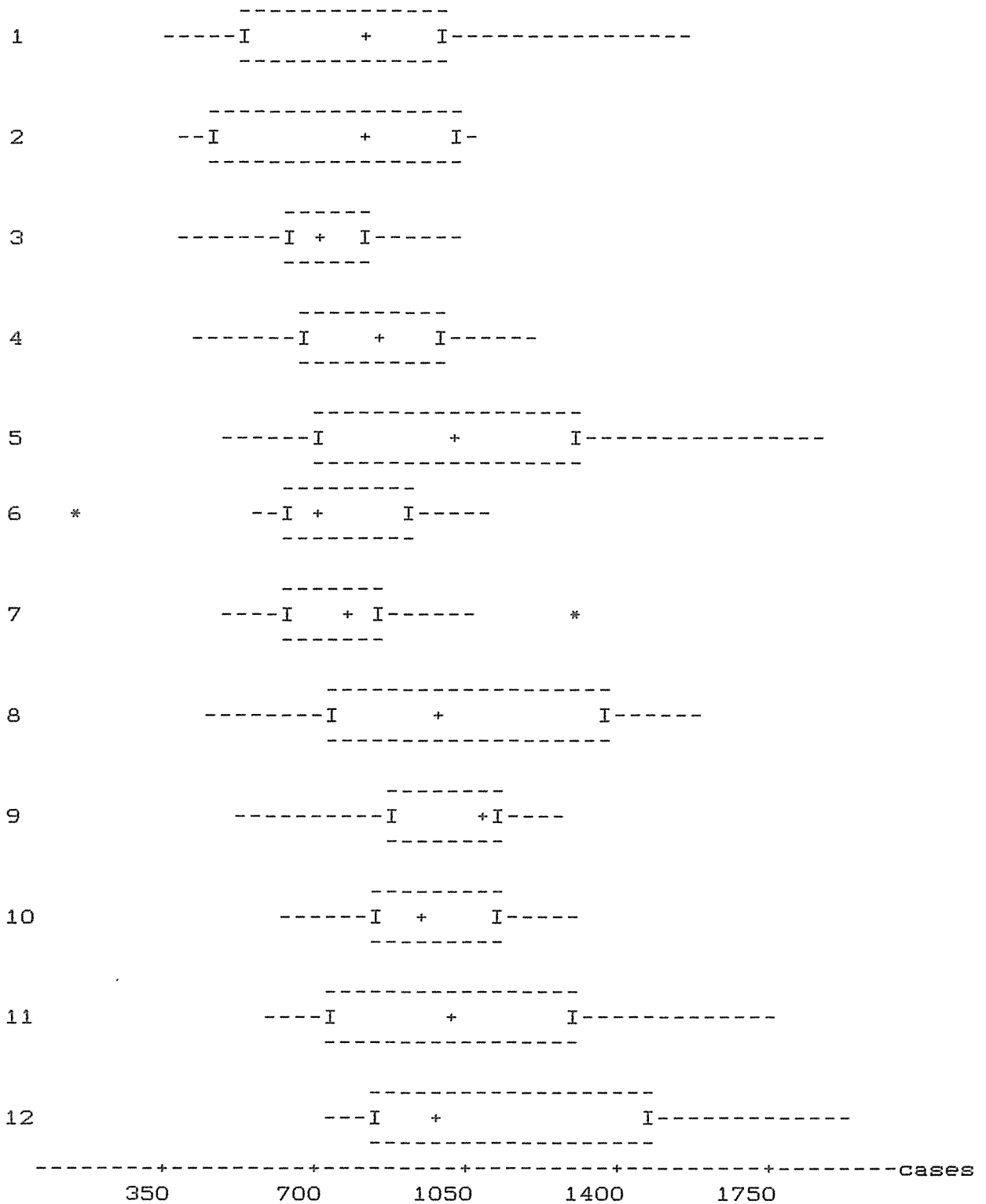
The following boxplots indicate a fairly constant price throughout the year. If anything, prices are perhaps highest in the latter part of summer. In terms of an overall pattern there may be a turning point in May, and another in October.

Month



Volumes appear to be lower in the first six months than in the last six months of the year. Turning points seem to be in May and August, and it appears that there are two volume seasons.

Month



6 CELERY

Celery is available all year and is grown in the Auckland, Manawatu, and Hawkes Bay regions.

The Yates seed catalogue describes three varieties which mature from about 85 to 115 days after transplanting to the field.

Ballinger (1980) notes that celery is planted out from October to March and takes 120 days to mature.

Tannock (1914) notes that sticks must be "crisp yet tender"; plants require plenty of water and sunlight; and by autumn growth is virtually completed.

Thompson and Kelly (1957) point out that the best conditions for celery are a cool temperature and and light even rainfall.

1 The expected behaviour of prices

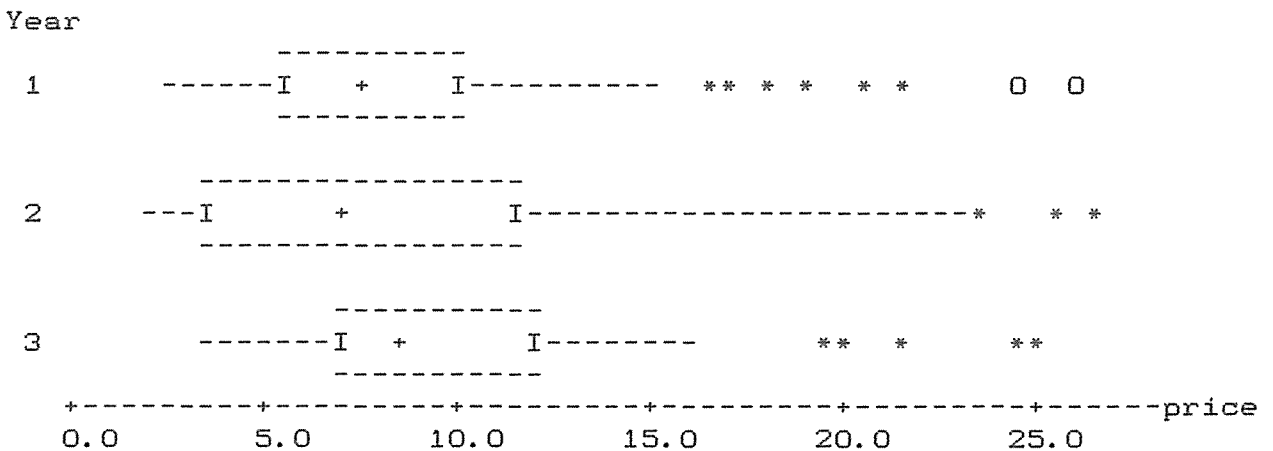
Celery yield is greatest in the winter months and we would expect prices in winter to be lower than prices in summer.

2 The behaviour of celery at auction

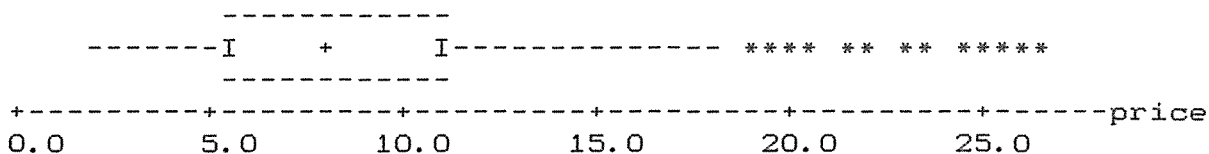
Celery was supplied continuously throughout the full three year period, and is quite an important vegetable in terms of volume. See table 15.

The mean weekly price for celery rose in each successive period. See table 13. Celery was characterised by many outside values for price.

The median price fell in year 2 and then recovered in year 3.



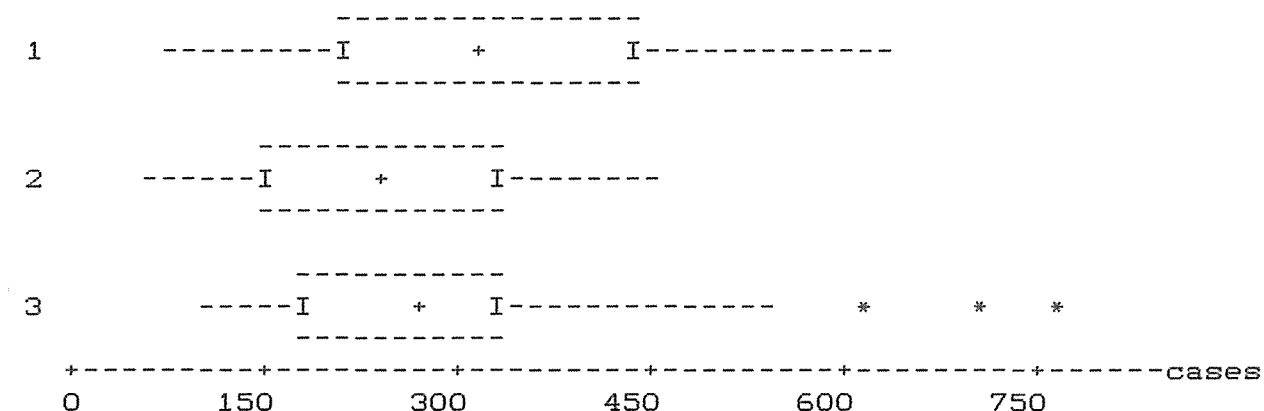
For the entire series price was right skewed about a median of \$7.79, with the lowest price being \$1.99 and the highest being \$26.29.



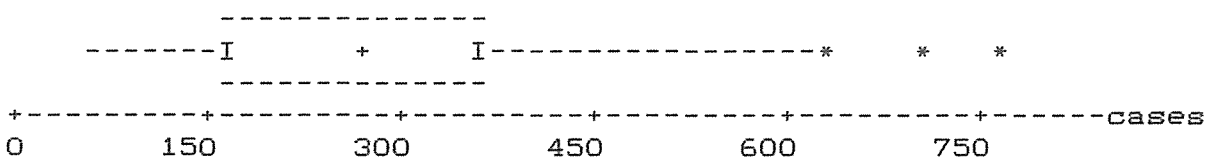
Annual volume fell by a little more than 38% in year 2 and then increased by nearly 20% in year 3. Total volume in year 3 was lower than in year 1. See table 14.

Median weekly volume fell in year 2 and then increased in year 3.

Year



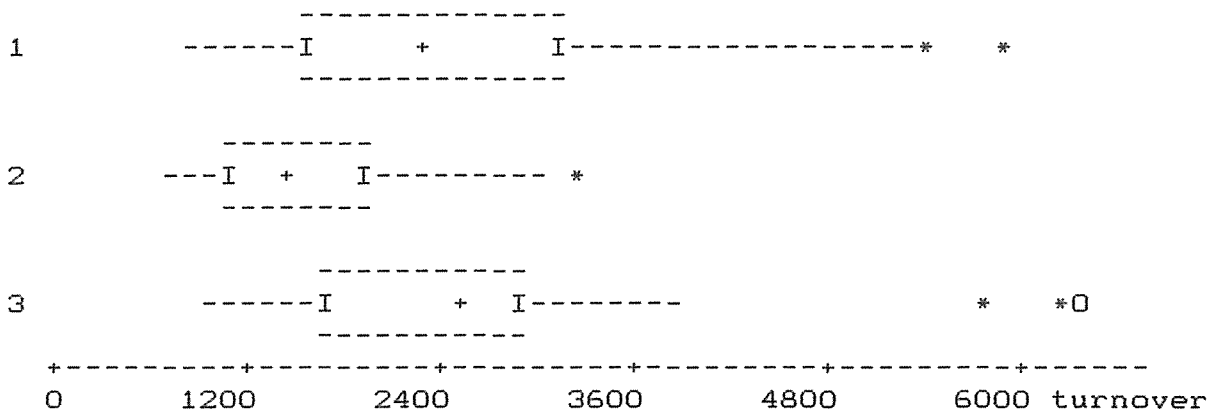
For the entire series weekly volume was right skewed about a median of 265 cases, with a minimum volume of 58 cases and a maximum volume of 767 cases.



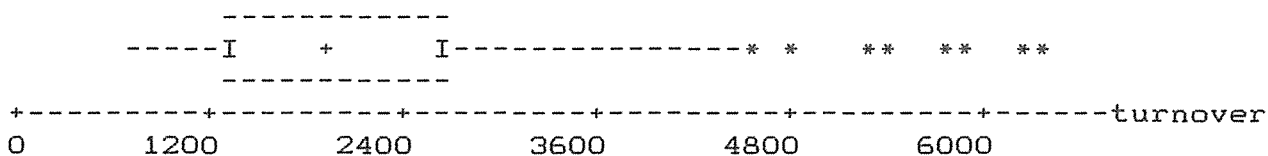
Annual turnover fell by 38% in year 2 and then increased by 61% in year 3. See table 15.

Median weekly turnover fell in year 2 and then increased in year 3. Outside and far outside values indicate that occasionally turnover was very high.

Year



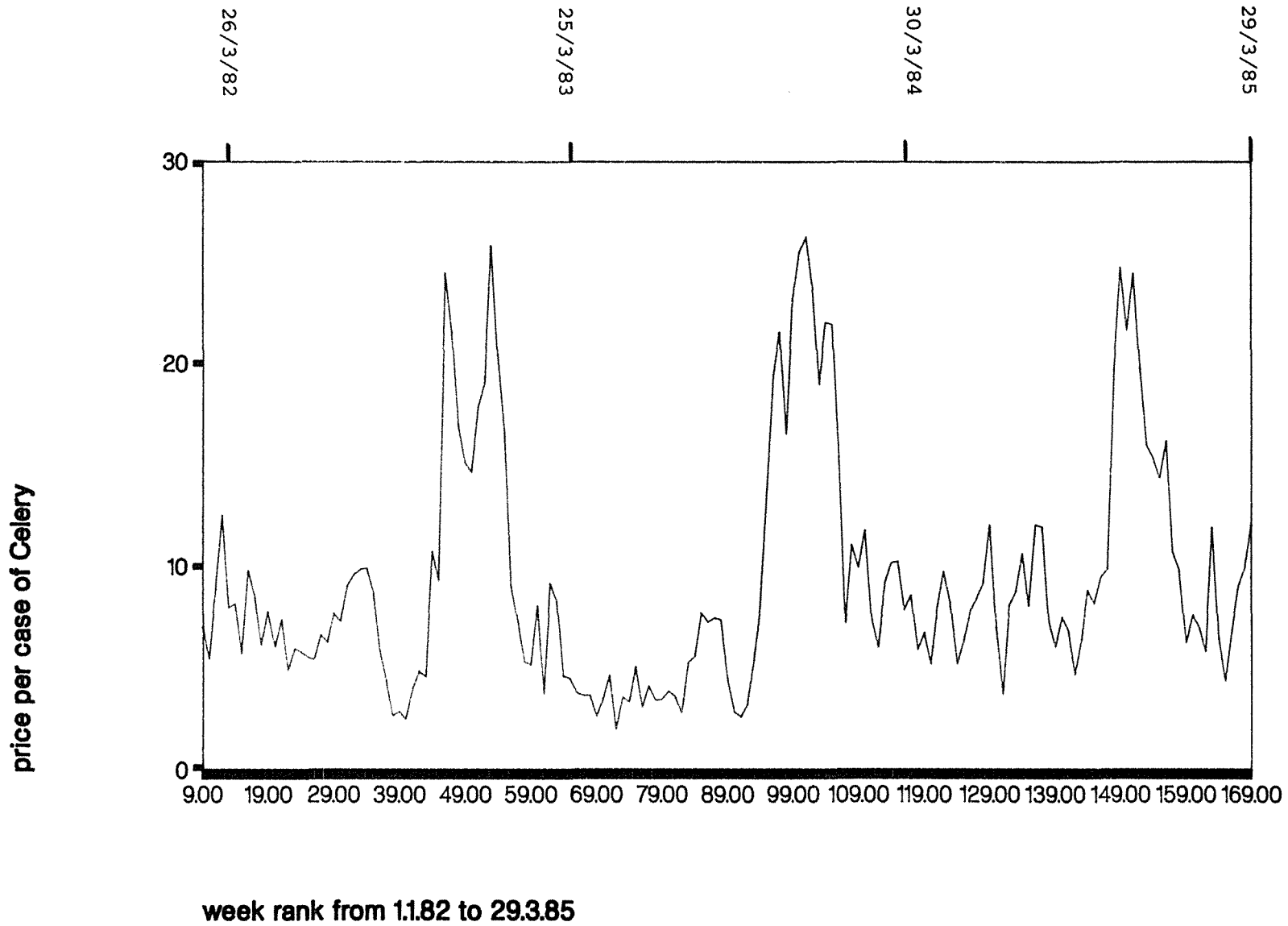
For the entire series weekly turnover was right skewed about a median of \$1904.00, with the lowest weekly turnover being \$701.00 and the highest being \$6388.00.

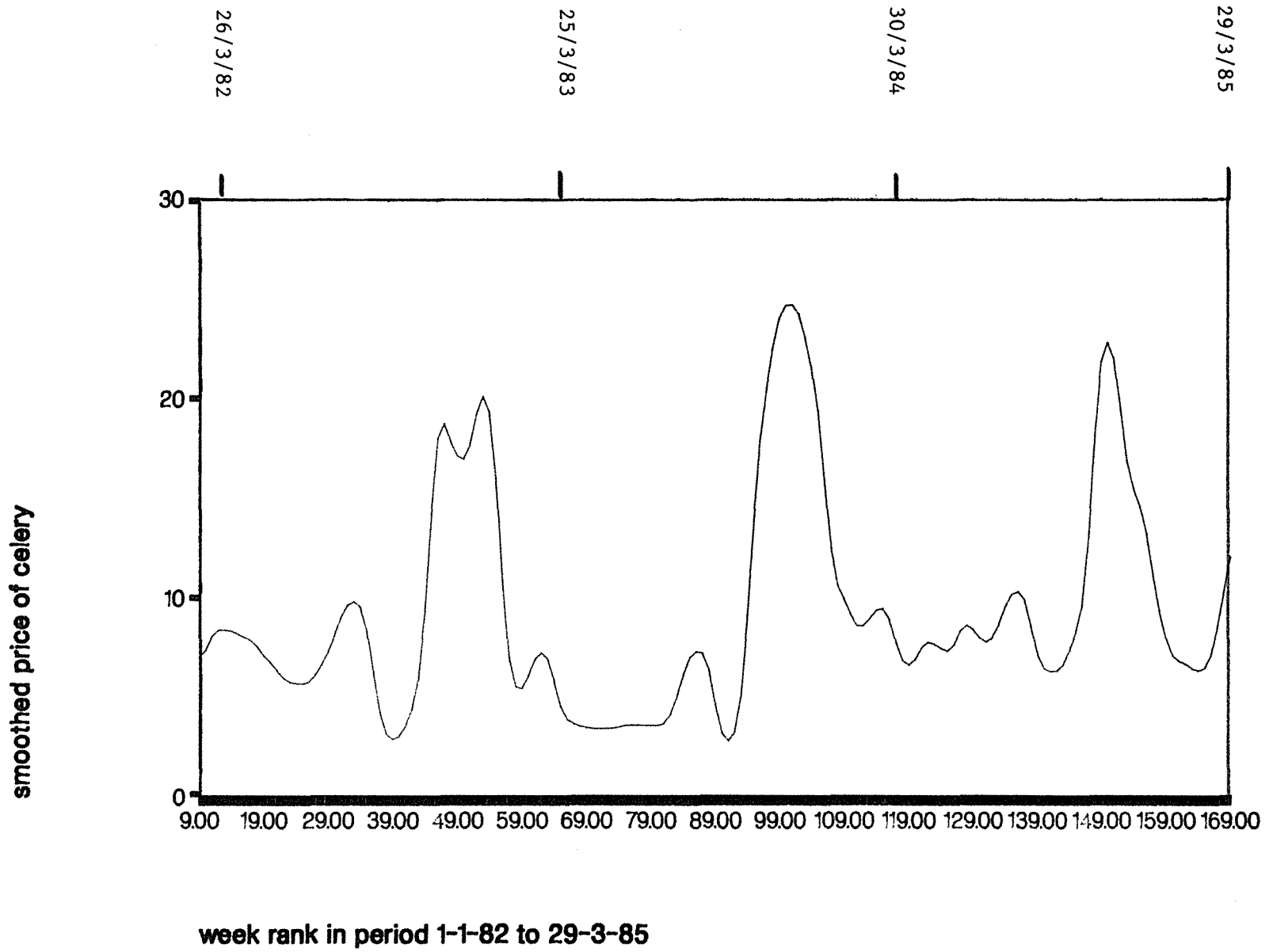


The boxplots above indicate that at times, celery prices exhibit extreme values.

Price was more variable than volume over the period.

	coefficient of variation
price	.62
volume	.51
turnover	.54





26/3/82

25/3/83

30/3/84

29/3/85

30

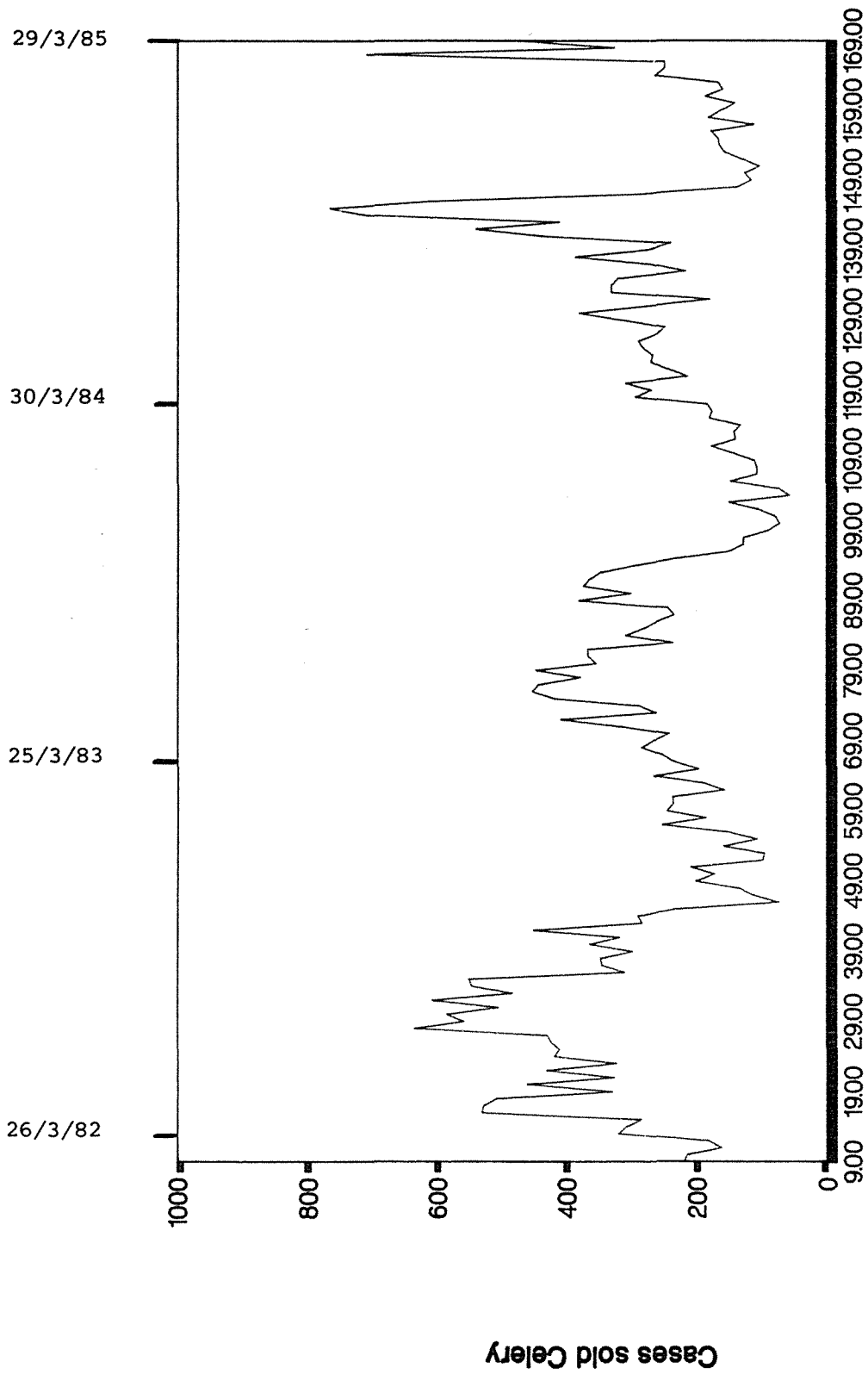
20

10

0

9.00 19.00 29.00 39.00 49.00 59.00 69.00 79.00 89.00 99.00 109.00 119.00 129.00 139.00 149.00 159.00 169.00

week rank in period 1-1-82 to 29-3-85



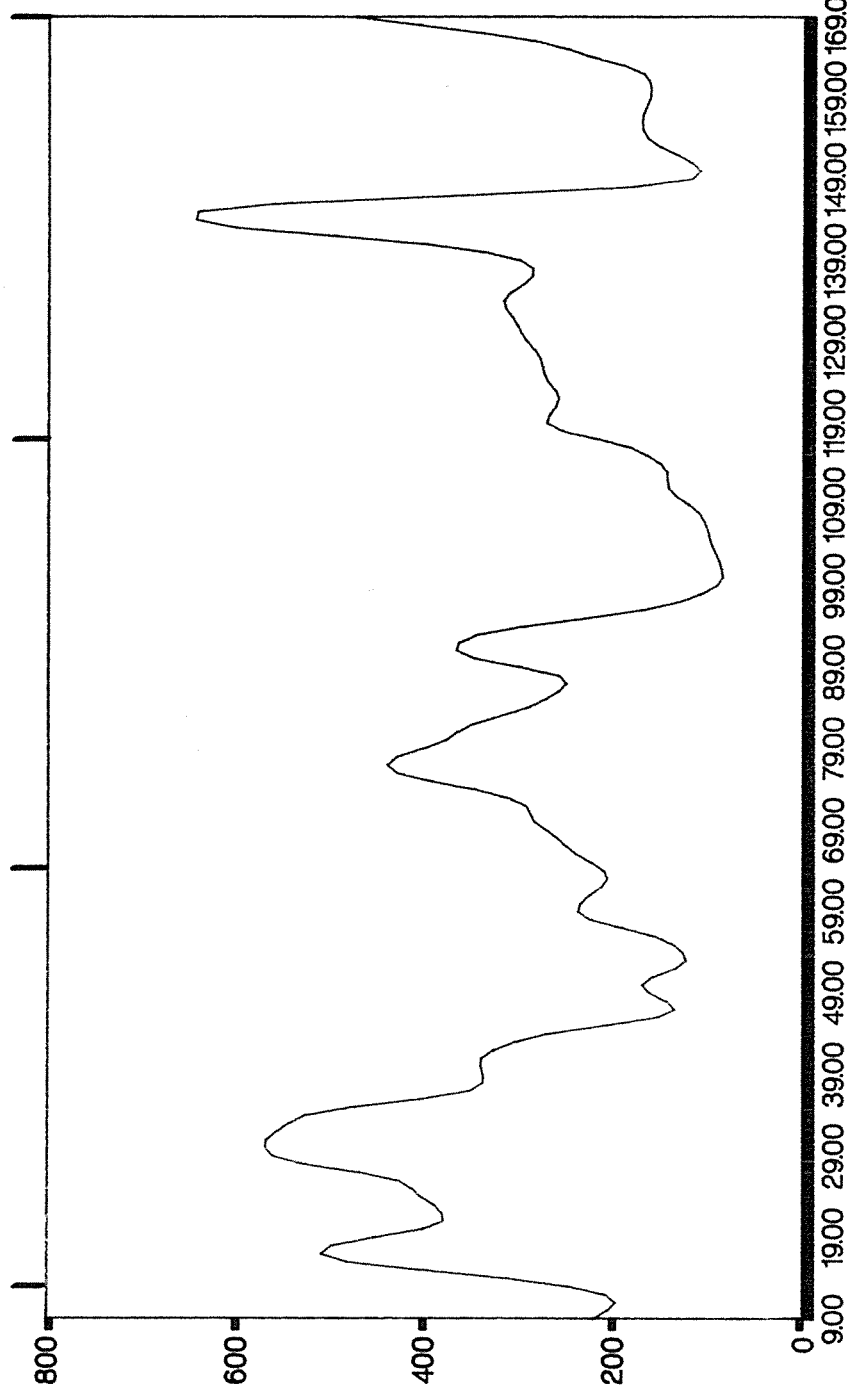
week rank from 1.1.82 to 29.3.85

29/3/85

30/3/84

25/3/83

26/3/82



smoothed volume of celery

week rank in period 1-1-82 to 29-3-85

Prices are highly variable within a season.

The smoothed price series suggests two seasons in each year for celery.

The first peak is relatively minor and begins in about late July and ends at the end of September.

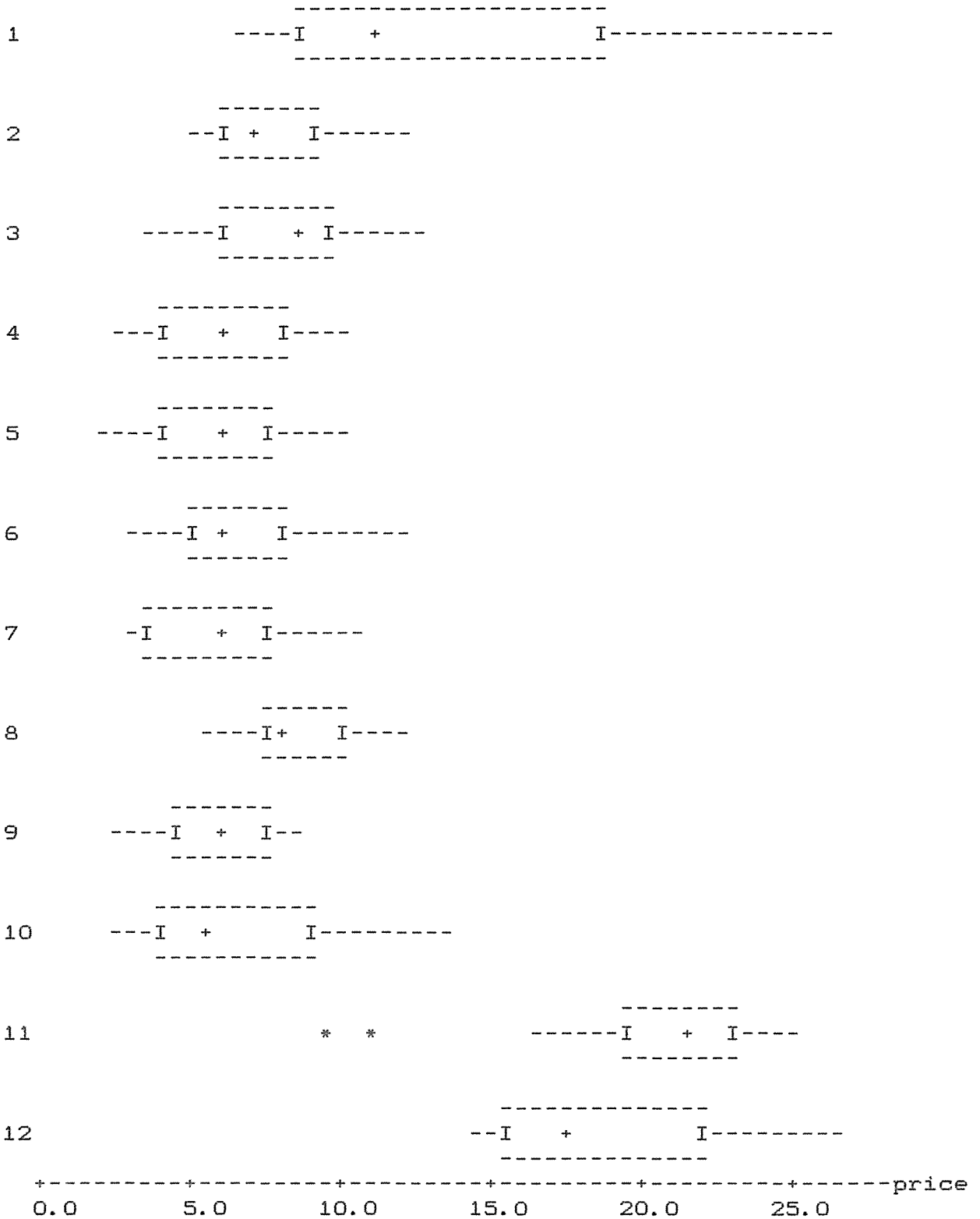
This is followed by quite a tall spike which begins at the beginning of November and ends in about the beginning of February.

The plot of cases sold clearly indicates that more is available in the winter months than in the summer months. Mid November to late January, late March, and mid February were the periods of least supply in each successive year.

The price and volume boxplots given below indicate that there is one season for celery. Summer months appear to be the times of greatest prices, and this appears to be due to quite low supply.

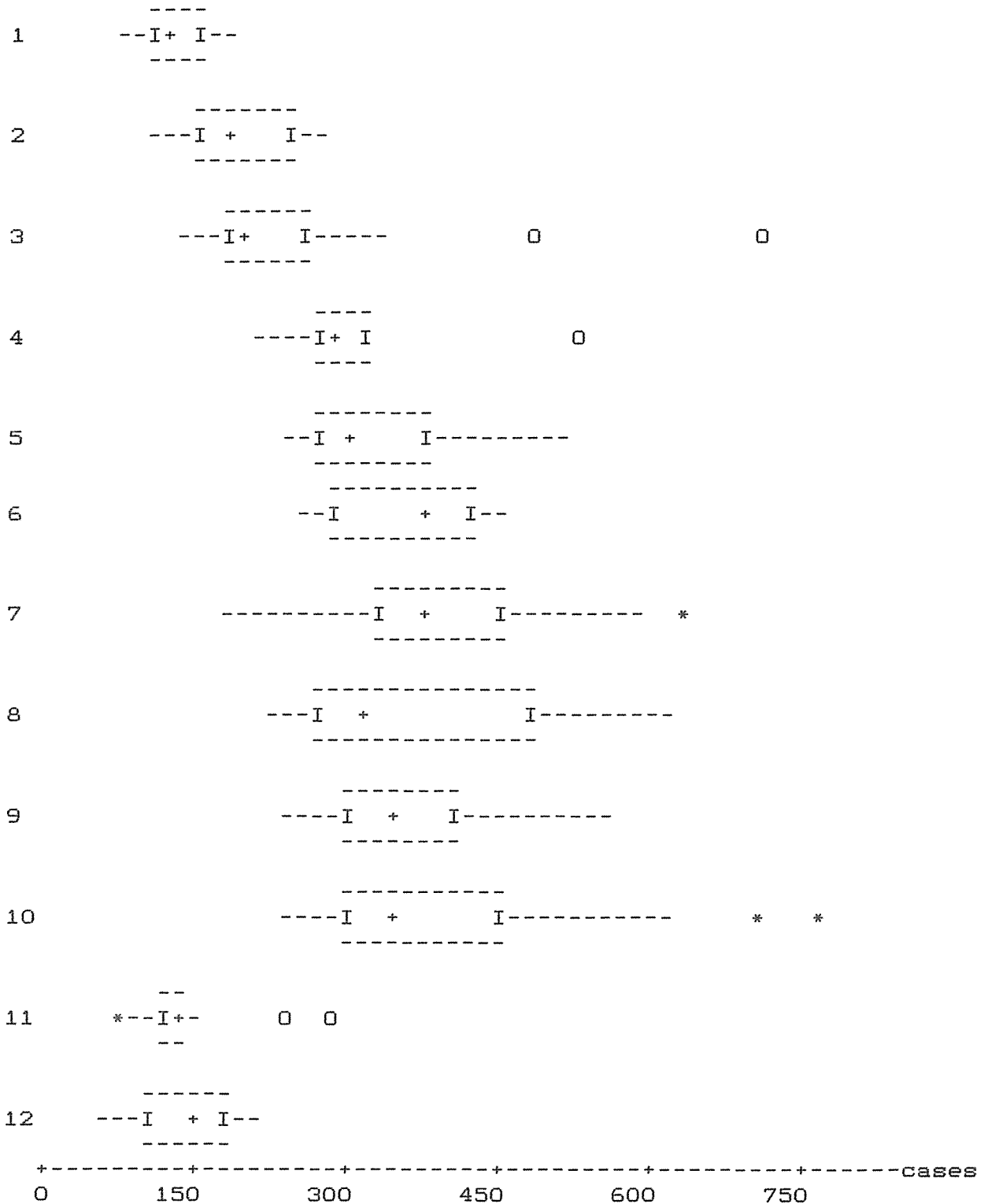
Prices are reasonably constant for most of the year. From February to October there is not much variation in prices, with only a small peak in August. Prices peak in November and are high in December and January.

Month



Volumes are lowest in November, December, and January. From February they rise steadily and are highest from June to October where volumes are reasonably constant.

Month



7 GARLIC

Garlic requires similar conditions to onions. It is planted in late May and is lifted in the middle of the following summer at the end of January or early February. Garlic takes about ten months to reach maturity and can be stored.

According to Ballinger (1980), garlic should be kept well watered and matures in about 220 days.

1 The expected behaviour of prices

We would expect prices to fall in mid summer as volumes begin to rise. Prices would be expected to rise gradually after harvest, peaking just before the next season's harvest, when the amount in storage is low and is perhaps of low quality.

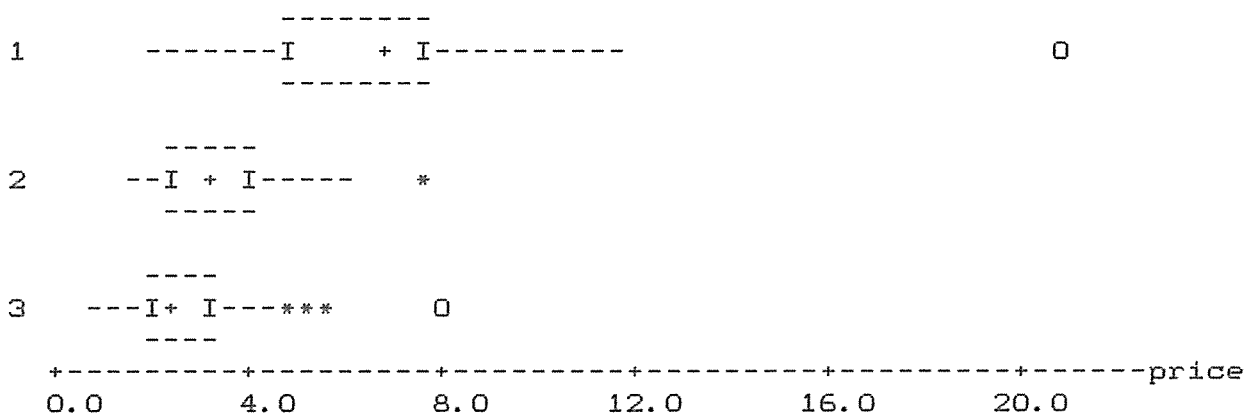
2 The behaviour of garlic at auction

There were two weeks when no garlic was supplied to the market. Values were inserted so that a smoothed series could be produced. These values are at weeks 52 and 75.

The average price of garlic fell considerably in successive years; 50% in year 2 and 16% in year 3. See table 13.

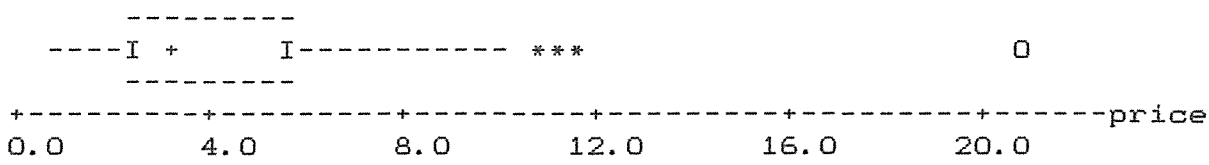
Prices fell in succeeding years as did the variation in price. For instance, in year 1 \$8.00 is the upper hinge price (approximately the upper quartile) whereas in year 3, \$8.00 is a far outside value. That is, it is an extreme outlier.

Year



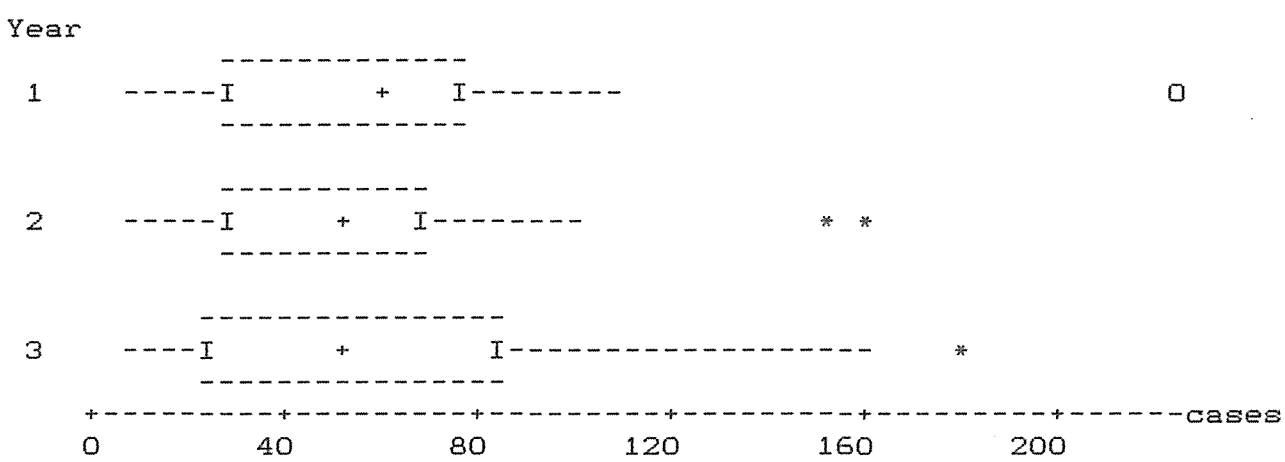
The median price changed considerably from year 1 to year 2, and fell a little in year 3. The hinge-spread for years 2 and 3 is quite narrow. This indicates that within a year prices do not vary much. This is what might be expected with an annual crop.

For the full series the price of garlic was right skewed about a median of \$3.37. The minimum price was \$0.74 and the maximum price was \$20.94.

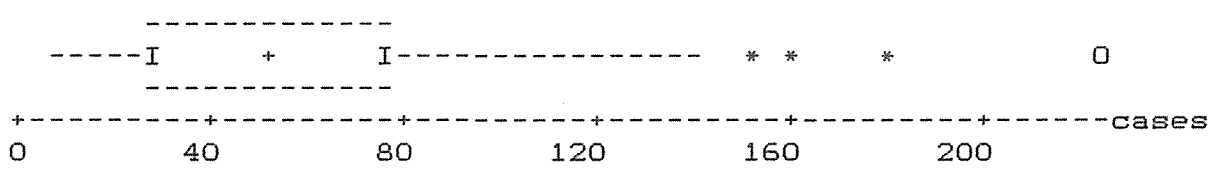


Total volume declined by about 7% for year 2, and then increased by about 9% for year 3. See table 14.

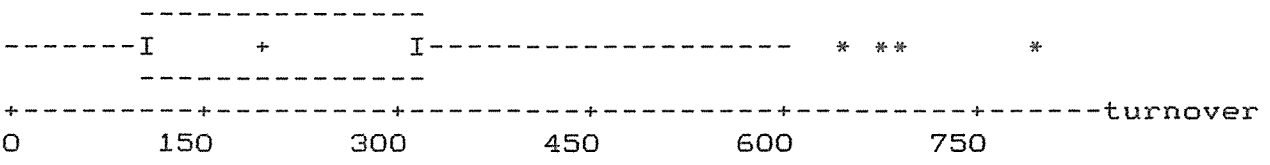
Median weekly volume fell in year 2 and remained at that level in year 3. The variation in weekly volume was higher in year 3 than in years 1 and 2.



For the entire series the median weekly volume was right skewed about a median of 52. The smallest volume was 6 cases the largest, 224.

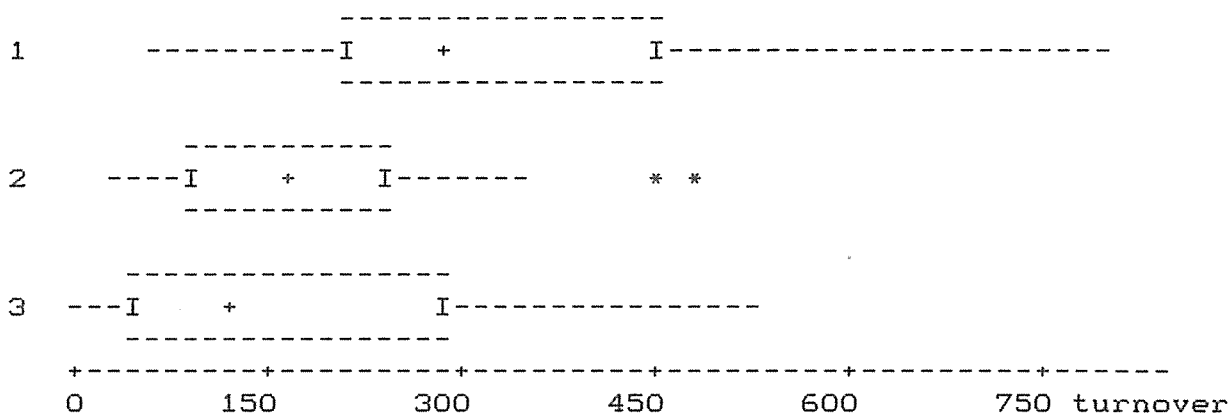


The percentage decline in turnover in year 2 was matched by an almost identical percentage decline in average price for year 2. See tables 13 and 15. For the entire series weekly turnover was right skewed about a median of \$198.00, with the lowest turnover being \$6.00, and the highest being \$795.00.

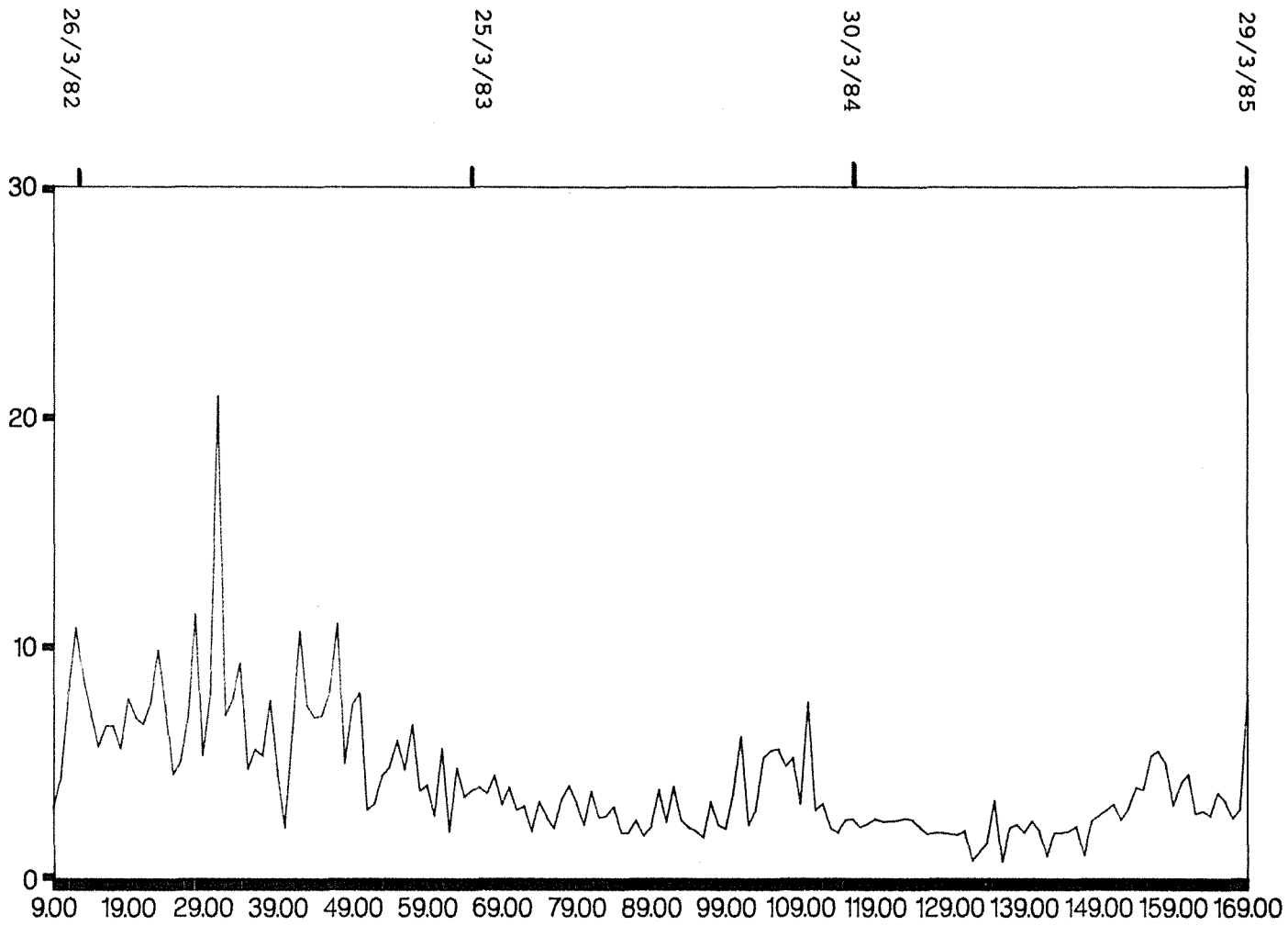


Median weekly turnover fell in successive years. In year 3 it was about half the value in year 1.

Year

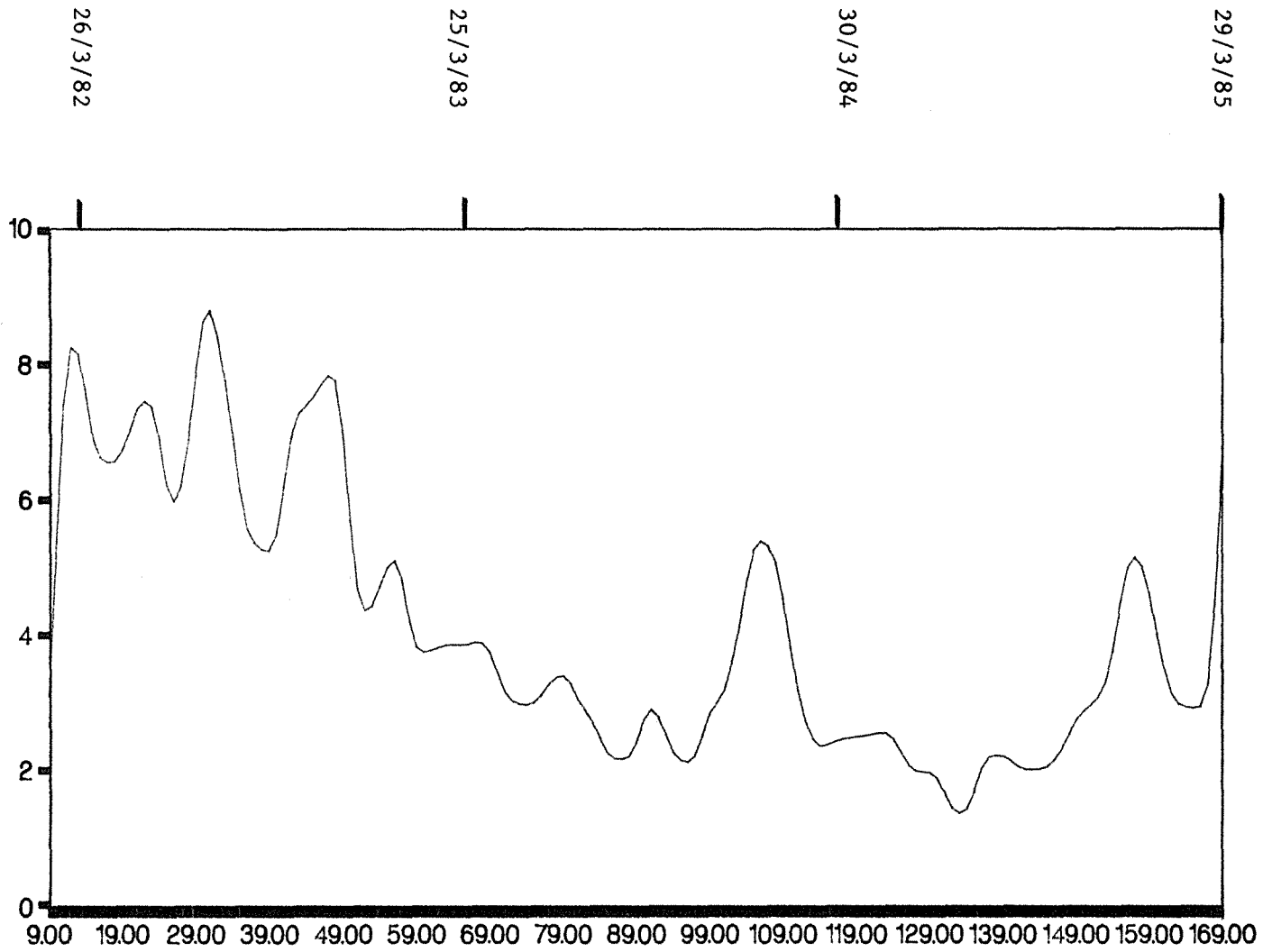


The median price remained the same after closing-up the series by inserting values for the two missing weeks. The mean before closing-up was \$4.272. After closing-up it was \$4.259. The standard deviation was \$2.649 before closing-up, and \$2.635 after closing-up. The closing-up has only slightly changed the summary statistics and has not affected the median at all.

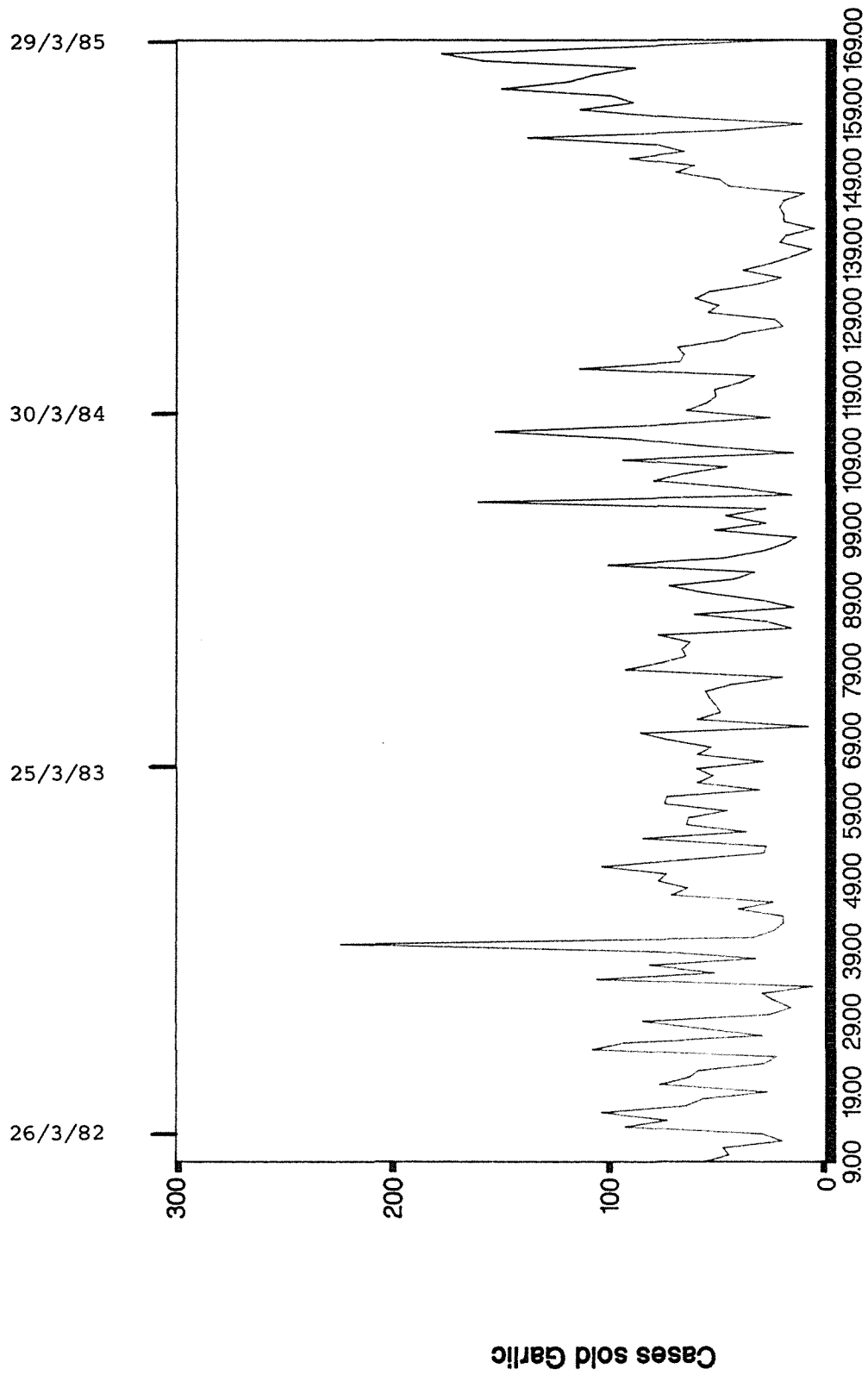


week rank from 1.182 to 29.385

smoothed price of garlic



week rank in period 1-1-82 to 29-3-85



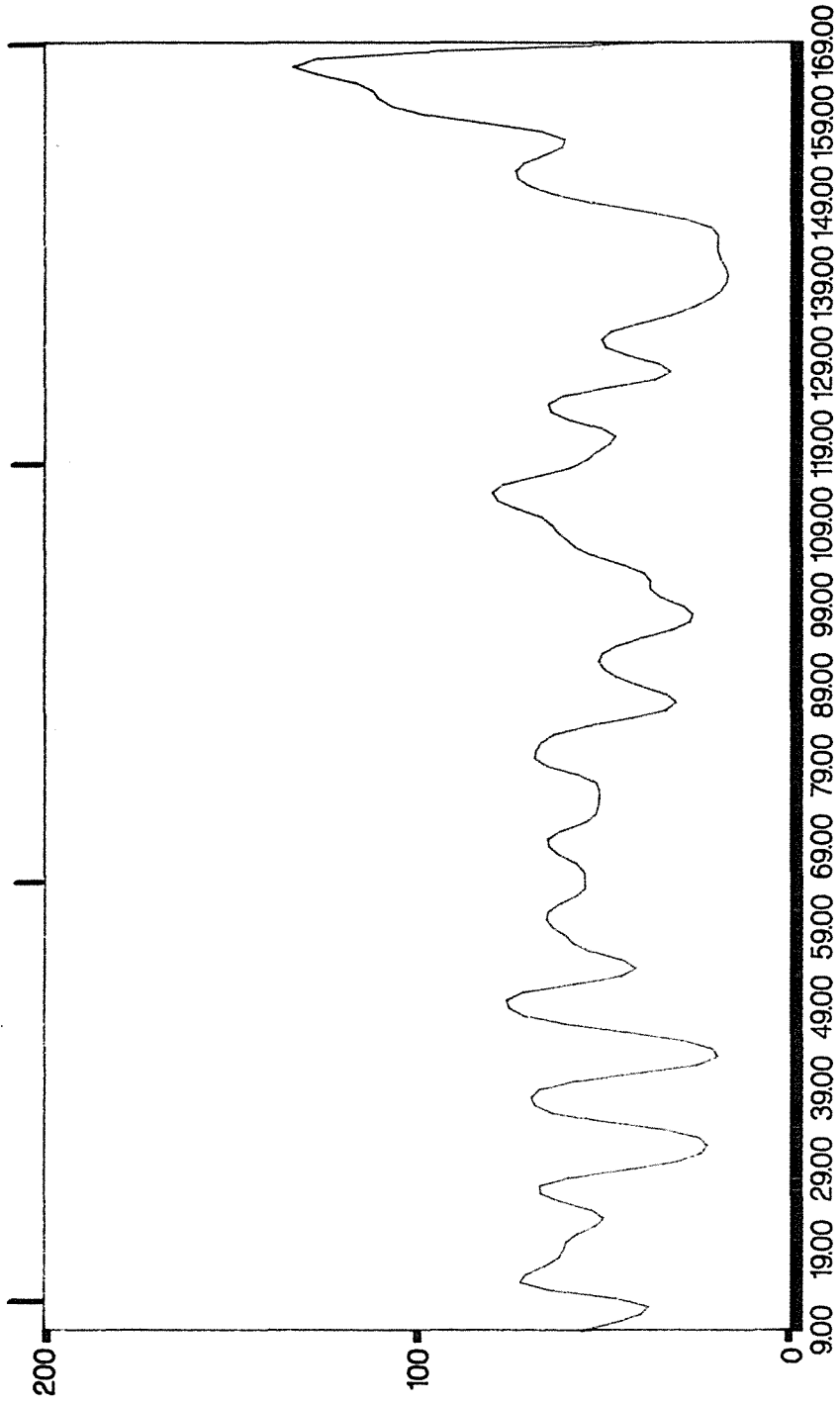
week rank from 1.182 to 29.3.85

29/3/85

30/3/84

25/3/83

26/3/82



smoothed volume of garlic

week rank in period 1-1-82 to 29-3-85

The price of garlic showed considerable instability in the first year and then settled down to a more predictable pattern in the following years.

In the three year period volume has been slightly more variable than price. Turnover has shown more variation than either price or volume.

coefficient of variation

price	.62
cases	.64
turnover	.71

The smoothed price plot clearly shows the reduction in variation from year 1 to year 3. Year 1 had three distinct peaks and one minor peak. The distinct peaks were from the end of May to the middle of June, mid July to mid August, and the end of October to the middle of December. The one minor peak occurred from mid January to early February.

Throughout year 1 a downward movement in the price series is evident.

Year 2 had two minor peaks and one distinct peak. The minor peaks occurred from the end of June to the middle of July, and from the middle of September to the middle of October. The major peak occurred from about mid December to mid February.

The downward movement in prices evidenced in year 1 seems to have levelled off in year 2 and it appears that prices have stabilised. This pattern may be indicative of a price cycle.

Year 3 had what appears to be one season, with a relatively constant price at about \$2.50 per case, and a period where price rose to about \$5.00 per case. This peak occurred at the end of December and continued to the middle of January. The prices in year 3 appear to have a slight positive trend.

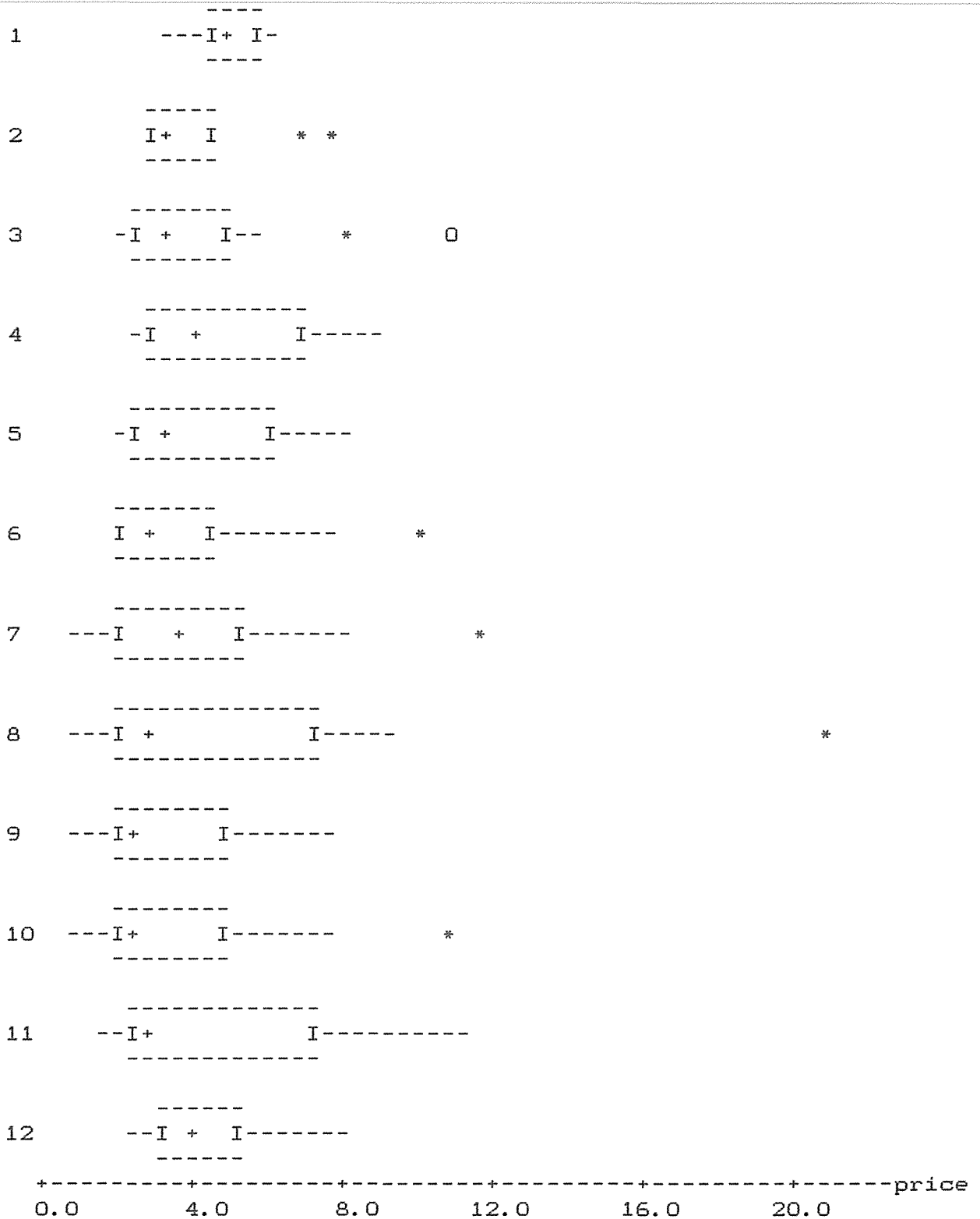
There were between 4 and 5 supply peaks in each year. These were mid to late April, mid to late July, mid to late September, December, and February.

An annual crop such as garlic would be expected to have one season. The week to week variation tends to obscure this.

The boxplots below indicate that median prices are reasonably constant throughout the year. Some months exhibit greater variation than others but this variation would probably be largely due to the small number of observations contained in each month.

Any seasonal pattern is not clear but prices are highest in December and January which is just prior to the harvest.

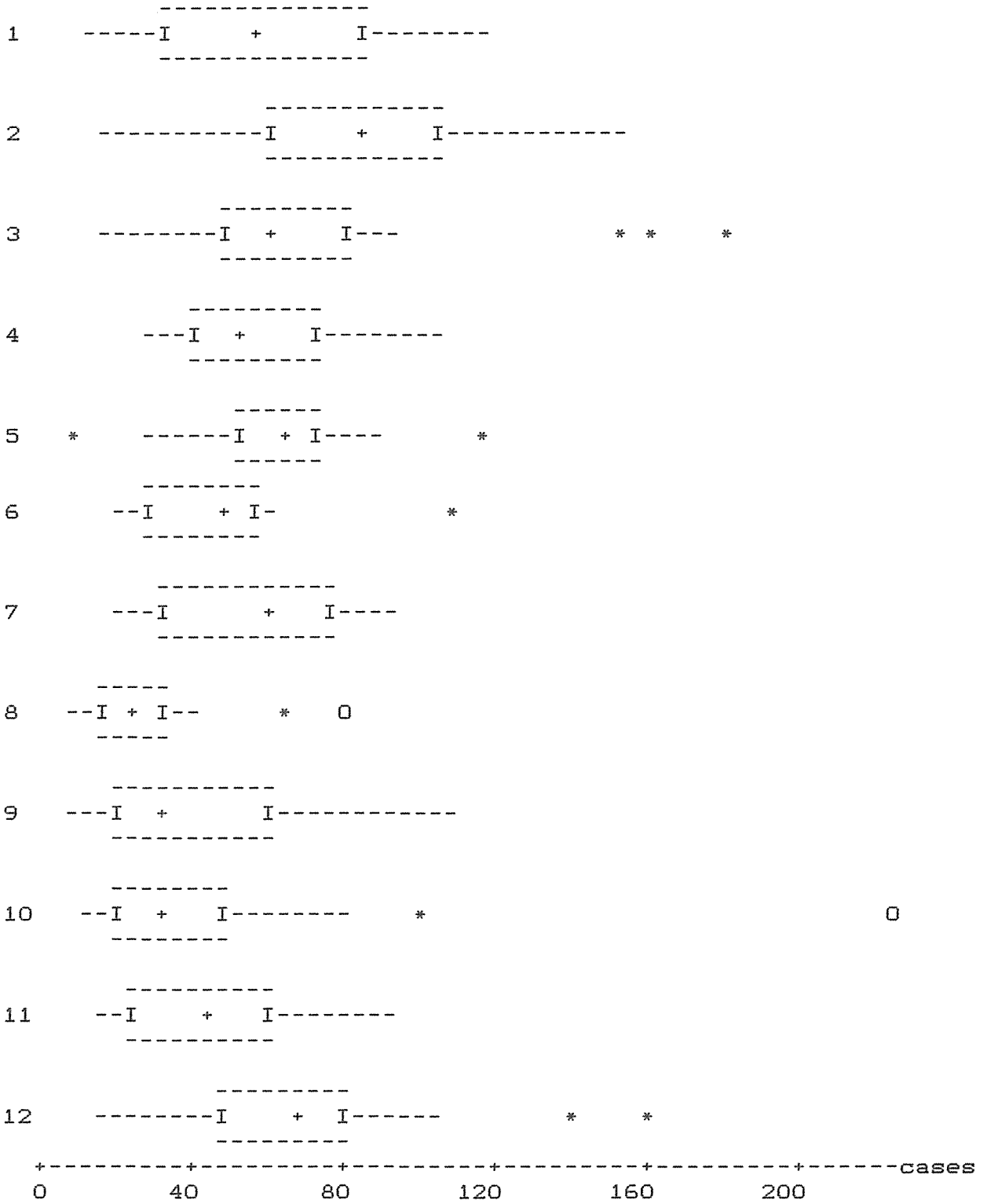
Month



Volumes are in general lowest in August, September, and October. They begin rising in November and are highest in February. Volumes are reasonably constant from March to July and then fall

away in August. There is a short lived peak in December and this is probably due to Christmas.

Month



8 KUMARAS

Kumaras are grown in warmer areas such as Northland, Auckland, and the Hawkes Bay regions. The vegetable is highly frost sensitive. A small amount is grown at Otaki in the Manawatu.

Ballinger (1980) notes that the best growing conditions for kumaras are in the north of the North Island. Plants are ready about five months after the setting out of the "slips" which is in about April. The time of setting out depends on the weather and the danger of frosts.

In April plants are lifted and cured.

Thompson and Kelly (1957), writing about sweet potatoes, note that a four month frost free period, with warm days and nights for most of this time, is necessary to get a good crop.

They discuss the various requirements for sweet potatoes to keep well in storage and comment that changes take place in storage such as weight loss. However, this weight loss does fluctuate very much during storage. During storage the starch content decreases and the sugar content increases.

1 The expected behaviour of prices

Mr Peter Arlidge commented that the market is almost completely supplied by one grower in northland. We would expect volumes to be highest in the months following harvest and during harvest. Volumes would then probably decline to a constant level in the winter months as produce is supplied out of storage.

Prices would be expected to be lowest in April during and after harvest when volumes are highest. They would then rise to peak just prior to the following season's harvest.

Some affect on price might occur as the length of storage increases; this will affect the quality of the produce.

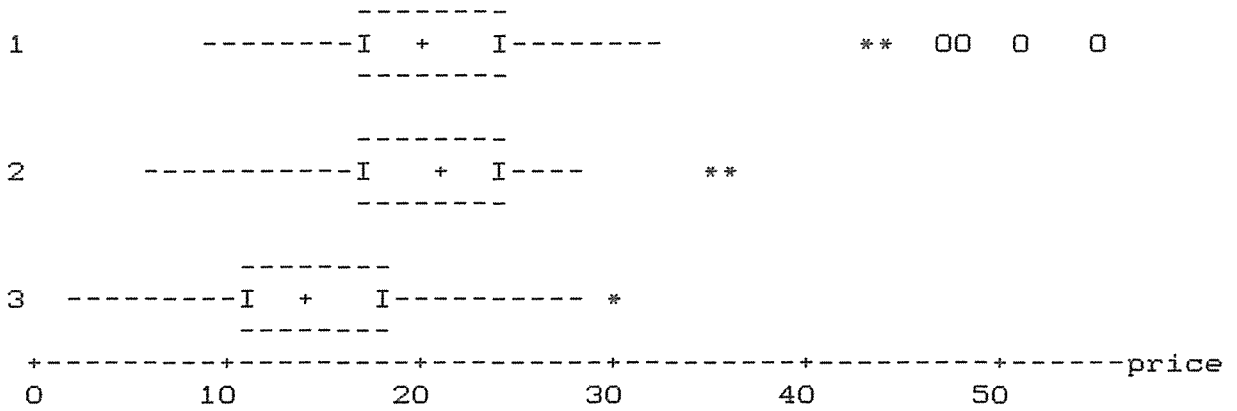
2 The behaviour of kumaras at auction

Kumaras were supplied continuously for the full period under study.

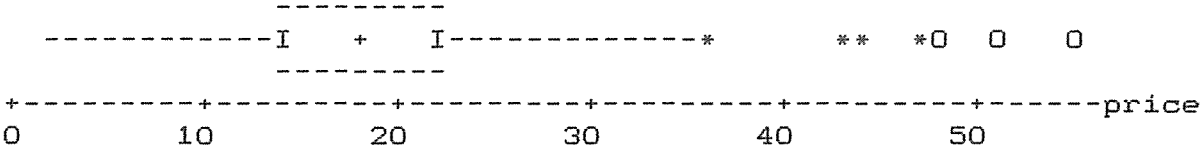
The average price fell in each successive year. In year 2 mean price fell by about 11% and in year 3 mean price fell by about 25%. See table 13.

Median weekly price increased slightly in year 2 and then fell by about \$10.00 in year 3. Fewer extreme prices were received in year 3 than in years 1 and 2.

Year



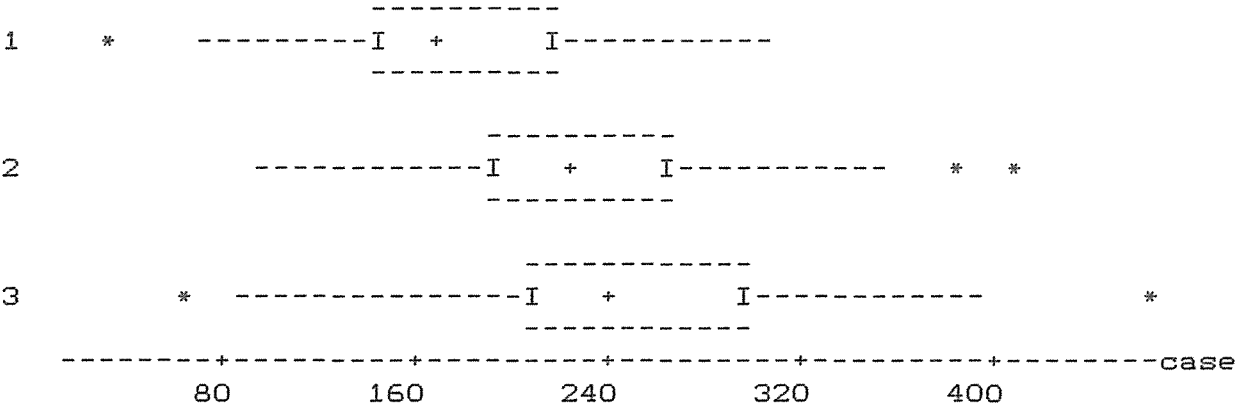
For the entire series weekly prices were right skewed about a median of \$17.92, and ranged from \$2.10 to \$54.98.



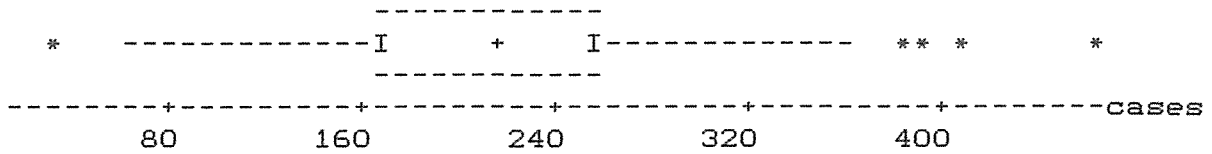
Annual volume increased by a little more than 29% in year 2 and by about 7% in year 3. See table 14.

The median weekly volume has increased in successive years, and the range has increased also.

Year



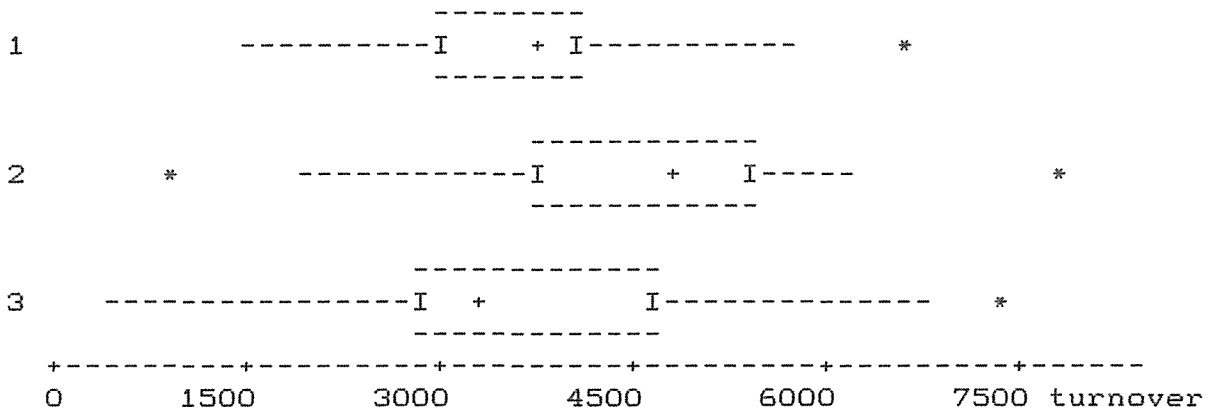
For the entire series weekly volume was quite symmetrically distributed about a median of 212 cases, and ranged from 32 cases to 463 cases.



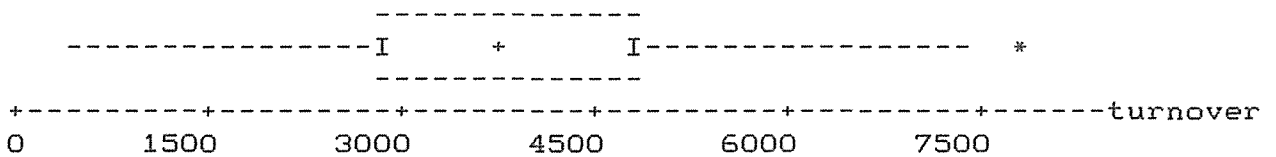
Annual turnover increased by about 22% in year 2 and then fell by about 18% in the following year. See table 15.

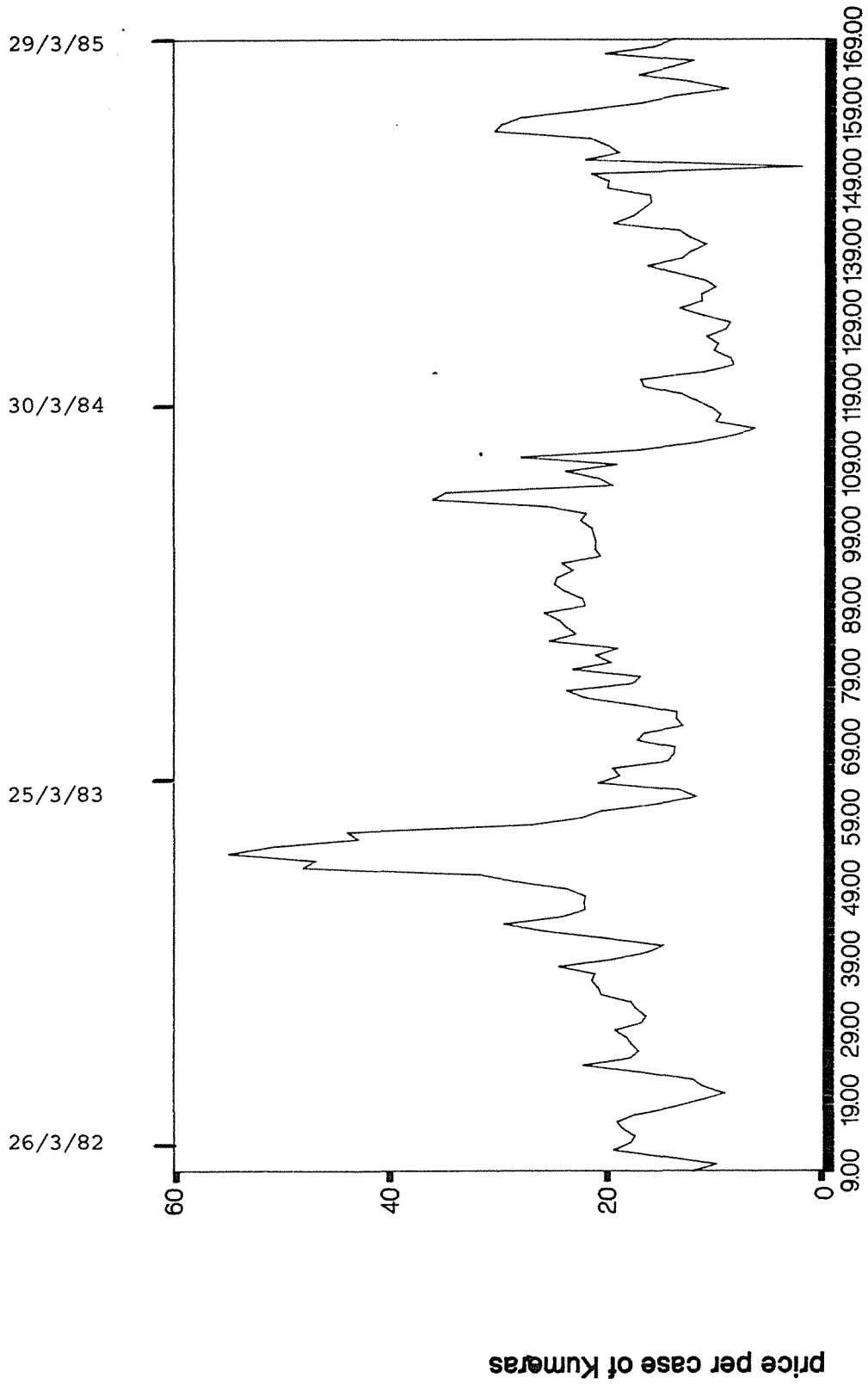
Median weekly turnover has increased and then decreased to below the level in year 1. The variation in weekly turnover has also increased.

Year



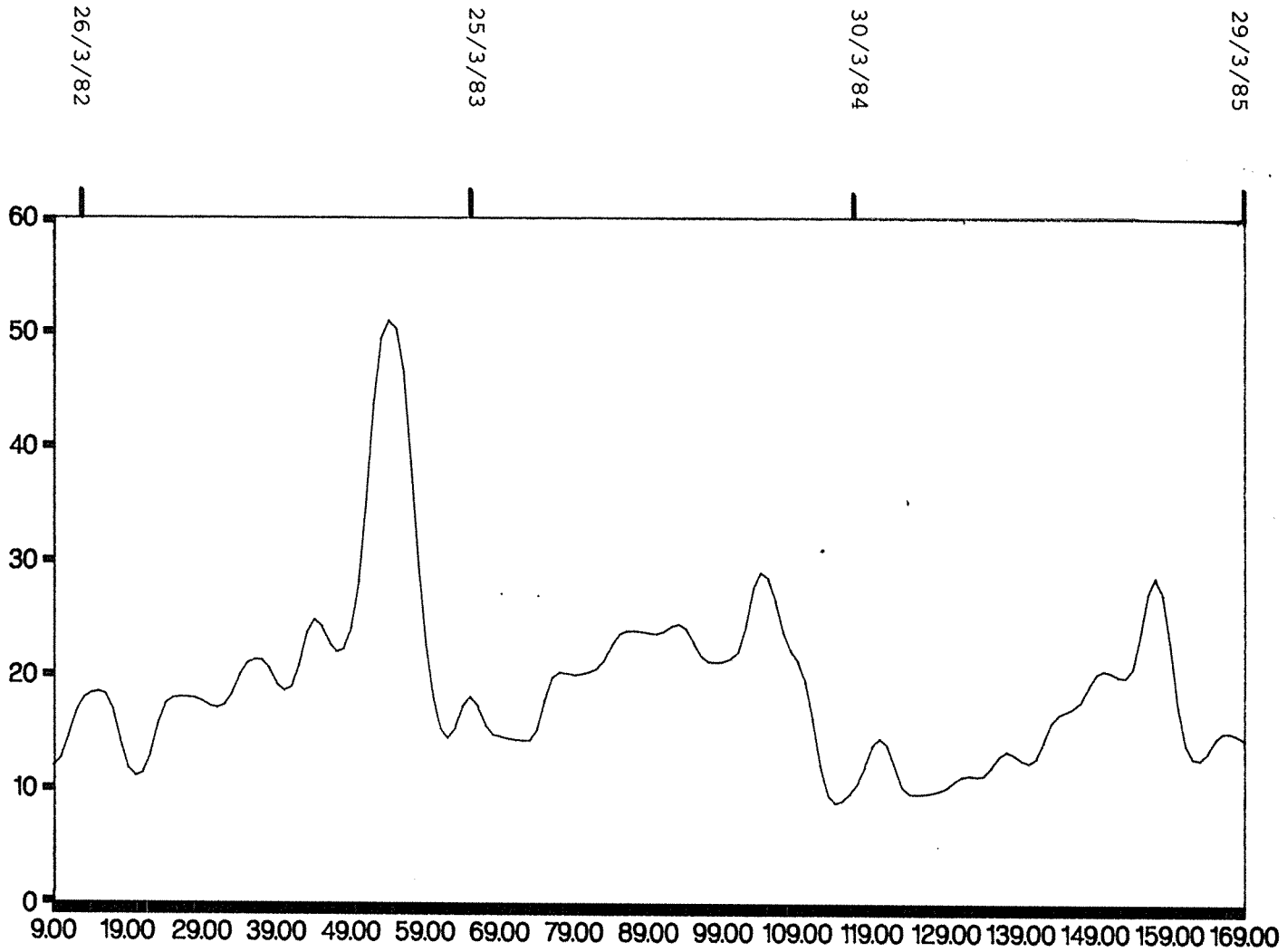
For the entire series weekly turnover was quite symmetrically distributed about a median of \$3798.00, and ranged from \$446.00 to \$7865.00.



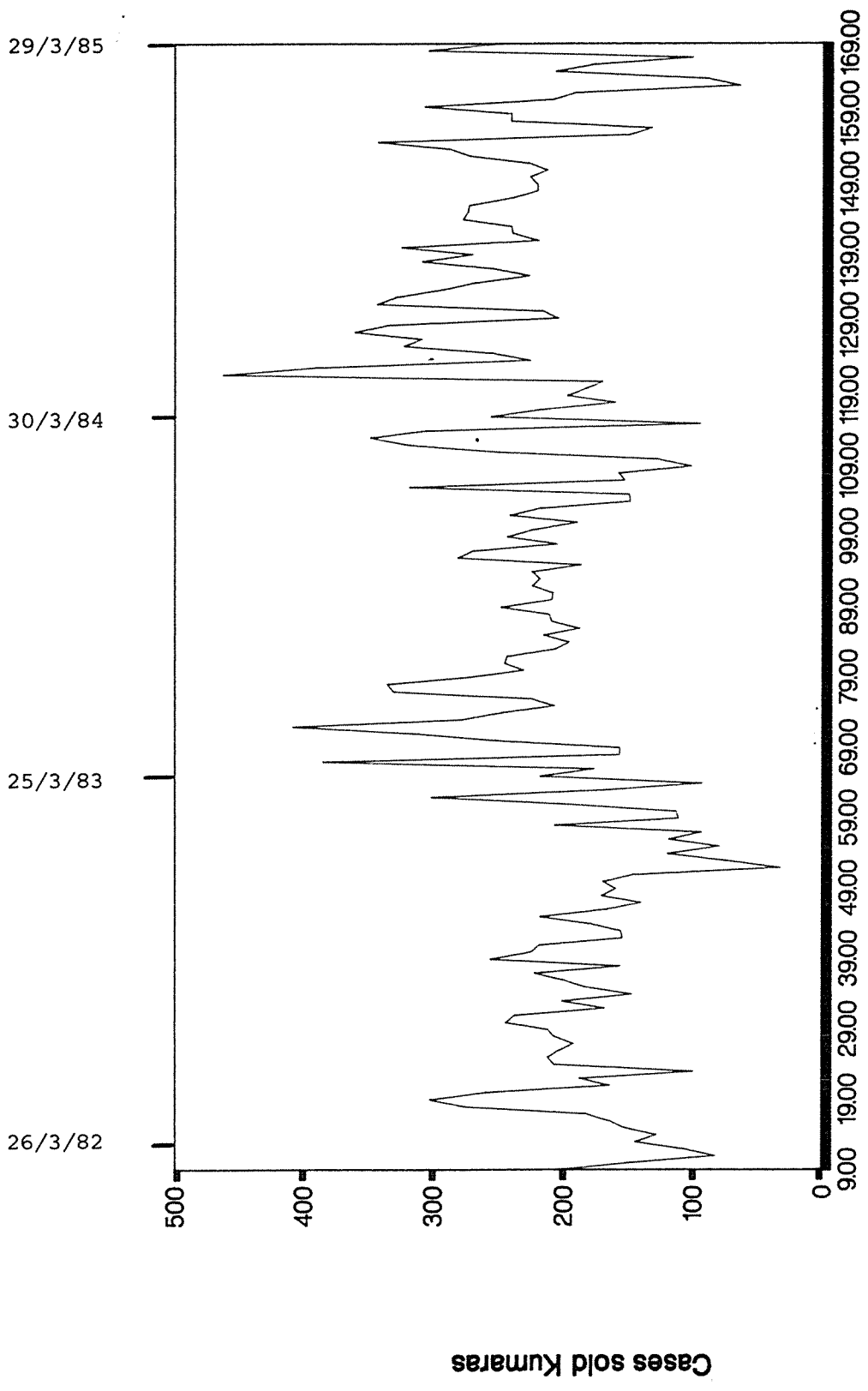


week rank from 1.182 to 29.385

smoothed price of kumeras



week rank in period 1-1-82 to 29-3-85



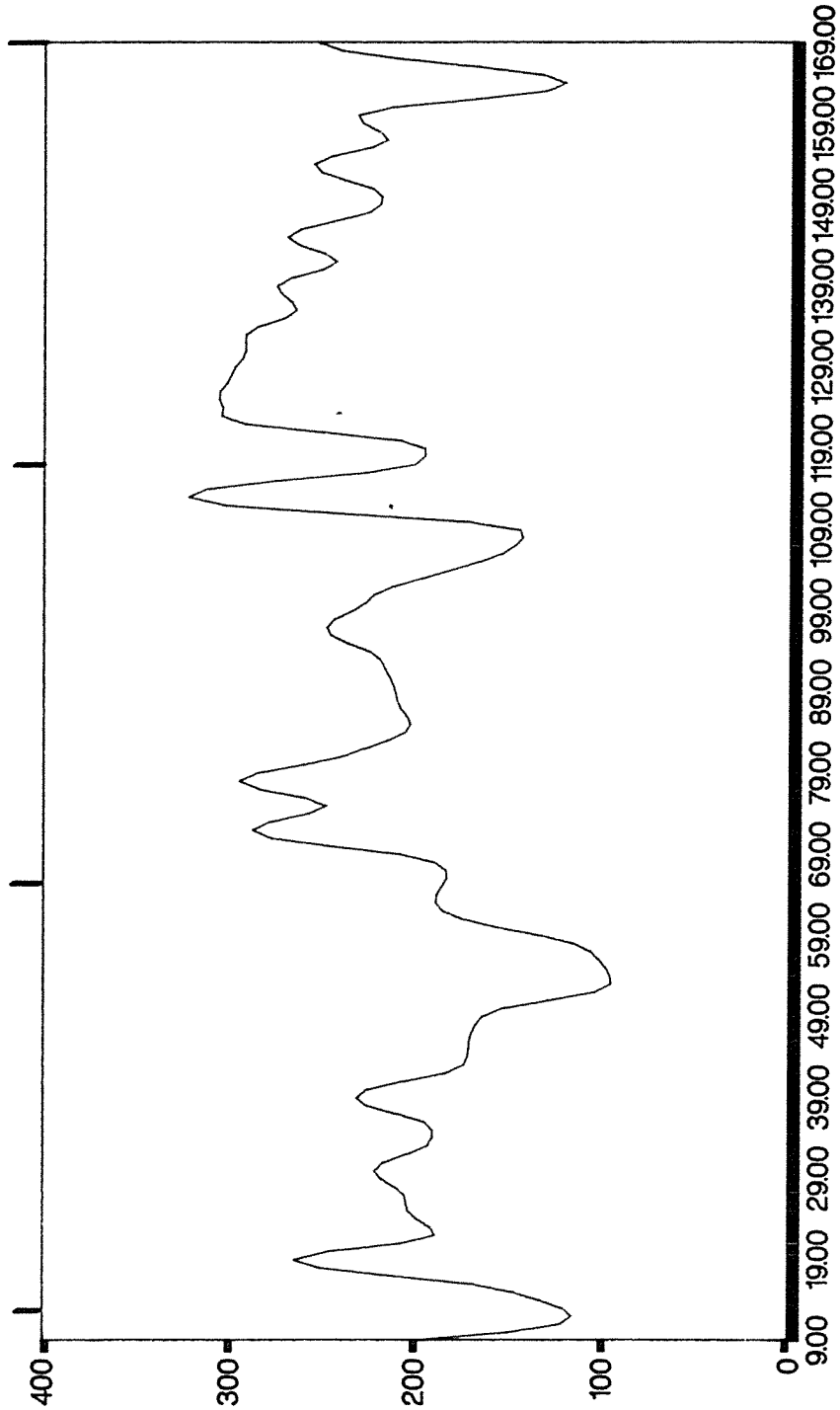
week rank from 1.182 to 29.3.85

29/3/85

30/3/84

25/3/83

26/3/82



smoothed volume of Kumaras

week rank in period 1-1-82 to 29-3-85

The price series has one season in each year.

There are three major spikes in the smoothed price series and these occur from the beginning of December to the end of February. Prices peaked at the end of December and the beginning of January and were lowest in February and March.

Volume fluctuated, but was reasonably constant during the winter months. It then started rising at the end of summer, and peaked in autumn.

The main volume peaks were mid July in year 1, mid May to mid July in year 2, and May to the end of July in Year 3. There also appears to be an upward trend in volumes.

There was about a 52 week period between times of minimum volume. These were at the beginning of January in year 1, the middle of January in year 2, and the beginning of February in year 3.

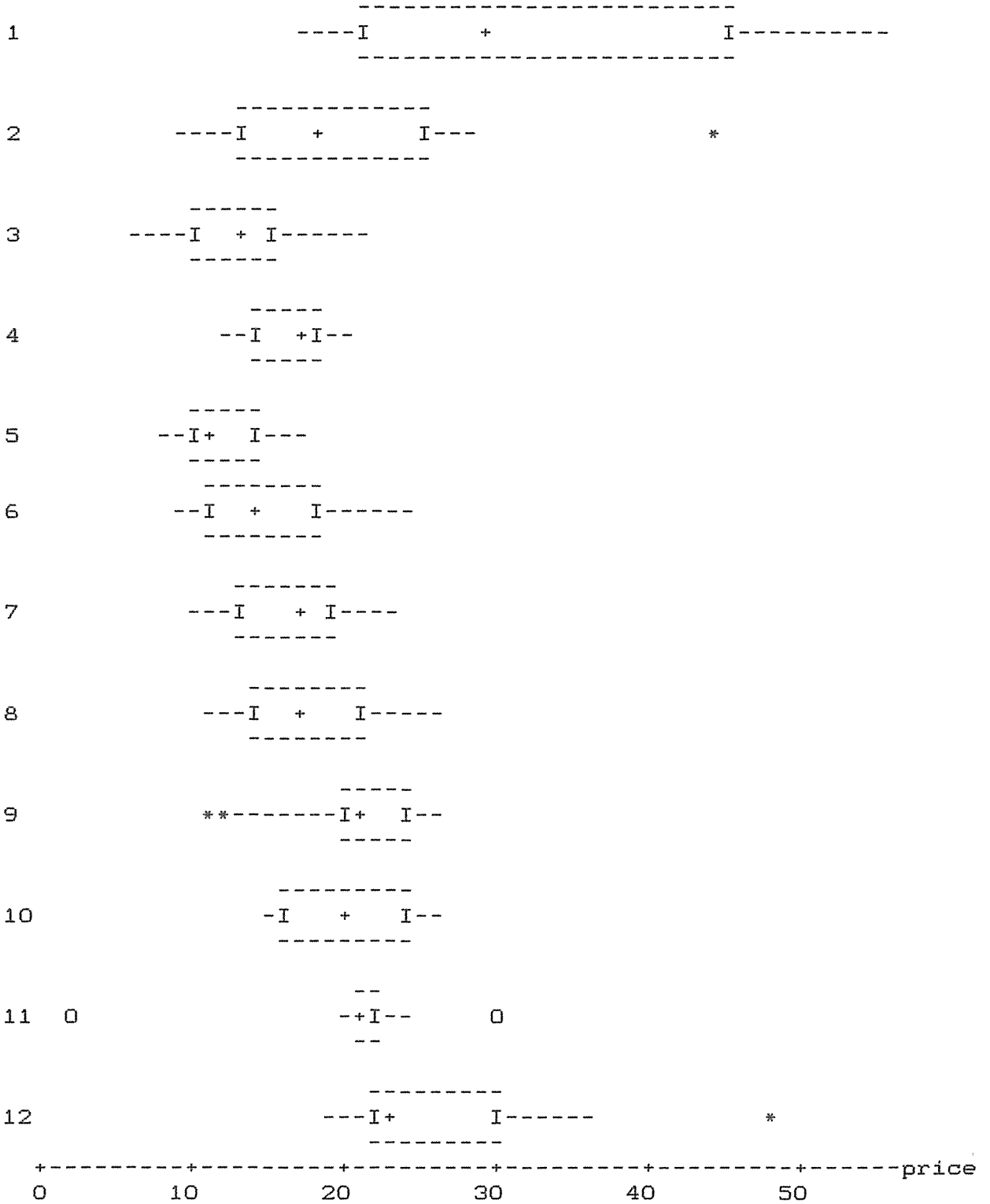
Price was more variable than volume for the three years under study.

coefficient of variation

price	.43
volume	.34
turnover	.35

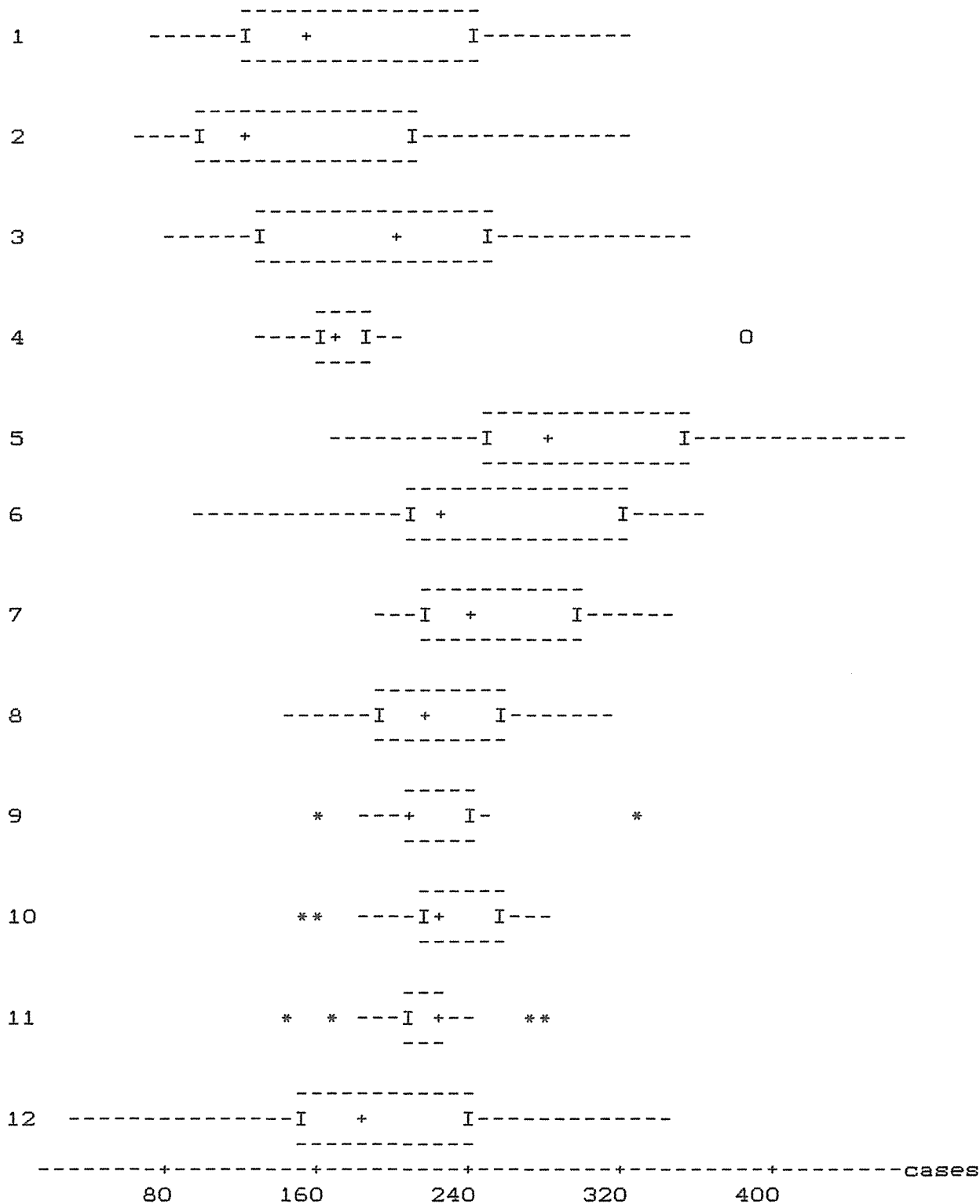
The boxplots below illustrate that prices were highest in December and January and lowest in May.

Month



Volumes exhibited a clear seasonal pattern. They were highest in May and declined steadily to be lowest in April the following year. The turning points for the volume series appear to be in April and May, and the boxplots illustrate the time when the new season's main crop becomes available.

Month



9 LEEKS

Leeks are grown in winter in the Manawatu and Hawkes Bay regions. According to Ballinger (1980) leeks are ready to be harvested in the winter months and are hardy plants. They are sown from about September to December and mature in about 120 days. After about 6 to 8 weeks they are transplanted to the field.

Thompson and Kelly (1957) note that leeks are given similar treatment as onions.

1 The expected behaviour of prices

Prices would be expected to be lowest in the middle of winter and highest in the summer months.

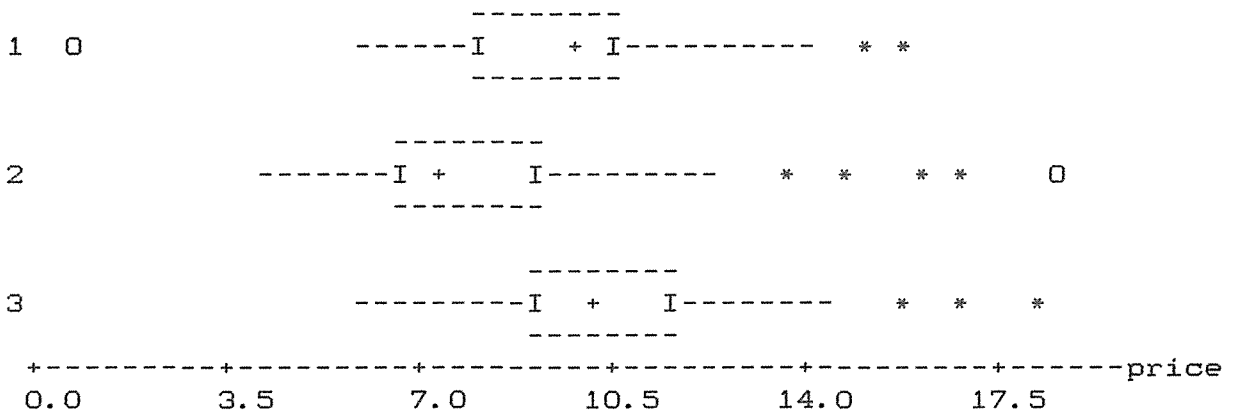
2 The behaviour of leeks at auction

Like brussels sprouts, leeks did not have a continuous supply during the three years under study. There was no supply in December, and very little in January and November.

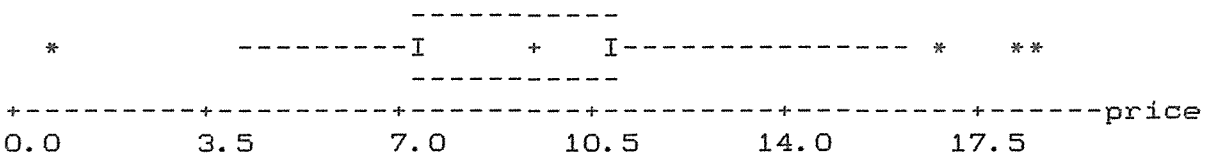
The mean weekly price of leeks fell by about 11% in year 2 and then rose by about 28% in year 3. See table 13.

In each of the three years, outlying values for price are observed. Excluding these outliers reveals that the variation in prices has remained about the same. Median weekly price has changed each year.

Year



For the entire series price was reasonably symmetrical about a median of \$9.43, with a lowest price of \$0.85, and a highest price of \$18.54.

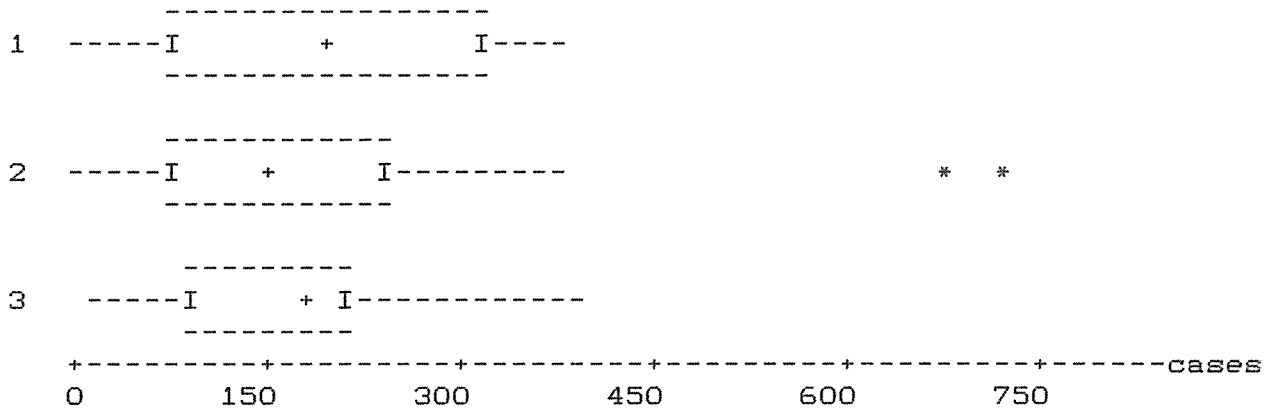


Yearly volume has fallen in successive years. It fell by 10% in

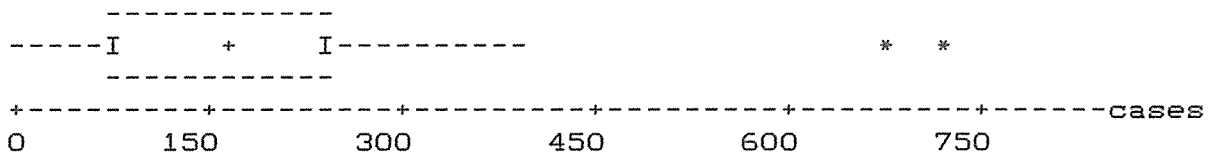
year 2 and by nearly 19% in year 3. See table 14.

However, median weekly volume fell in year 2 and then increased in year 3. The variation in weekly volume has remained about the same.

Year



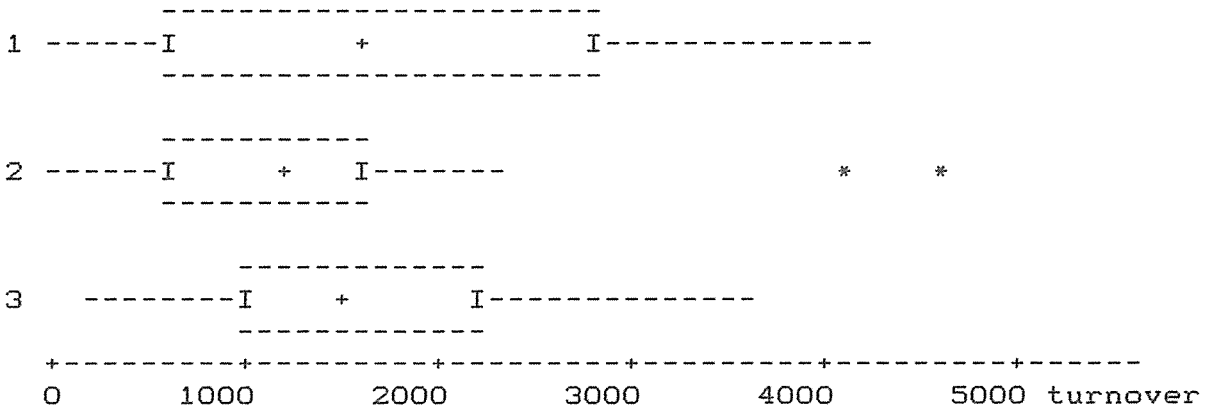
For the entire series weekly volume was right skewed about a median of 167 cases. The lowest volume was 2 cases and the highest was 723.



Turnover fell by almost 33% in year 2 and then rose by about 17% in the following year. See table 15.

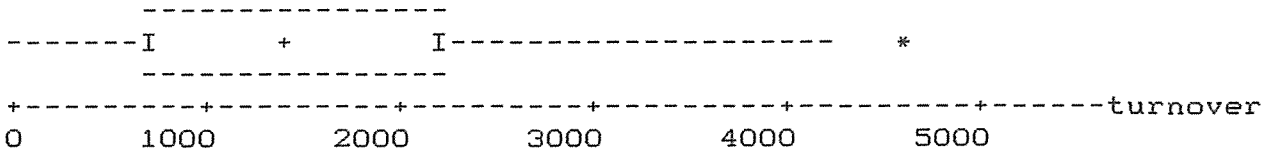
Median weekly turnover fell in year 2 and then increased in year 3.

Year



For the entire series, weekly turnover was right skewed about a

median of \$1358, the lowest weekly turnover being \$14.00, and the highest \$4565.00.



The leeks time series could not be smoothed without inserting many values to close-up the series.

The period of no supply shifted a little during the three years under review. In year 1 no leeks were supplied from late November to mid January. In year 2 the period of no supply was slightly longer from early November to the end of January. In year 3 the period of no supply was slightly longer still, being from mid October to early February.

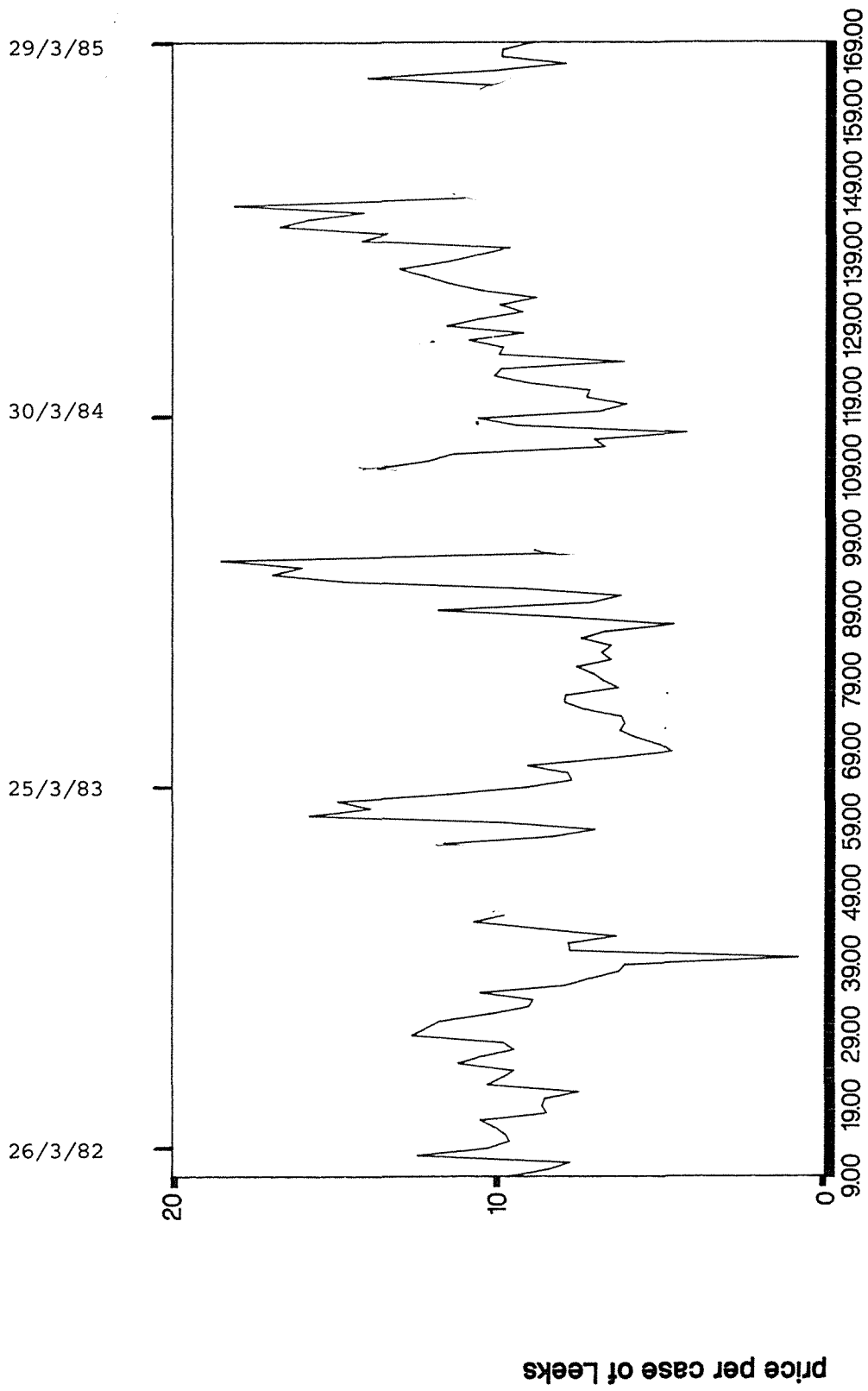
From the volume plot it can be seen that leeks had one season a year. Volumes began rising near the end of January, peaked in June and July, and then fell away to nothing at the beginning of November.

Prices were sometimes (two times out of three) highest two or three weeks prior to the end of the supply season. Prices generally were high at the beginning of the season, fell away as supply increased and then rose steadily to be highest at the end of the season. Prices were lowest in August and September.

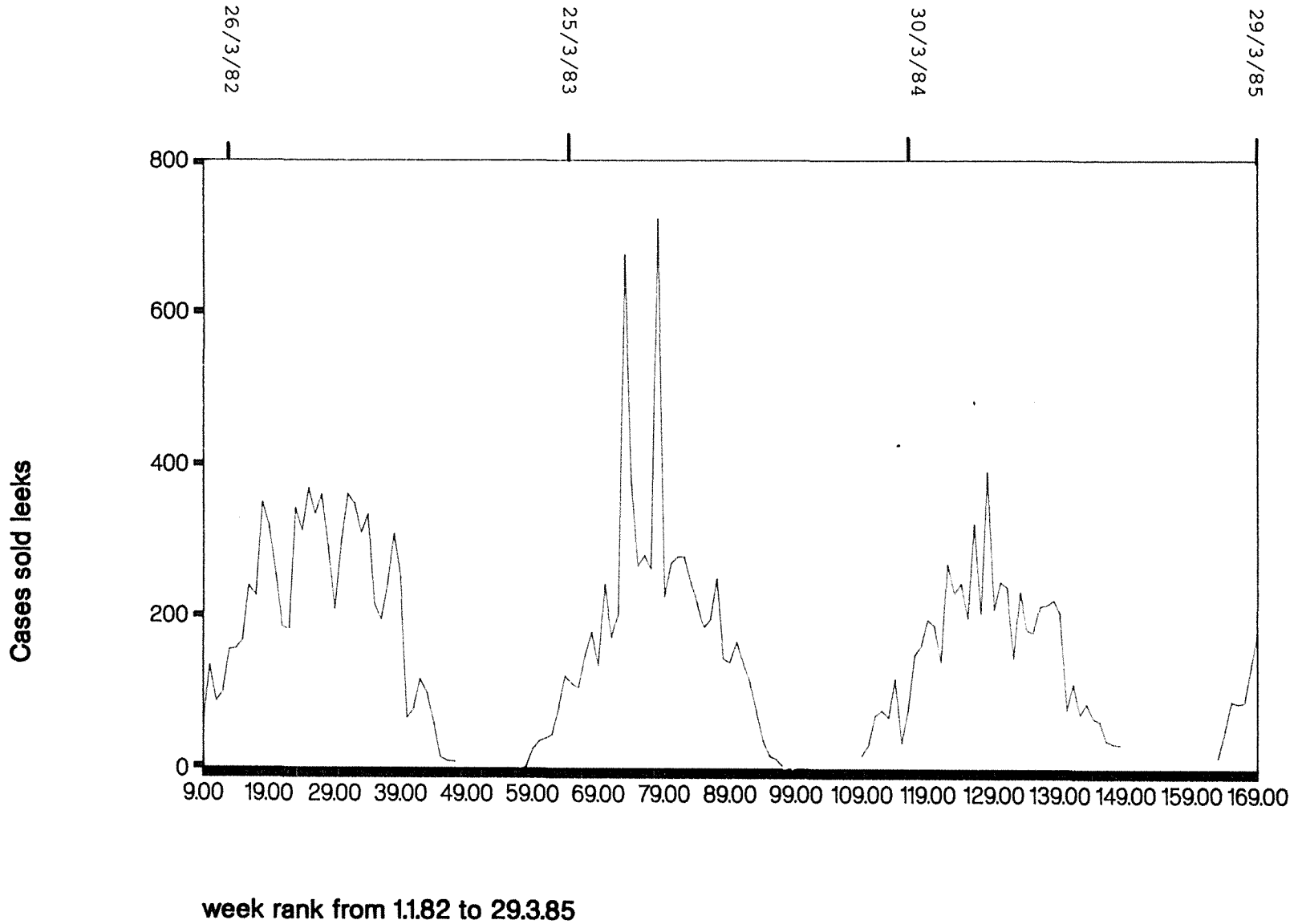
Volume was considerably more variable than price.

coefficient of variation

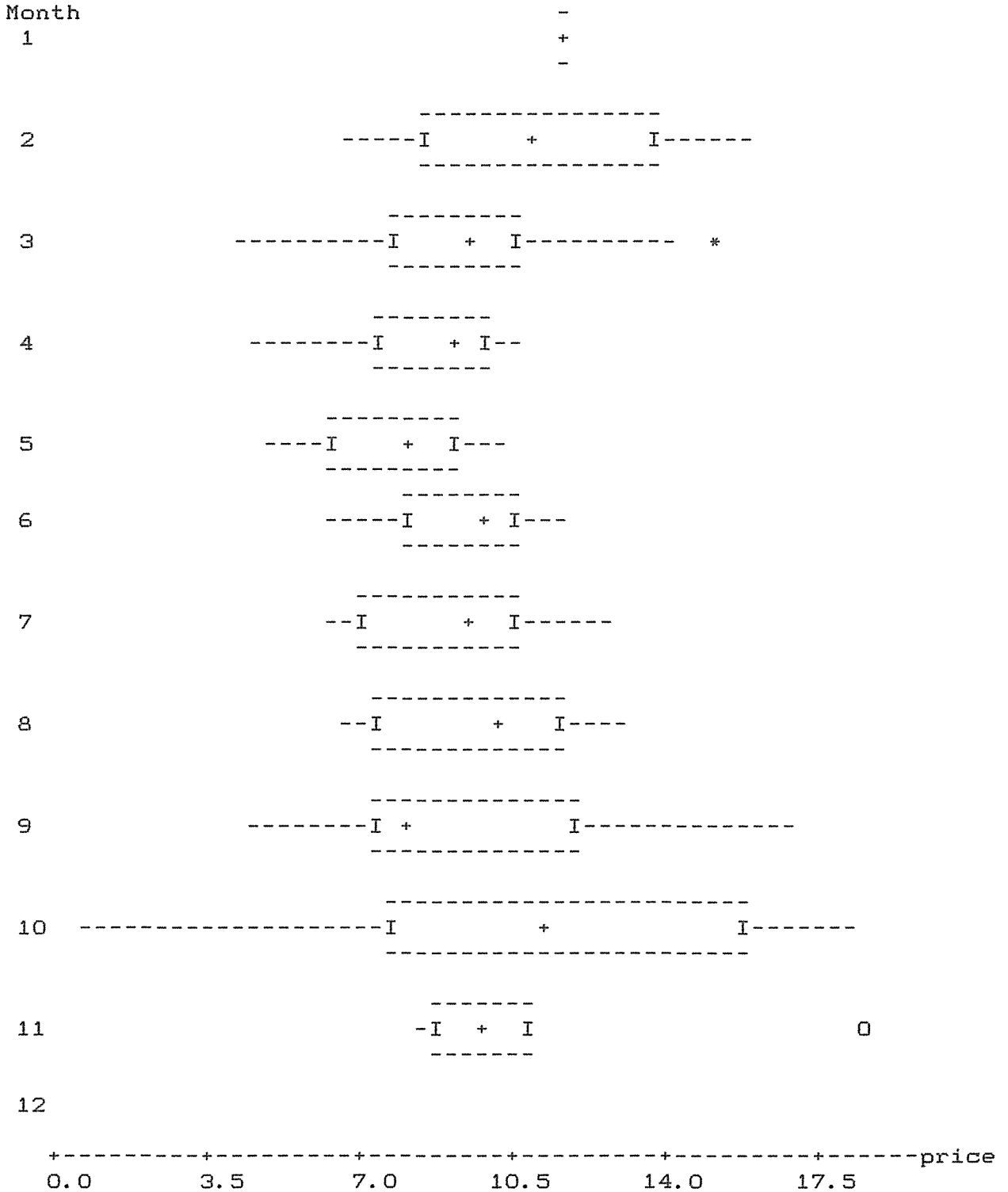
price	.31
volume	.70
turnover	.67



week rank from 1.182 to 29.385

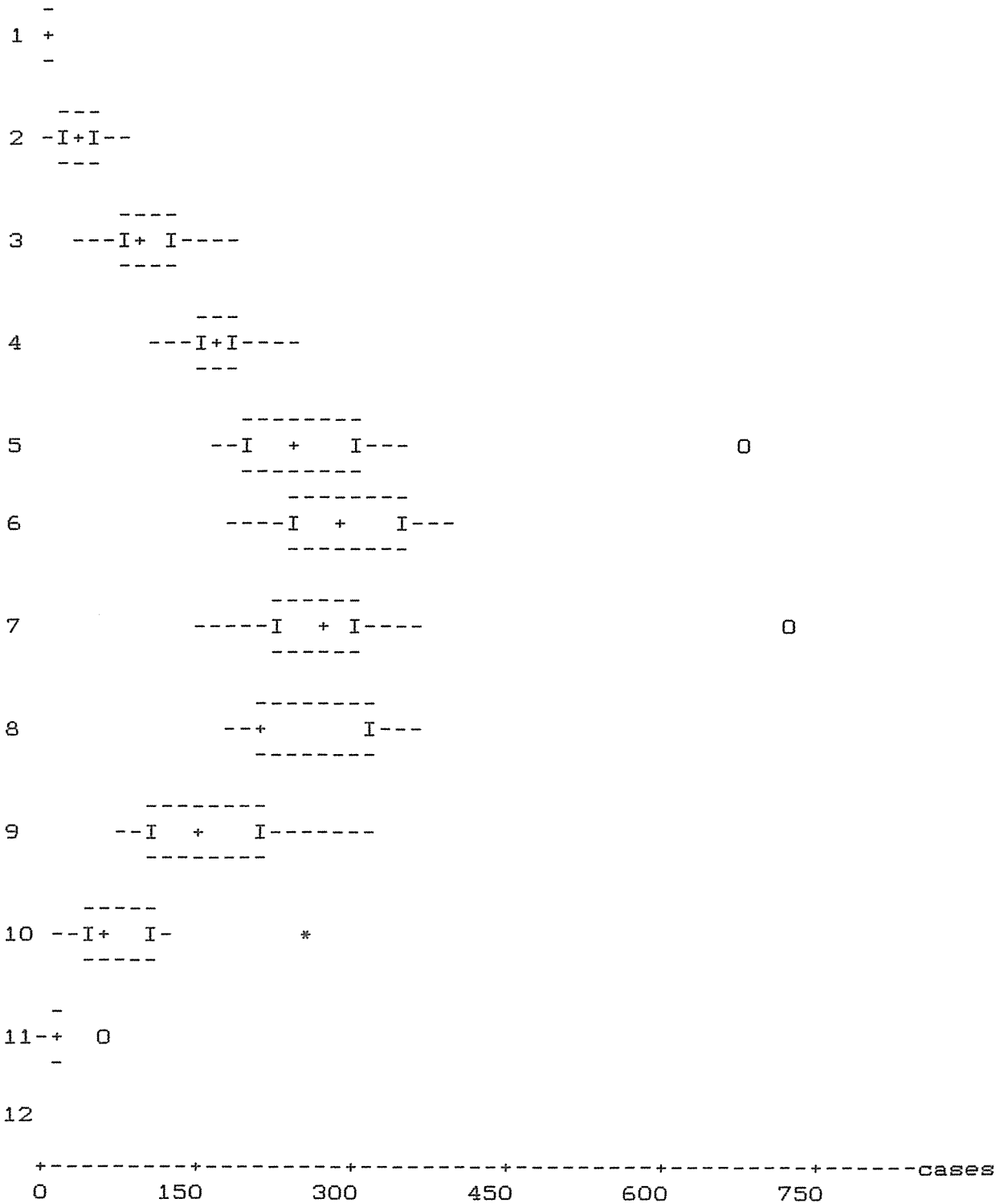


The boxplots which follow summarise the behaviour of prices and volumes. The biggest range of prices was in October. The general pattern was for prices to be high at the beginning of the season and at the end of the season. No product was supplied in December and very little in January. Prices appear to have been lowest in May and highest in February and October. However, in October some very low prices were recieved.



Leek volumes peaked in June and were lowest in January and November, which are the beginning and end of the season.

Month



10 LETTUCE

Lettuce is supplied to the auction floor all year. It is grown in all regions.

According to the Yates seed catalogue, the many varieties of lettuce mean that supply for the fresh market is guaranteed throughout the year. Ballinger (1980) notes that frames and cloches allow for lettuces to be available all year. Maturity is from 60 to 90 days depending on the time of the year. Summer cultivars can be sown from August to February, and winter cultivars from March to August.

Thompson and Kelly (1957) note that lettuce prefers a relatively cool growing season where summers are cool and winters are mild.

1 The expected behaviour of prices

Lettuces are grown all year and grow better when conditions are warm and not too wet. In general we would expect prices to be lowest in the summer and highest in the winter. We would expect volumes to be highest over the summer, especially late summer early autumn, and lowest in the winter.

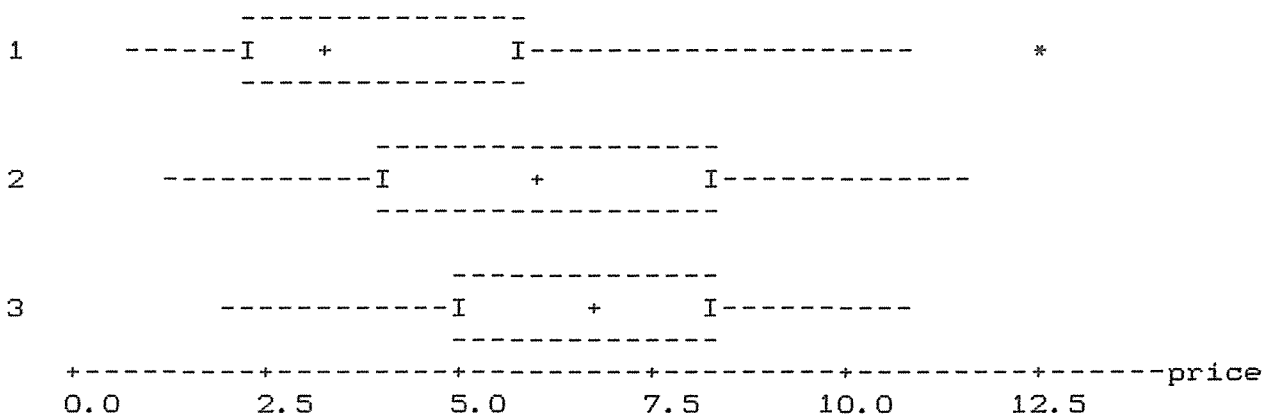
2 The behaviour of lettuces at auction

Lettuces were supplied continuously for the full 3 years under study.

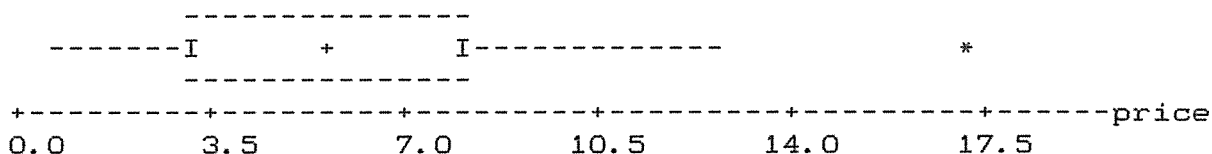
The average weekly price increased by about 41% in year 2 and by 7% in year 3. See table 13.

In each year the weekly median price has increased and the range of prices has declined. The price of lettuce is highly variable.

Year



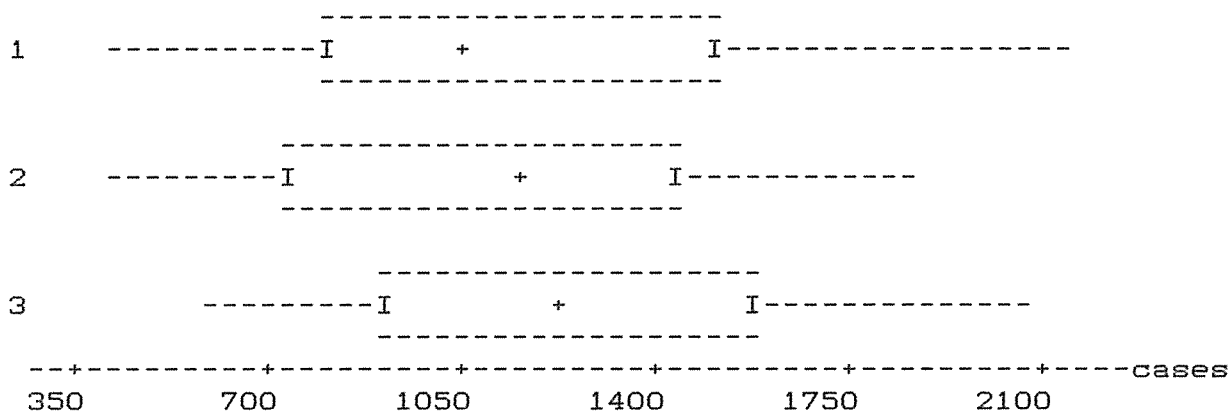
For the full three year period the price of lettuce has been reasonably symmetrical about a median of \$5.66, with a minimum price of \$.65, and a maximum price of \$17.00.



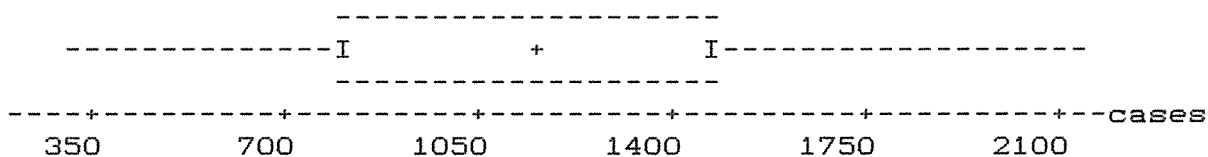
Annual volume increased in year 2 by about 5% and increased in year 3 by about 12%. See table 14.

Median weekly volume has increased in successive years and the variation in volume has decreased.

Year



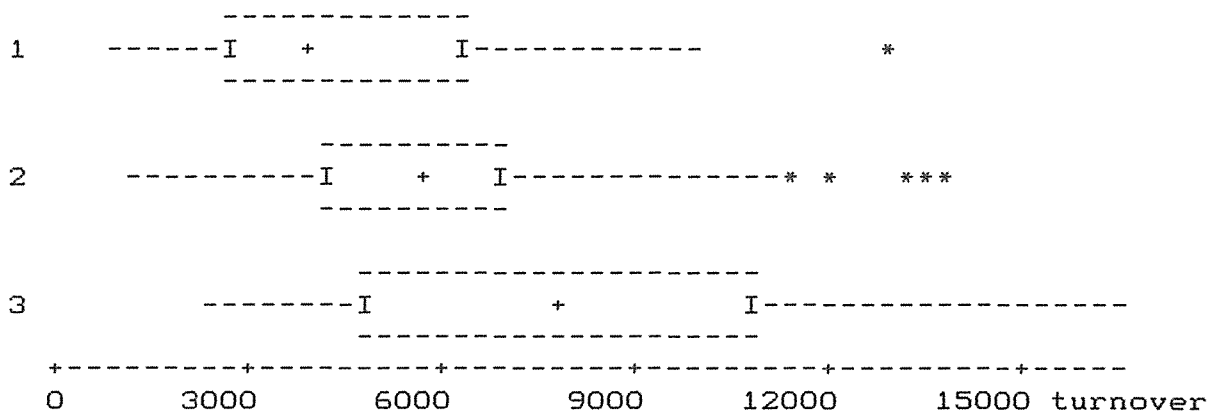
For the entire series weekly volume was normally distributed about a median of 1165 cases per week, with a minimum volume of 326 cases a week, and a maximum volume of 790 cases per week.

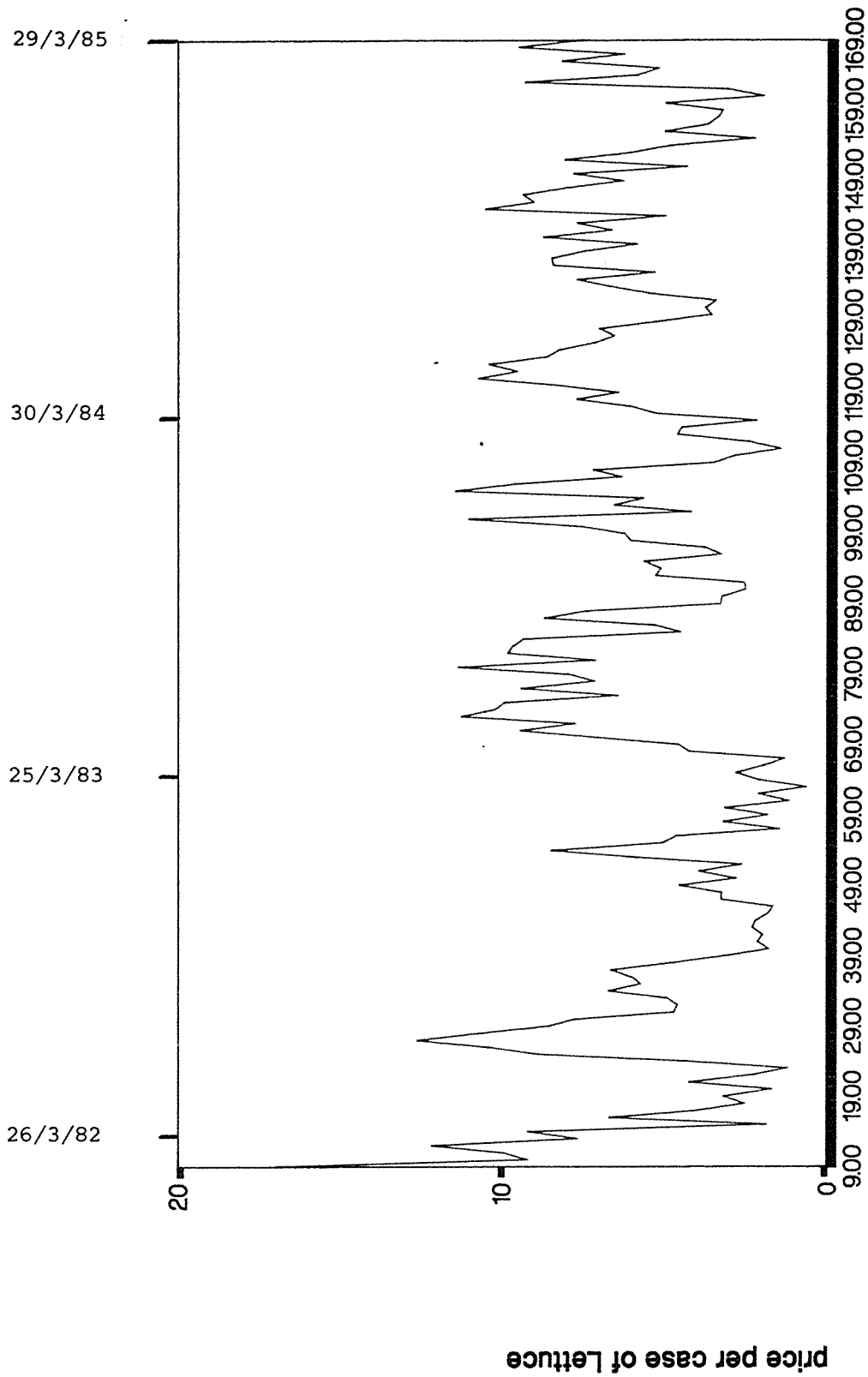


Annual turnover increased by about 34% in year 2 and by about 29% in year 3. See table 15.

Median weekly turnover has risen in each year and both the weekly minimum and weekly maximum turnover have risen as well.

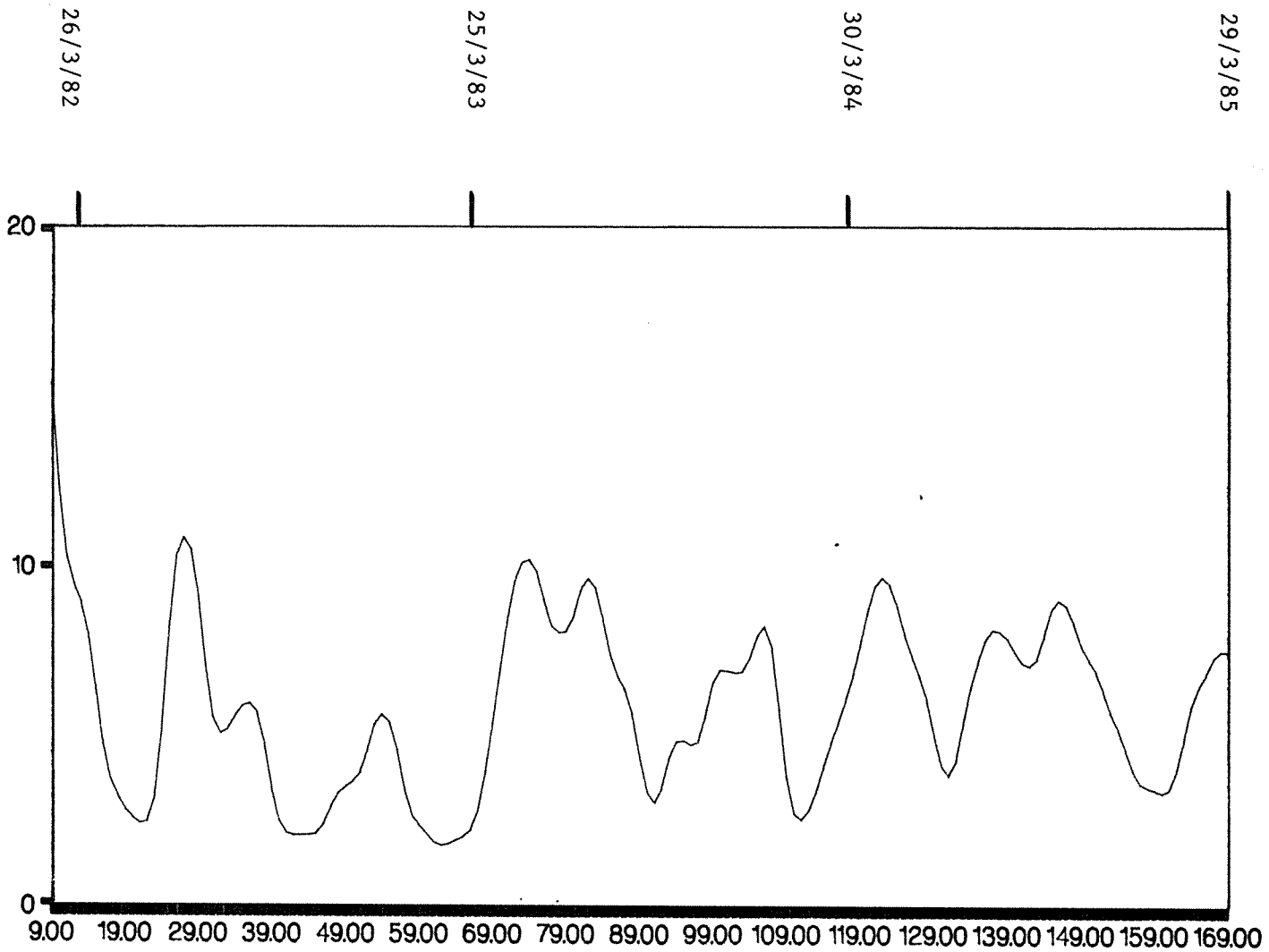
Year



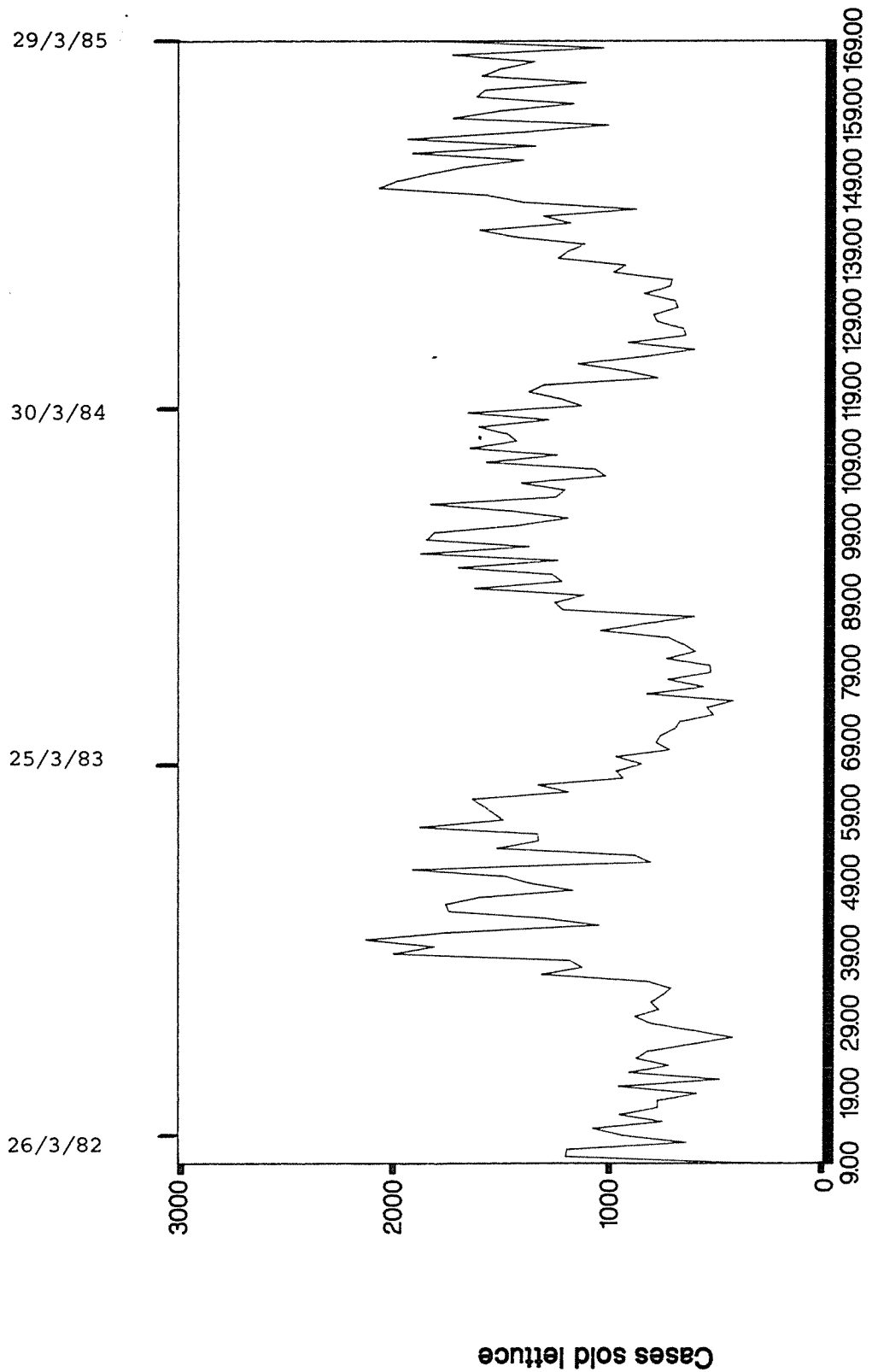


week rank from 1.182 to 29.3.85

smoothed price of lettuce



week rank in period 1-1-82 to 29-3-85



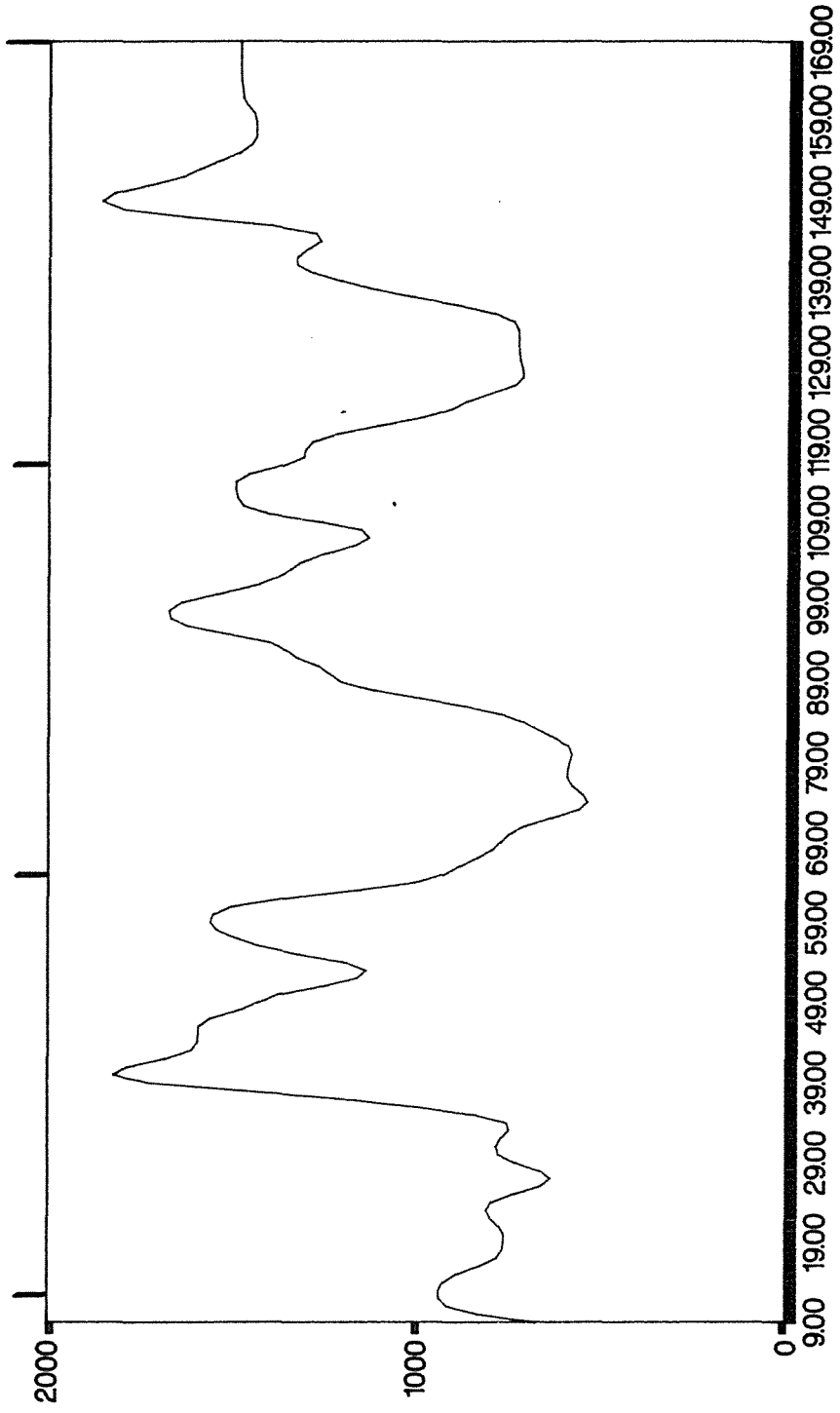
week rank from 1.182 to 29.3.85

29/3/85

30/3/84

25/3/83

26/3/82



smoothed volume of lettuce

week rank in period 1-1-82 to 29-3-85

After smoothing the price series, three seasons each year seem apparent. On closer examination the two peaks in each year, which are about four weeks apart, probably constitute the same season.

There seem to have been two quite distinct seasons for lettuces. The duration and temporal position of these seasons is not consistent. Prices were in general highest in the winter months June to the end of September and the summer holiday season, the end of December to the end of January. This is what we would expect. In winter less product is available than at other times, in summer perhaps greater demand for lettuces for salads pushes the price up. Prices were generally lowest in February.

The smoothed volume plot does not bear the second assertion out. Nominal prices do appear slightly higher for the Christmas period in year 2 (weeks 103 and 104) where a given volume sold in the Christmas period fetched a slightly higher price than for the same volume in weeks 116 and 117.

Lowest prices sometimes lagged highest volumes.

Price was more variable than volume over the three years.

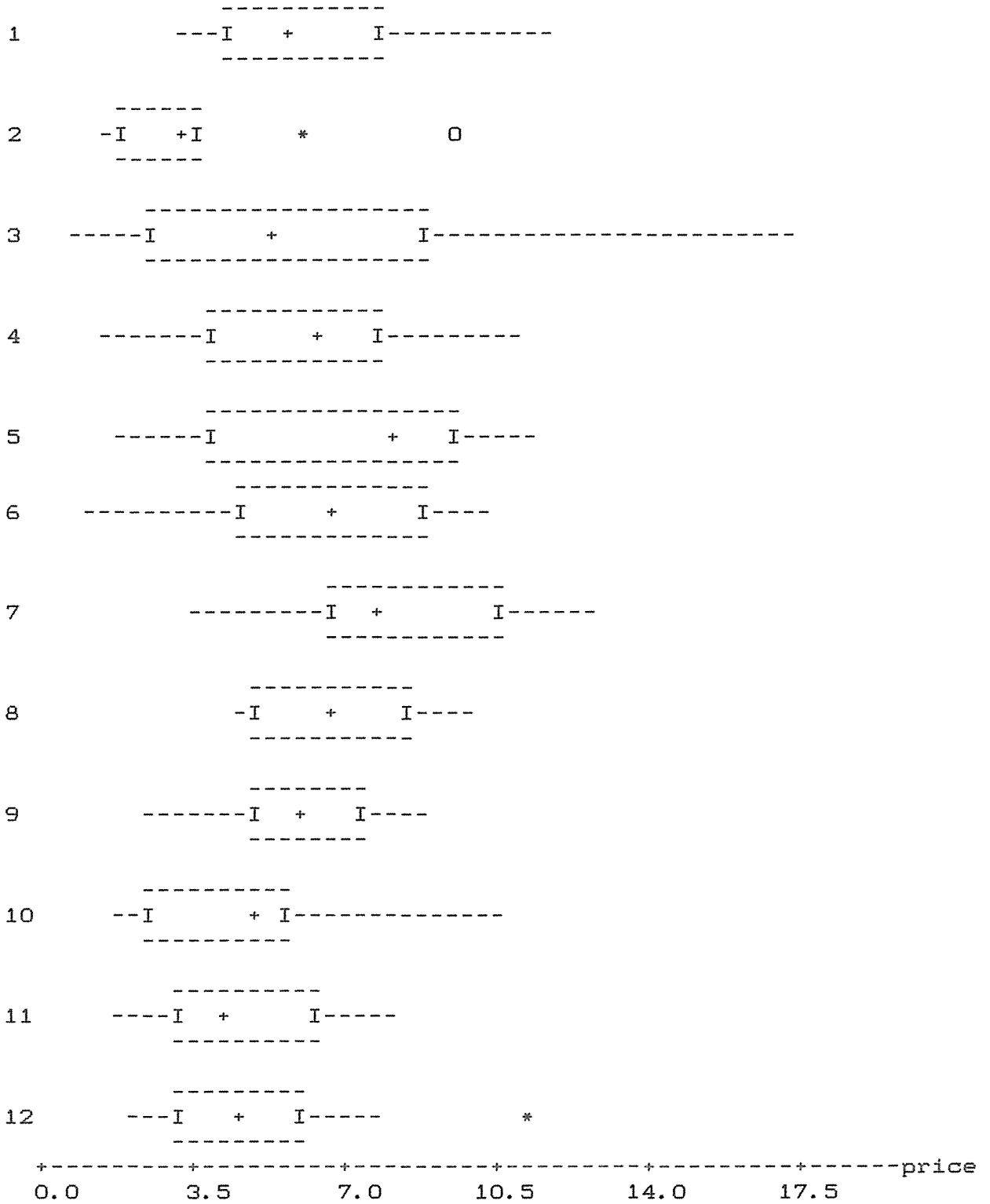
coefficient of variation

price	.50
volume	.36
turnover	.52

The boxplots which follow indicate that lettuces have only one season and that the "hiccup" in prices in January is within the range of prices in the surrounding months.

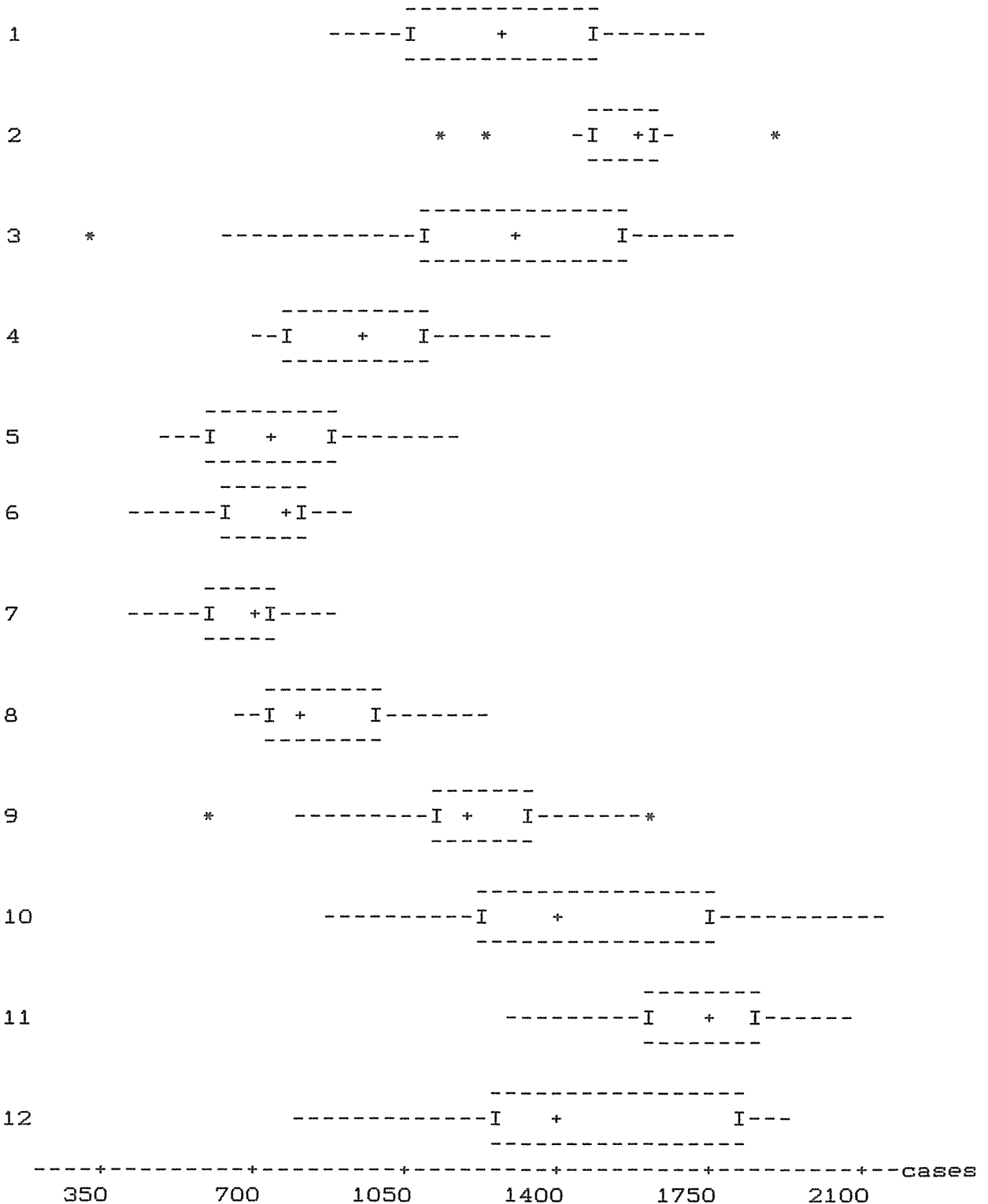
The boxplots indicate that lettuce prices were highest in the middle of winter and, in general, were lowest in the beginning and end of summer. The rise in price in January was a result of the decline in volume in January. This decline in volume was probably due to the climate.

Month



Overall, volumes were highest in October, November, December, and February. There was a fall in January but volumes were still in the range of the surrounding months. Volume was lowest in June and July. Turning points appear to have been in February and July.

Month



11 MUSHROOMS

Mushrooms are grown indoors in light and temperature controlled conditions. They are not subjected to seasonal weather variations.

Tannock (1914) notes that the main prerequisites for a successful crop are darkness and an even temperature. The length of time beds bear depends on the depth of the bed. Yield depends on humidity, temperature, and the goodness of the manure.

Cook (1979) comments that managerial ability plays a large role in determining yield. He found significant relationships between yield per unit area of bed cropped and (1) quantity of compost per unit area of bed cropped, and (2) spawning rate per unit area cropped. He noted that in Ireland, the number of crops per year varied from one to five crops.

Clearly mushrooms are subject to uncertainties regarding yields, which is probably due to different crop management practices and levels of management ability.

According to Lorenz and Maynard (1980) mushrooms have a short storage life, of about three to four days.

1 The expected behaviour of prices

Mushrooms are not directly influenced by weather conditions. Input costs probably increase in winter when the costs of maintaining the artificial climate are higher. We would expect prices and volumes to be relatively constant throughout the year.

Any systematic fluctuations in price may be due to demand fluctuations. For instance, demand in summer for use as a salad vegetable may be higher than in winter. With a relatively constant supply this would cause price to rise.

Their short storage life implies that small quantities are probably brought often and it would not be expected that volume demanded would fluctuate much.

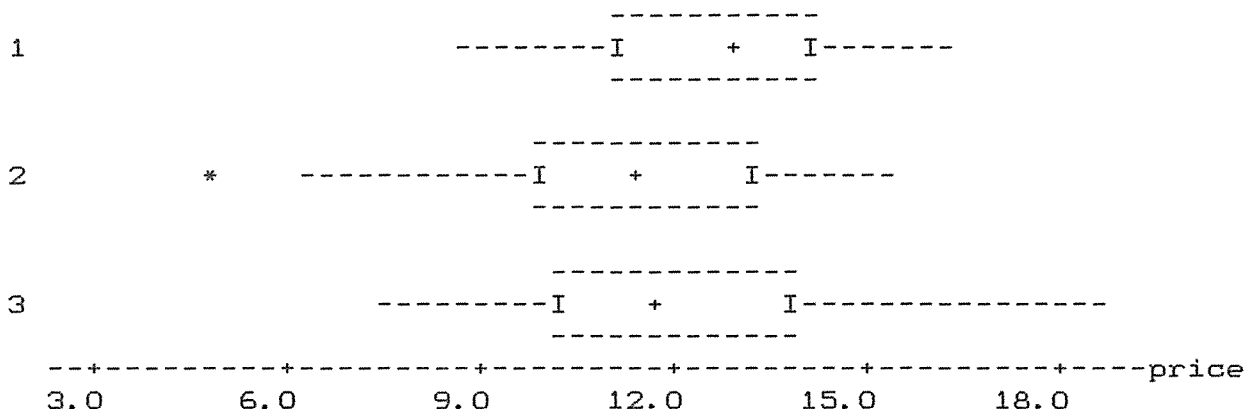
2 The behaviour of mushrooms at auction

Mushrooms were supplied for the full period under study.

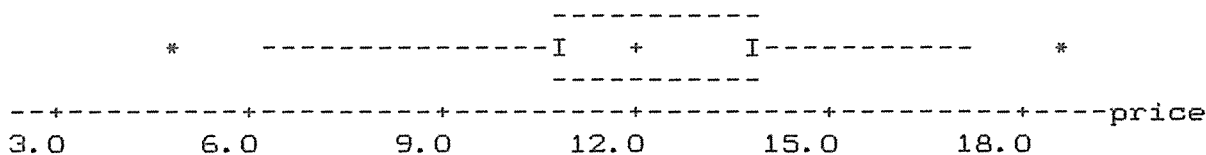
The weekly average price fell in year 2 by about 13% and then increased by about 7% in year 3. See table 13.

Median price fell in year 2 and then rose slightly in year 3. The variation in weekly price was higher in year 3 than in the other two years.

Year



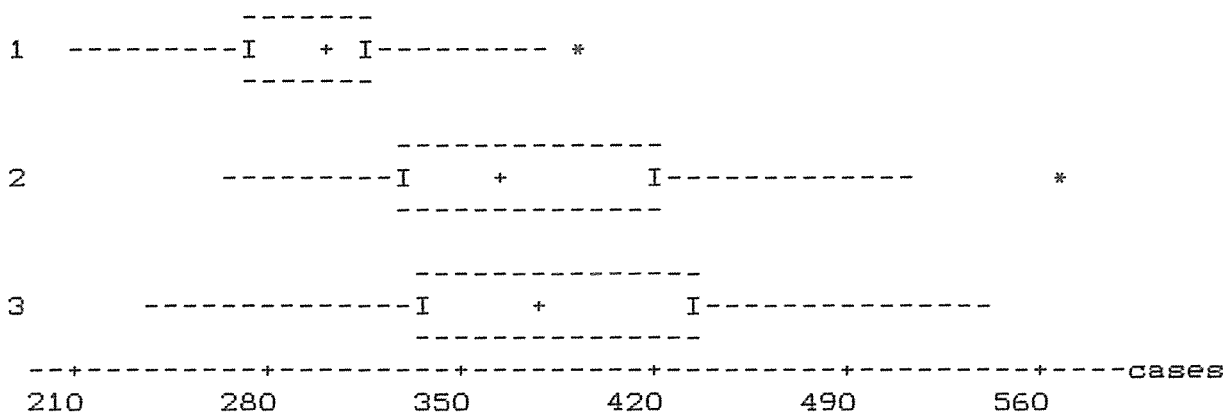
For the entire series price was reasonably symmetric about a median of \$12.04, with a low of \$4.94, and a high of \$18.51.



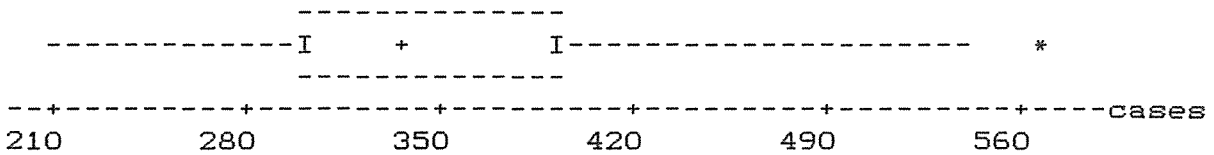
Annual volume increased by about 25% in year 2 and by about 2% in year 3. See table 14.

Median weekly volume has risen, and there was more variation in weekly volume in year 3 than in years 1 and 2. The considerable increase in volume in year 2 resulted in about a 13% price drop for that year.

Year



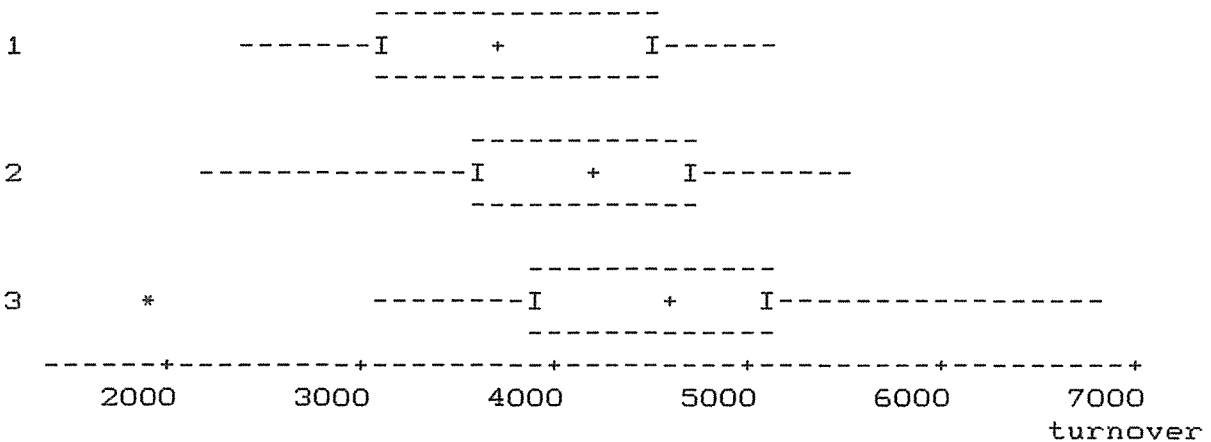
For the entire series weekly volume was right skewed about a median of 337 cases. Minimum weekly volume was 210 cases and the maximum weekly volume for this period was 568 cases.



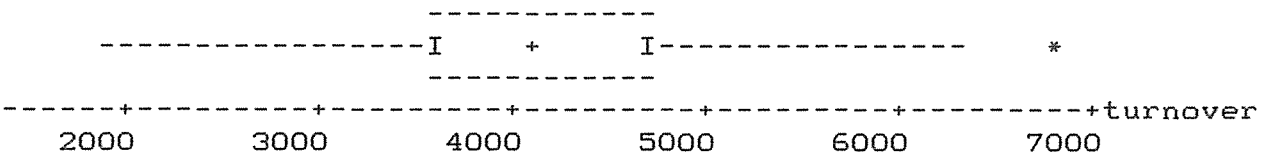
Annual turnover increased by about 7% in year 2 and increased by about 11% in year 3. See table 15.

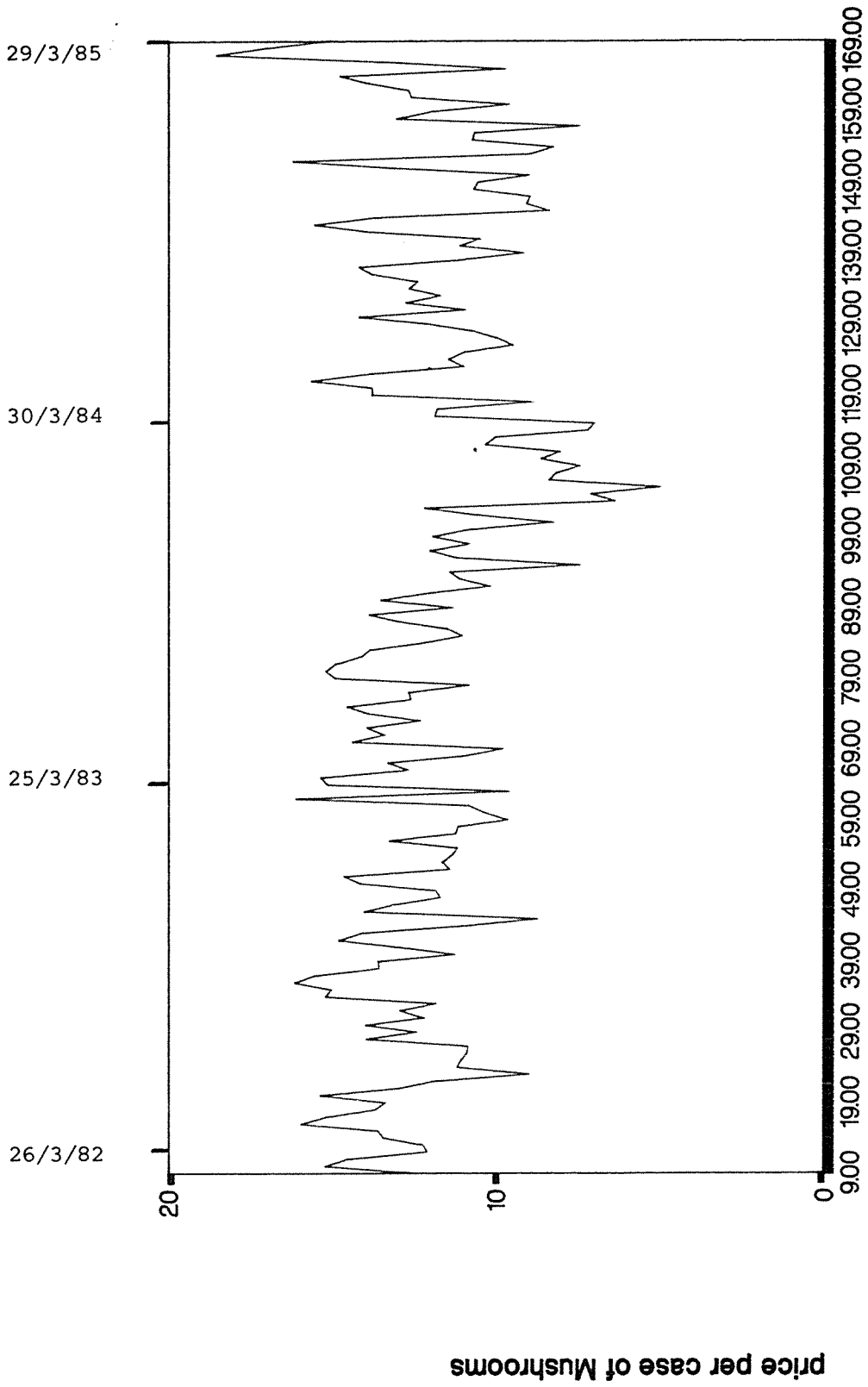
Median weekly turnover increased steadily in each year.

Year

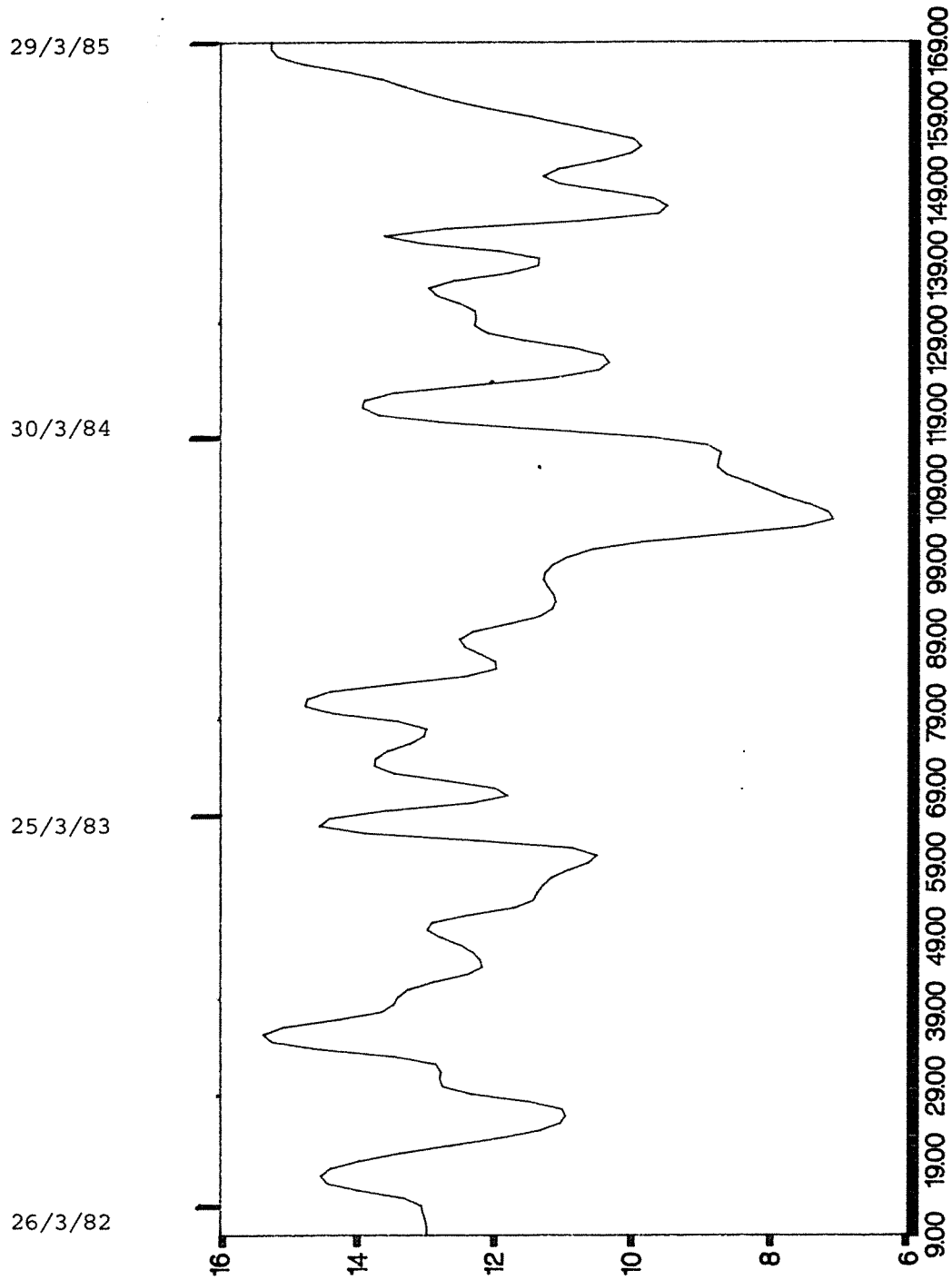


For the entire series weekly turnover was quite symmetrically distributed about a median of \$4113.00, and ranged from \$1886.00 to \$6773.00.





week rank from 1.182 to 29.3.85



week rank in period 1-1-82 to 29-3-85

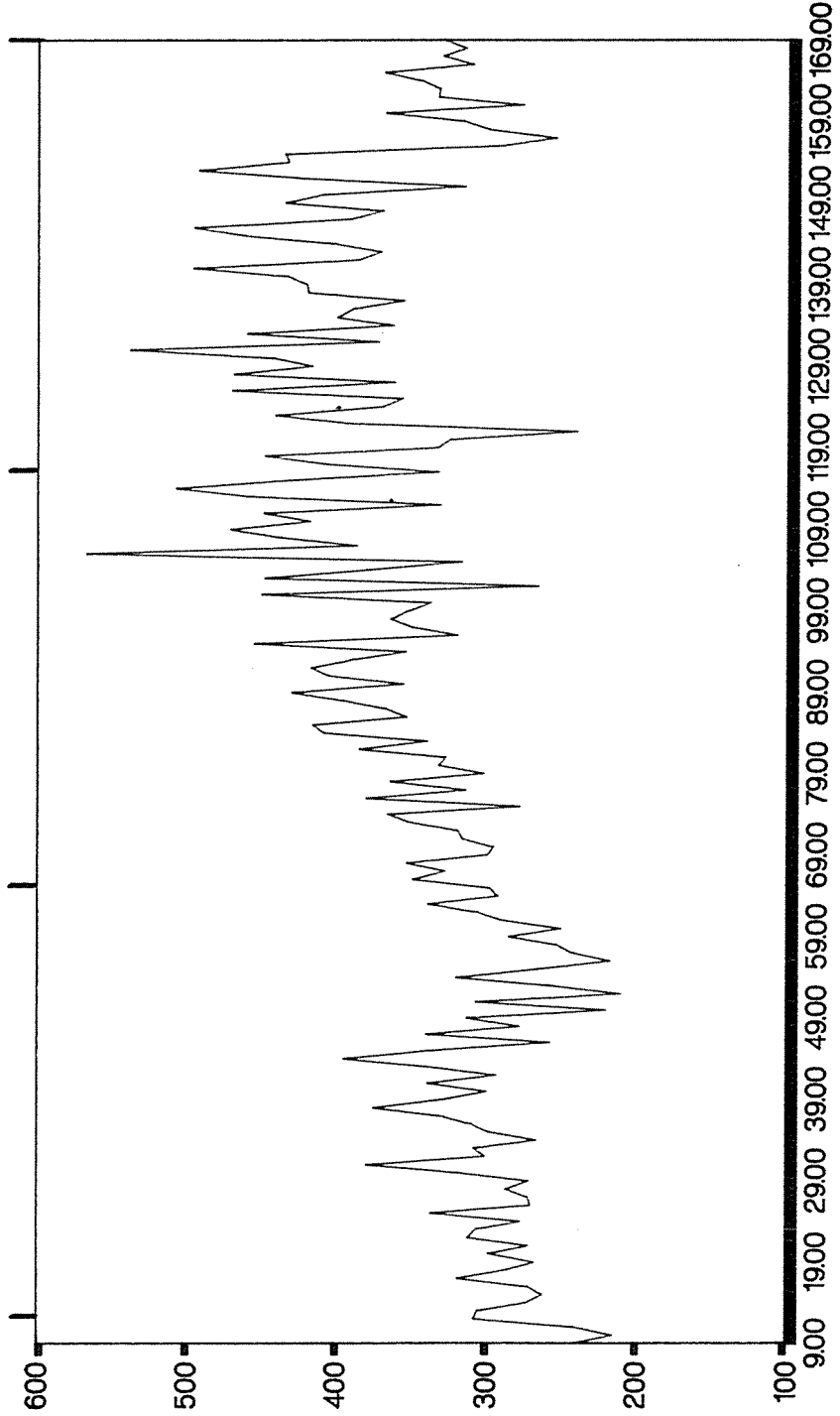
smoothed price of mushrooms

29/3/85

30/3/84

25/3/83

26/3/82



Cases sold Mushrooms

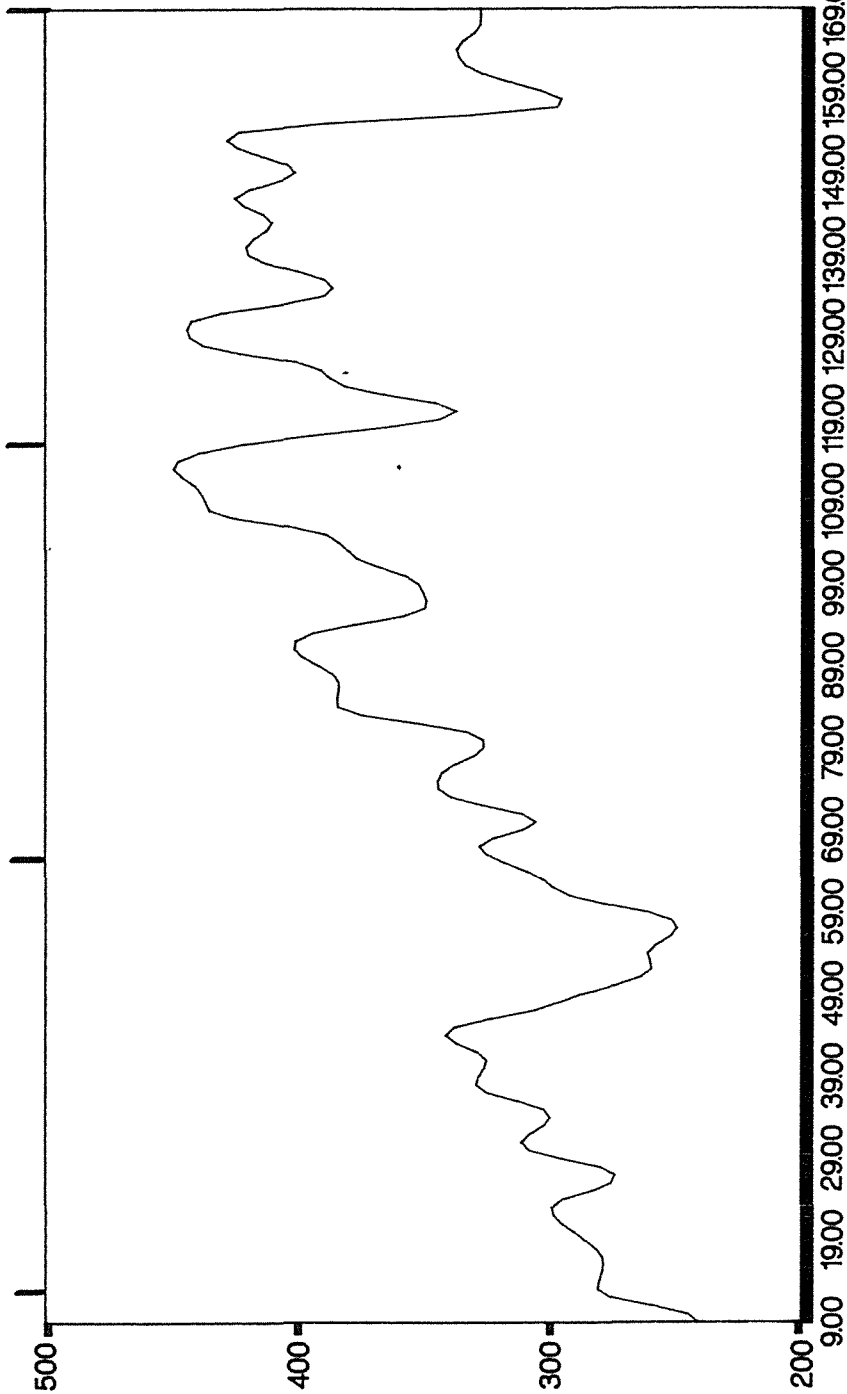
week rank from 1.182 to 29.385

29/3/85

30/3/84

25/3/83

26/3/82



9.00 19.00 29.00 39.00 49.00 59.00 69.00 79.00 89.00 99.00 109.00 119.00 129.00 139.00 149.00 159.00 169.00

smoothed volume of mushrooms

week rank in period 1-1-82 to 29-3-85

For a protected crop mushrooms exhibit quite surprising price variation but no clear pattern is detectable. From the smoothed price plots there seem to be four seasons in each year and these are not constant in duration or temporal position.

There is some consistency in that prices are highest in March, April/May, July, September and November. These are times of relatively low volumes.

High prices often did not correspond to times of low supply.

It is also very difficult to determine a constant pattern in the volume series. In general quantities have increased in successive years. August and September seem to be times of relatively high supply, as do February and March, and to a lesser degree June. The volume series indicates a positive trend and appears to be cyclical.

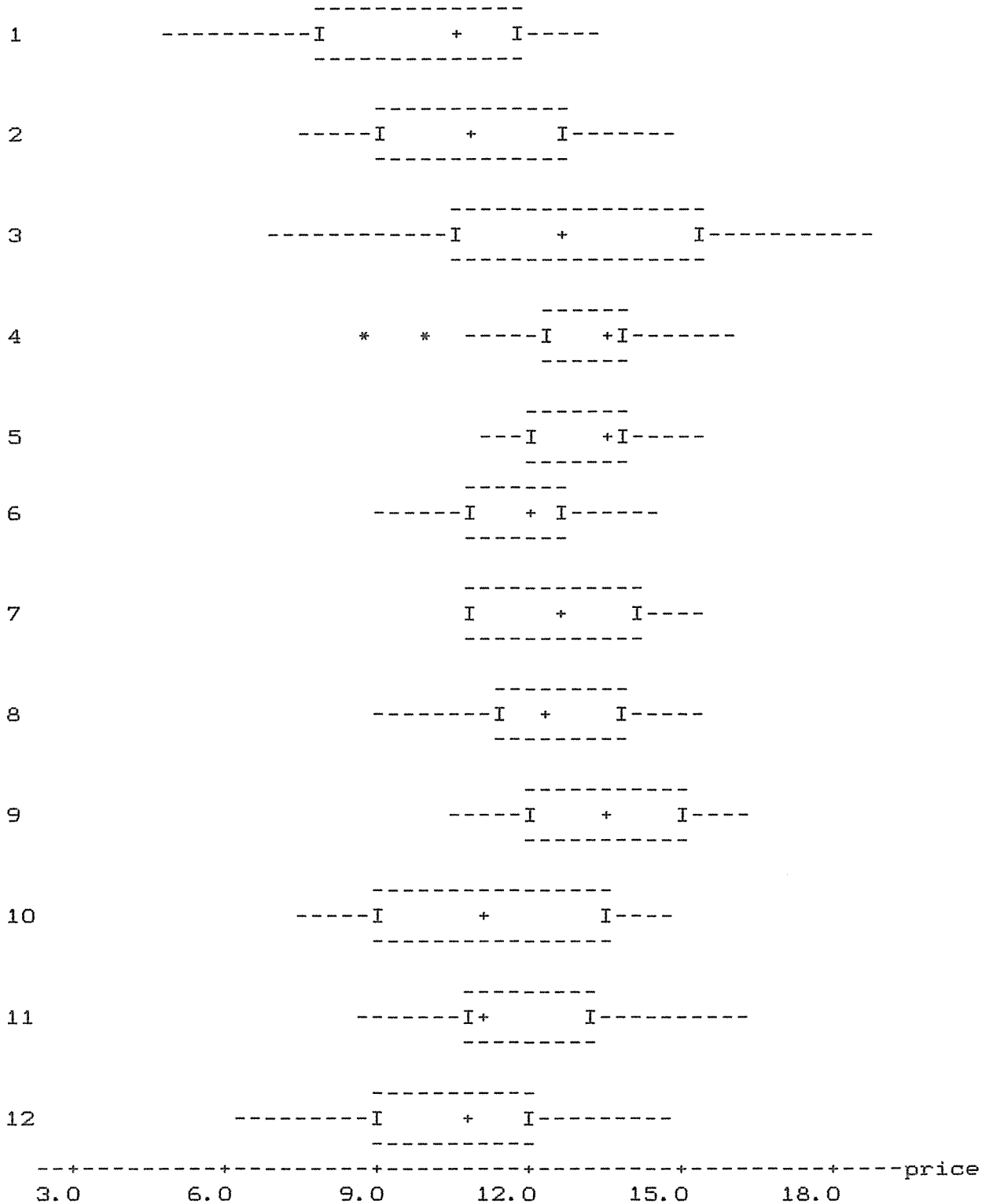
Mushroom prices have behaved rather erratically though both prices and volumes have not varied about the mean price and mean volume greatly.

coefficient of variation

price	.20
volume	.20
turnover	.21

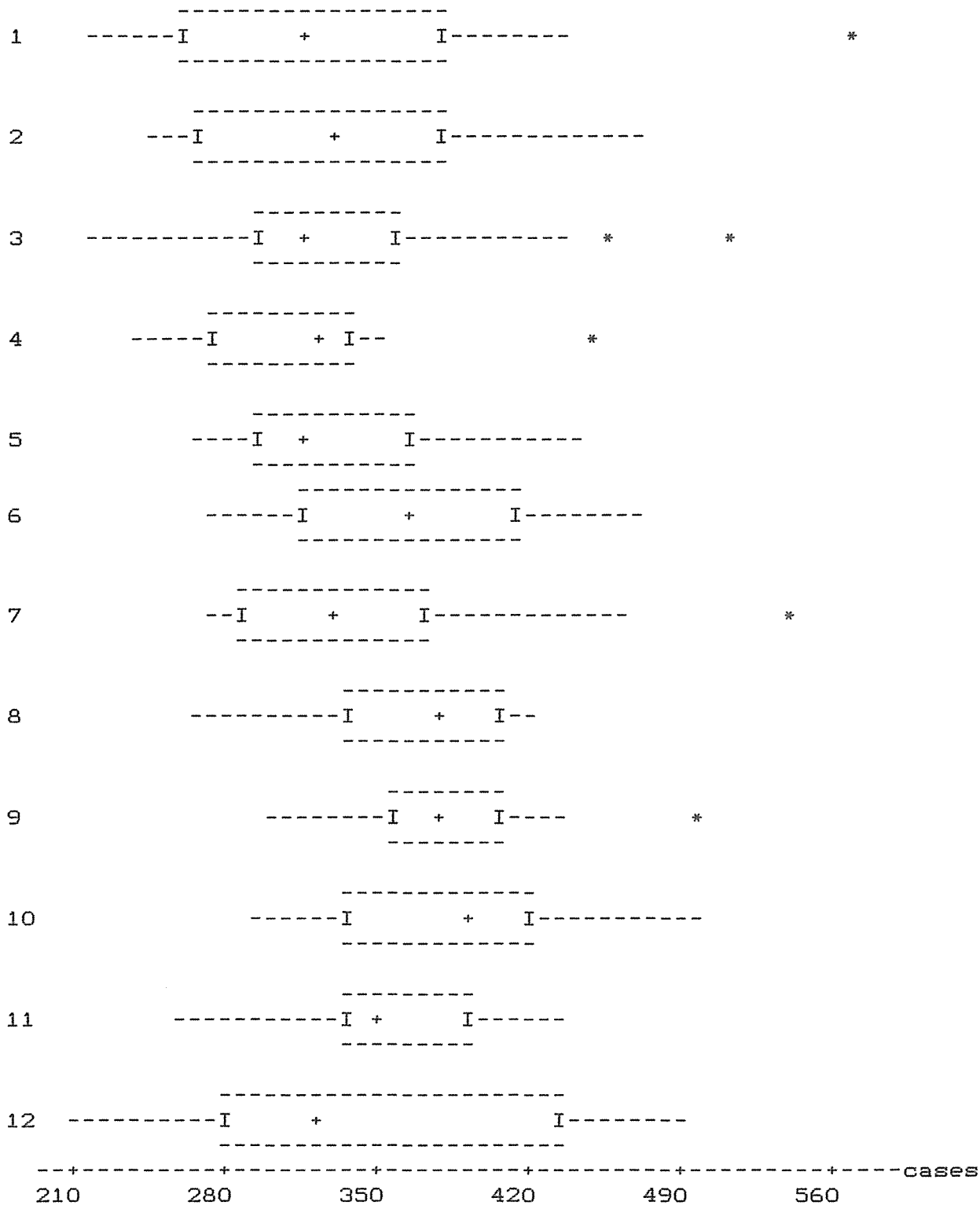
The boxplots below indicate that mushroom prices were reasonably constant in autumn and winter. They fell in the spring and increased at the end of summer. It may be that there is a demand season and that prices have been lowest in summer and highest in winter.

Month



Volume was lowest from December to May, and highest from June to November. Turning points appear to have been in May and October. The volume series suggests that there is one season in a year.

Month



12 ONIONS

The Yates seed catalogue describes the many different varieties as having either early or medium maturity and as having different storage lengths. Maturity is reached in 170 to 200 days depending on the variety.

Different varieties can be planted at different times of the year to extend the season.

Thompson and Kelly (1957) comment that onions are hardy, and that growth is affected by photoperiod.

Ballinger (1980) notes that onion growth depends on day length and writes that onion development must be completed by the longest day.

Various researchers cited by Thompson and Kelly have found that bulb formation depends on high temperature and long day length.

Onions are cured for storage by allowing them to dry. Thompson and Kelly assert that successful storage requires "thorough ventilation, uniform comparatively low temperature, dry atmosphere, and protection against actual freezing." They also point out that if left in the ground too long, onions will develop roots, which reduces their market value.

The time to sow onions varies from the middle of June to August, depending on the region. Sowing can be done earlier in the north and later in the south. "Early cultivars ... are sown even earlier from the end of January and planted out in March or April so that mature bulbs are ready by December", Ballinger (op cit).

Carson (1985) notes that onions require a large investment in sowing and harvesting machinery and storage facilities.

1 The expected behaviour of prices

Onions can be stored for long periods so we would expect relatively constant volumes for a large part of the year. Likewise prices could be expected to be relatively constant for a large part of the year. At the time of harvest of main crops, in about February and March, we would expect large volumes to be available, especially since storage is limited. At this time prices should be lowest.

Prices would be expected to rise slowly but steadily as markets were supplied out of storage.

Prices would perhaps peak at the end of the storage period. This would occur because not only are onions becoming more scarce but presumably stocks will be reduced by onions which have not stored well.

In general, we would expect volumes to be higher in summer than in winter and prices to be higher in winter than in summer.

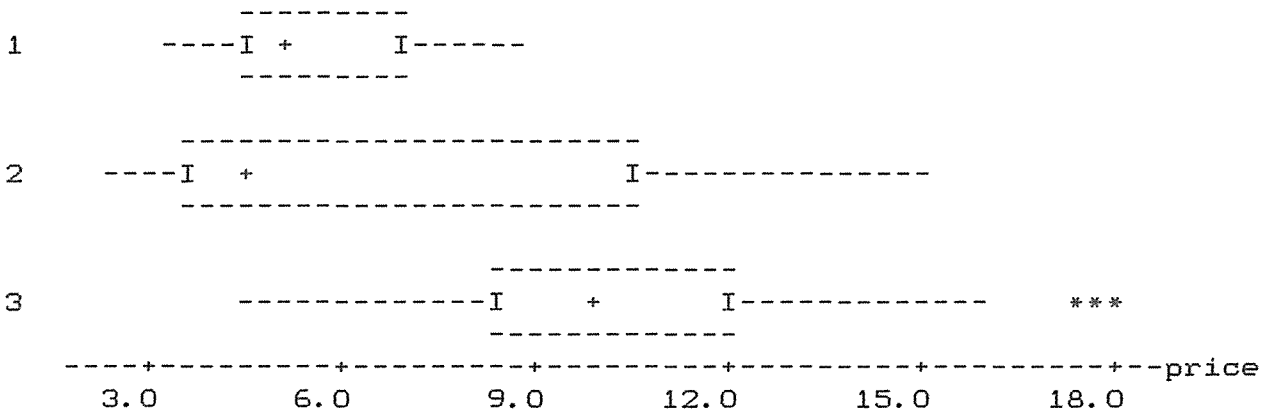
2 The behaviour of onions at auction

Onions were supplied continuously throughout the period under review.

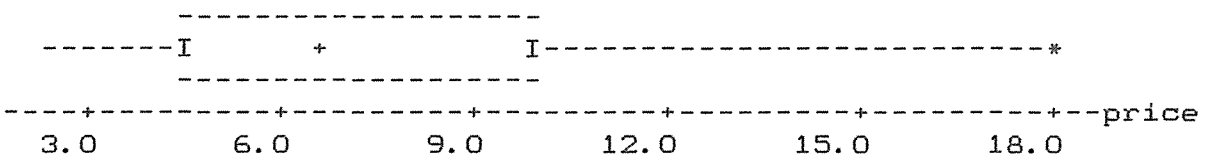
Mean onion prices rose by about 20% in year 2 and by about 50% in year 3. See table 13.

Median price has risen considerably with the variation in prices increasing also. In year 2 over half of the prices received were very low.

Year



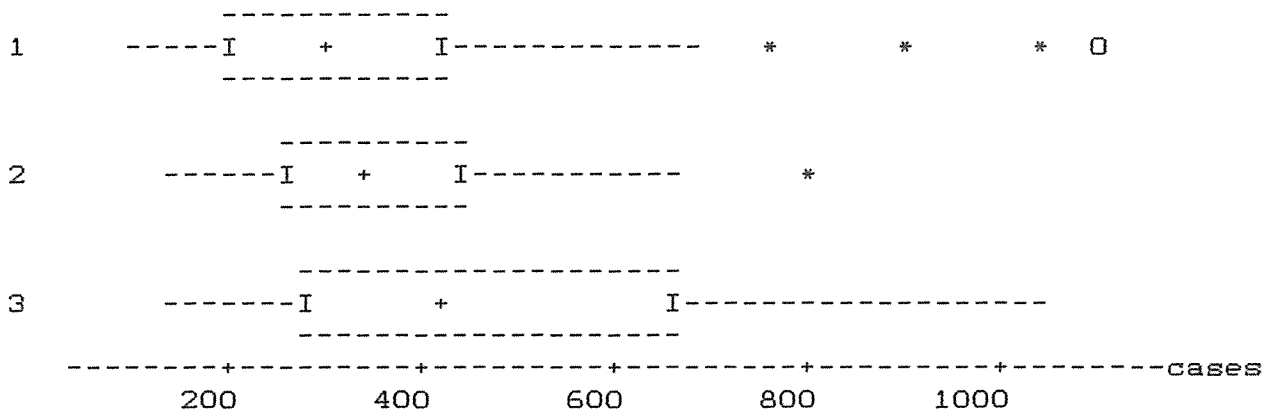
For the entire series, onion prices were right skewed about a median of \$6.74, with a minimum price of \$2.44, and a maximum price of \$18.04.



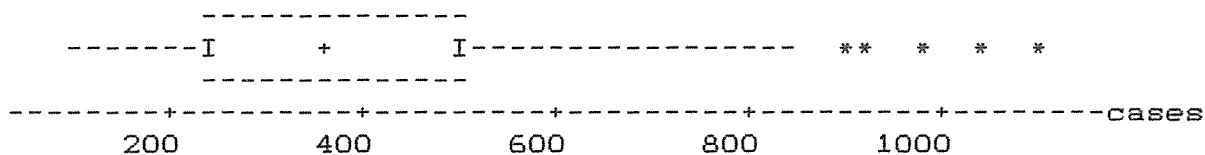
Volume fell by less than 1% in year two and then rose by nearly 34% in year 3. See table 14.

Median weekly volume rose in each successive year, and the range of values has become larger. More "normal" variation in weekly cases can be seen in year 3 than for years 1 and 2.

Year



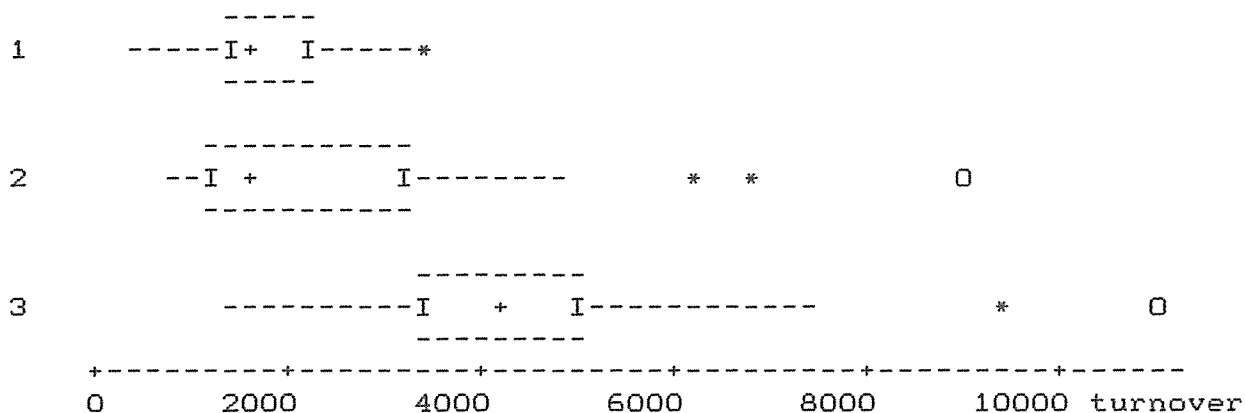
For the entire series volume was right skewed about a median of 360 cases. The minimum volume was 92 cases and the maximum 1106.



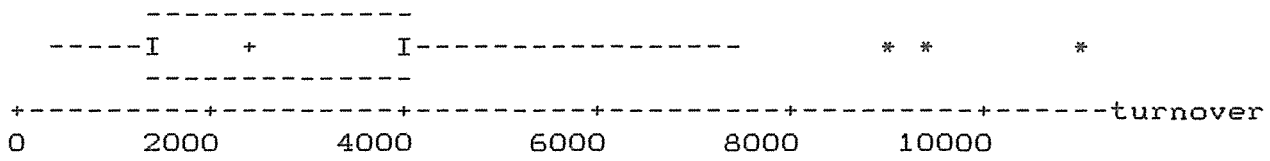
Yearly turnover increased by about 29% in year 2. This was followed by a 92% increase in turnover in year 3. See table 15.

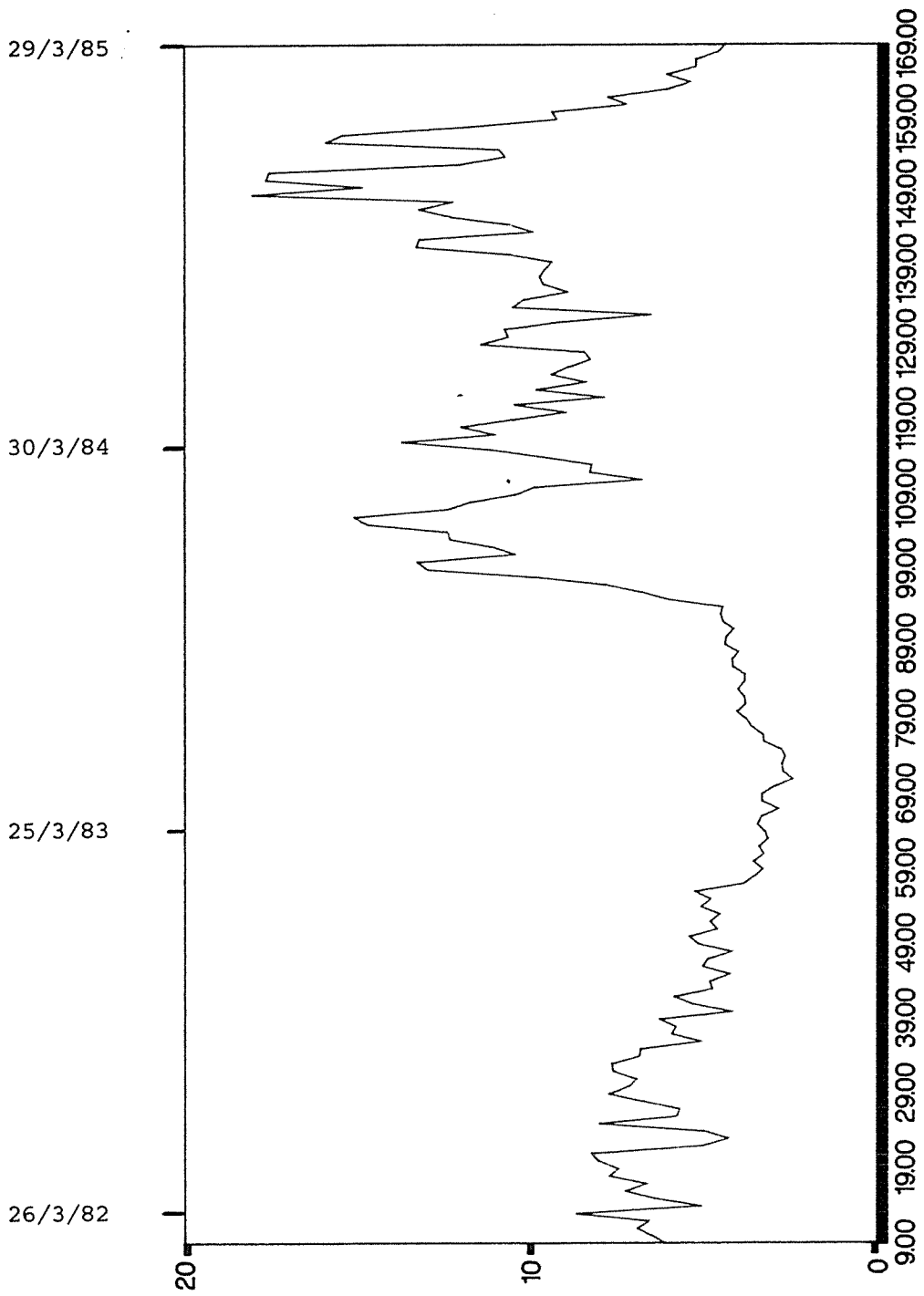
For years 1 and 2 median weekly turnover remained about the same and was followed by a large increase in year 3.

Year



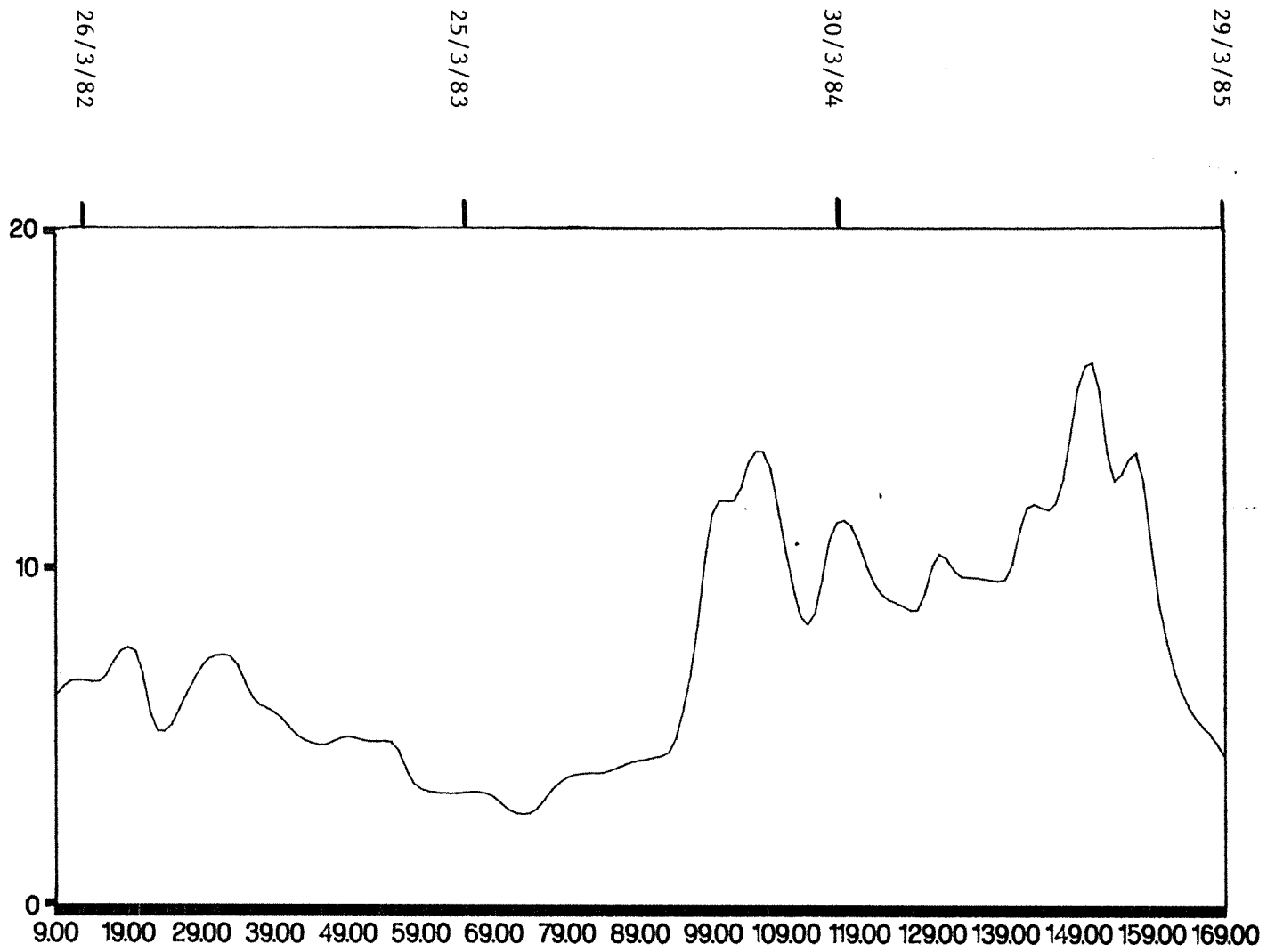
For the entire series turnover was right skewed about a median of \$2335. Minimum and maximum turnover were \$444 and \$11086 respectively.



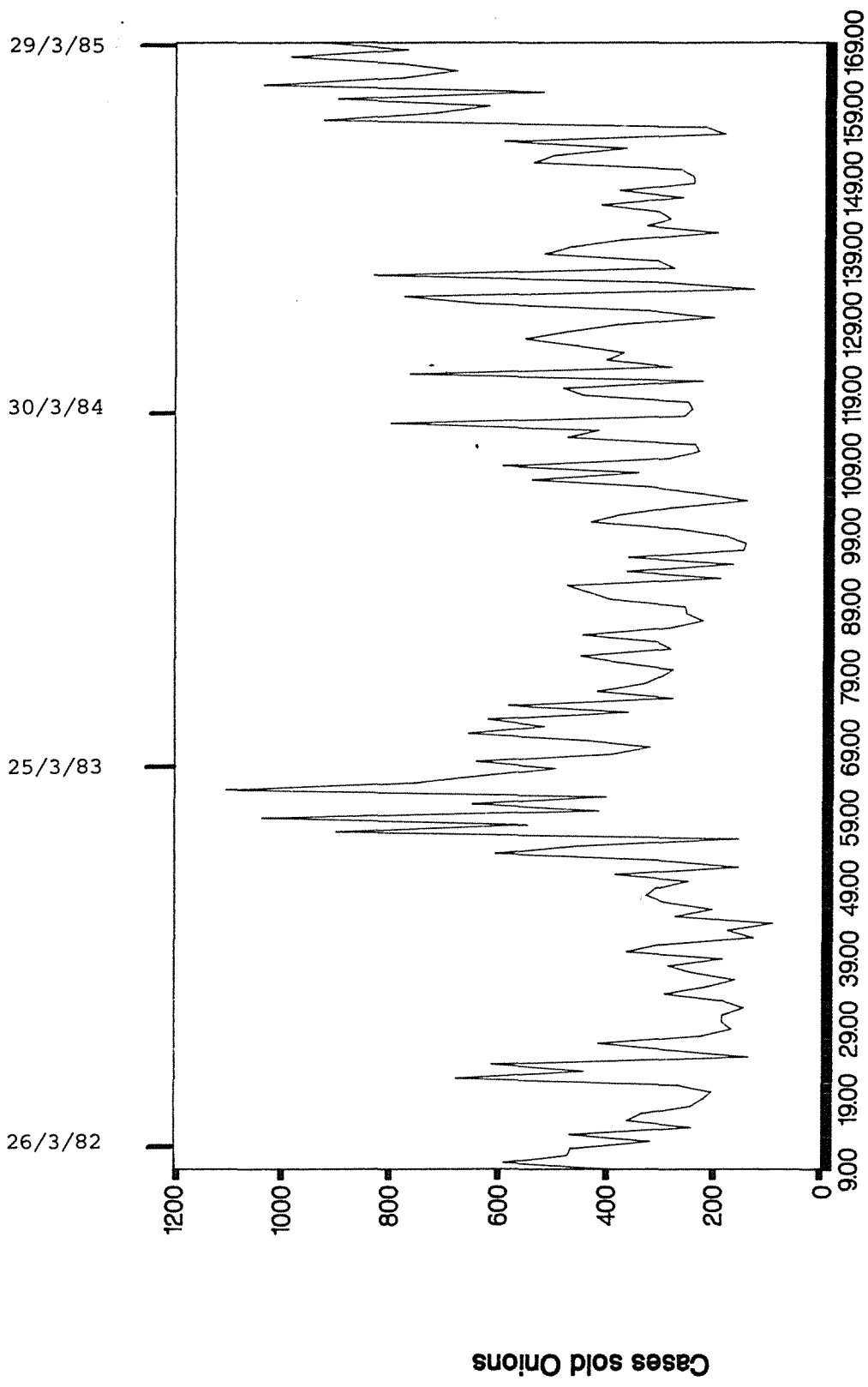


week rank from 1.1.82 to 29.3.85

smoothed price of onions

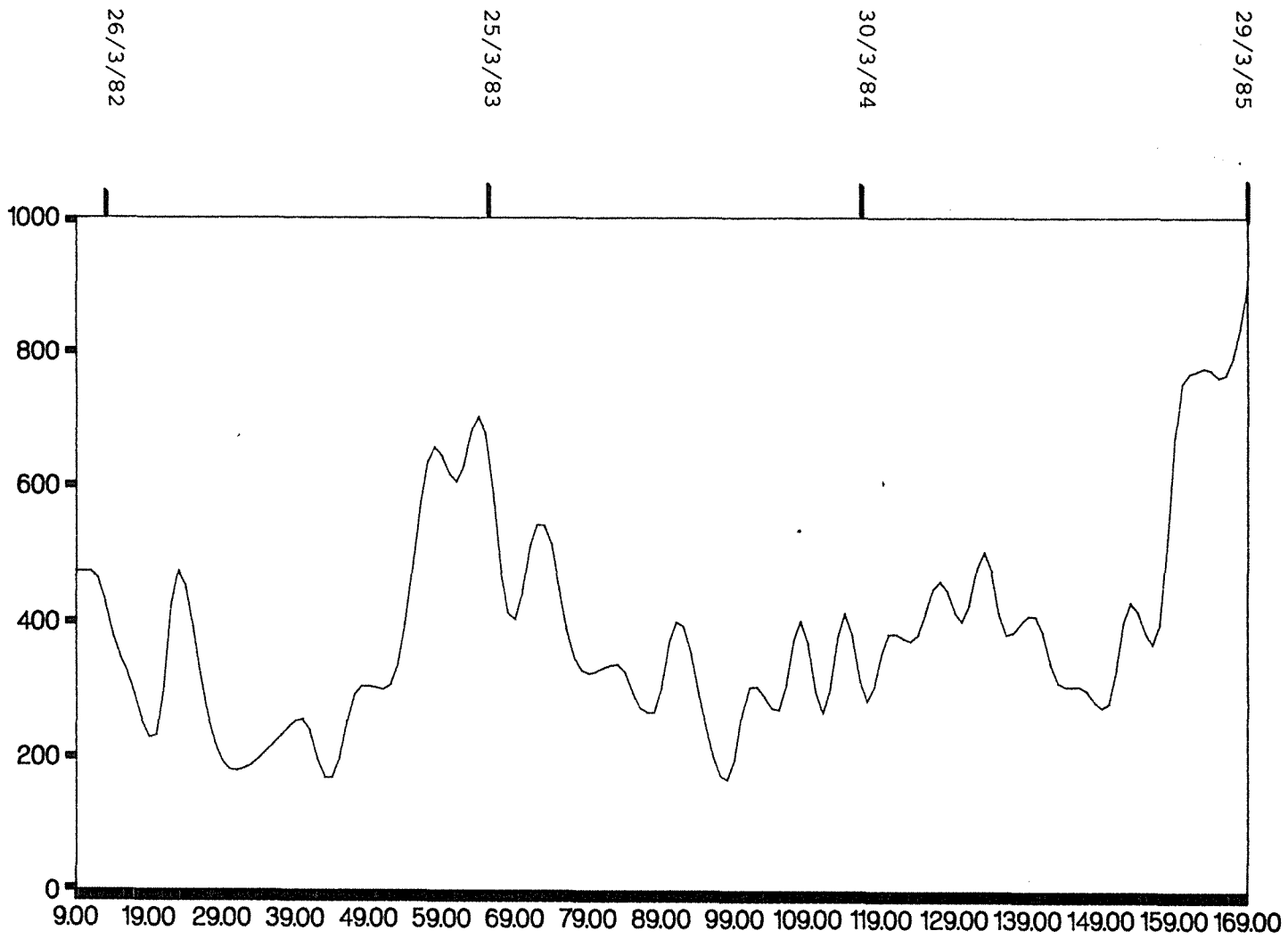


week rank in period 1-1-82 to 29-3-85



week rank from 1.182 to 29.3.85

smoothed volume of onions



week rank in period 1-1-82 to 29-3-85

The variance in price was less for the first half of the series than the second half.

The smoothed price series is quite flat in year 1 with a mild peak in mid May followed by a mild trough in early June. Prices began rising quite steeply in mid October 1983 reaching a peak at the beginning of January 1984. Prices fell shortly after rising to another lower peak in late March. The next major peak was reached in mid November 1984. Prices peaked again at the beginning of January 1985, and then fell steeply.

The onions price series exhibits periods of constant prices, probably due to the fact that onions are a stored commodity.

The smoothed series may be indicating cyclical behaviour in onion prices and volumes with about a two year cycle. Unfortunately the series is too short to be certain of this.

At times the same volume fetched very different prices.

For the three years volume was slightly more variable than price.

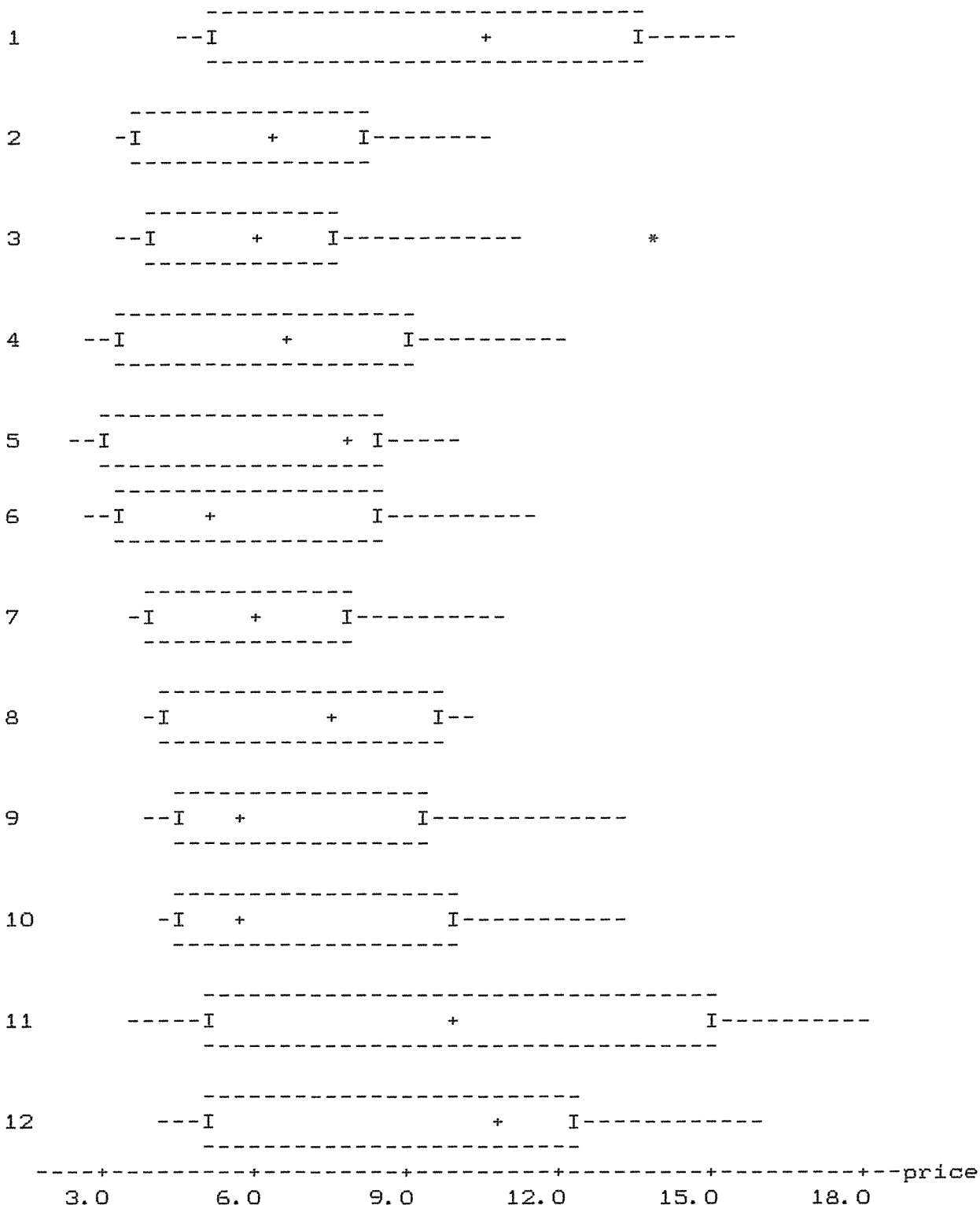
Coefficient of variation

Price	.48
volume	.53
turnover	.65

The following boxplots indicate one price season for onions, which is what would be expected given that it is an annual.

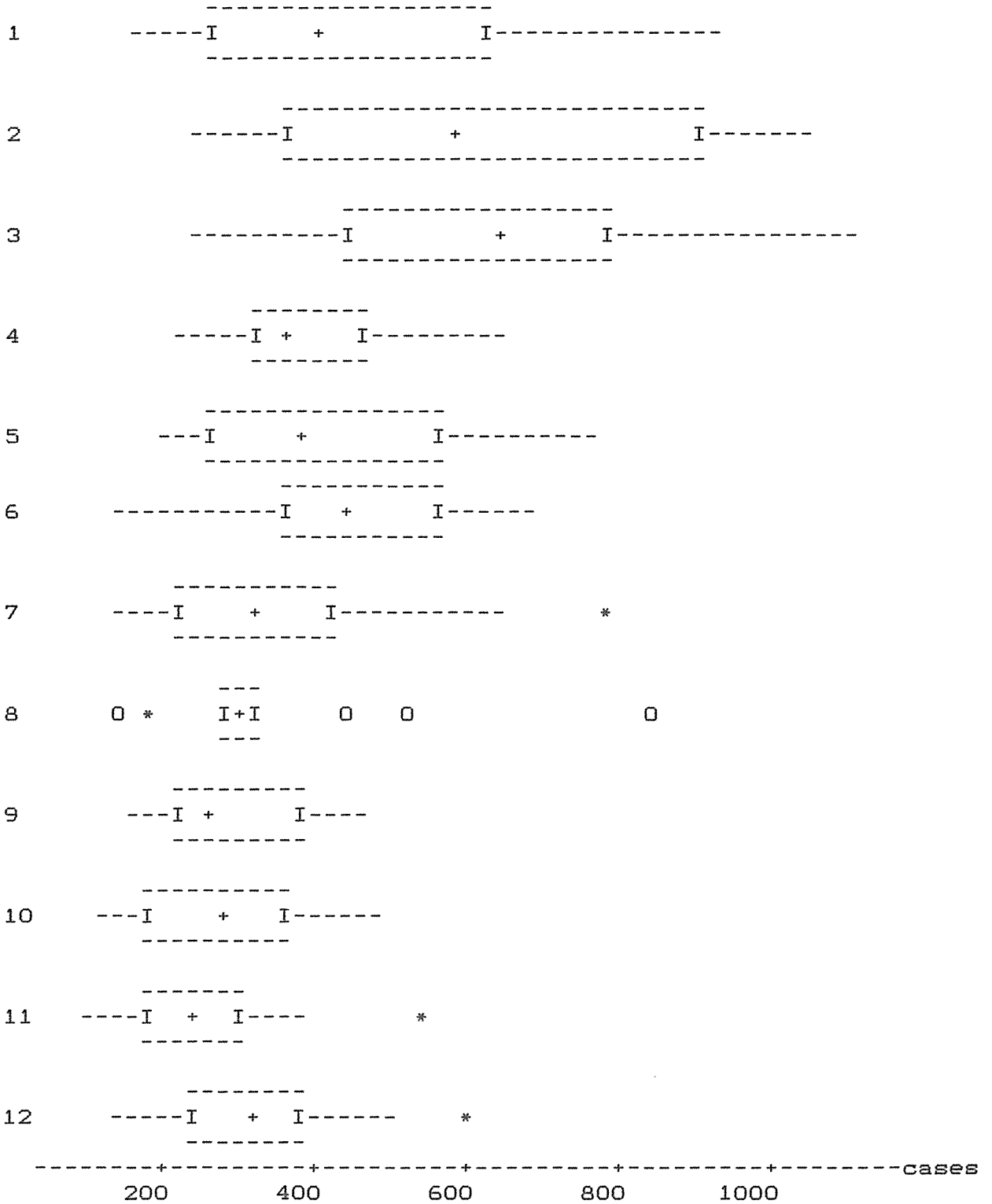
During the year onion prices were in general lowest in February, March, April, May, and June. Prices increased in July and were highest in November, December, and January.

Month



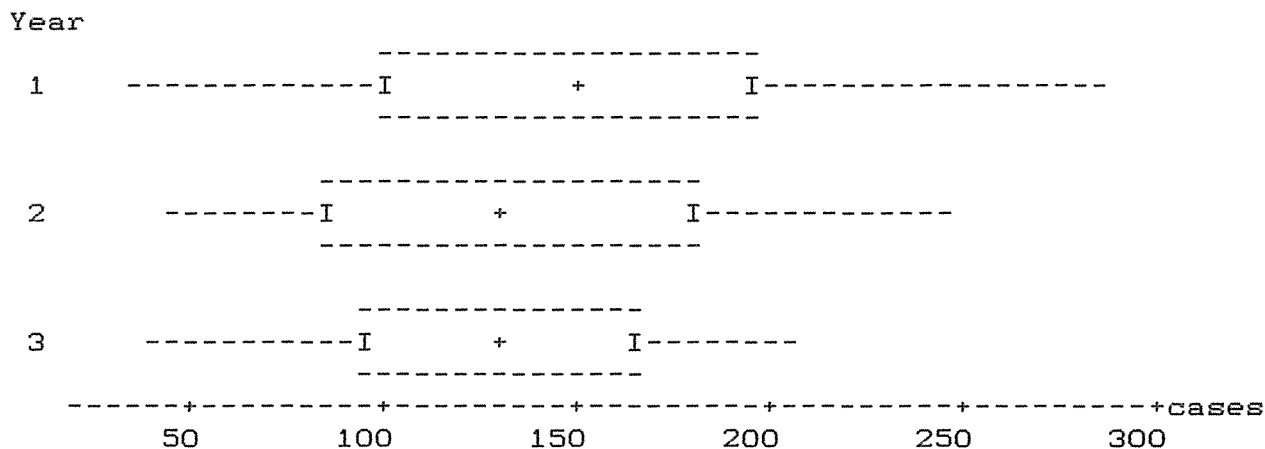
Volume peaked in February and March and then fell steadily to be lowest in November. Volume began rising again in December.

Month

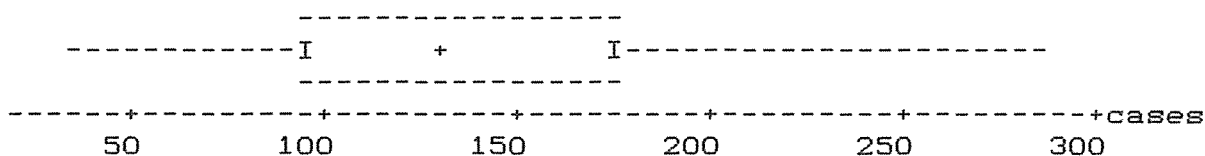


Volume decreased in each year. Year 2 volume was about 13% lower than year 1 volume and year 3 volume was about 1% lower than year 2 volume. See table 14.

Median weekly volume declined in year 2 and stayed at the year 2 level in year 3. The range of volume has declined.

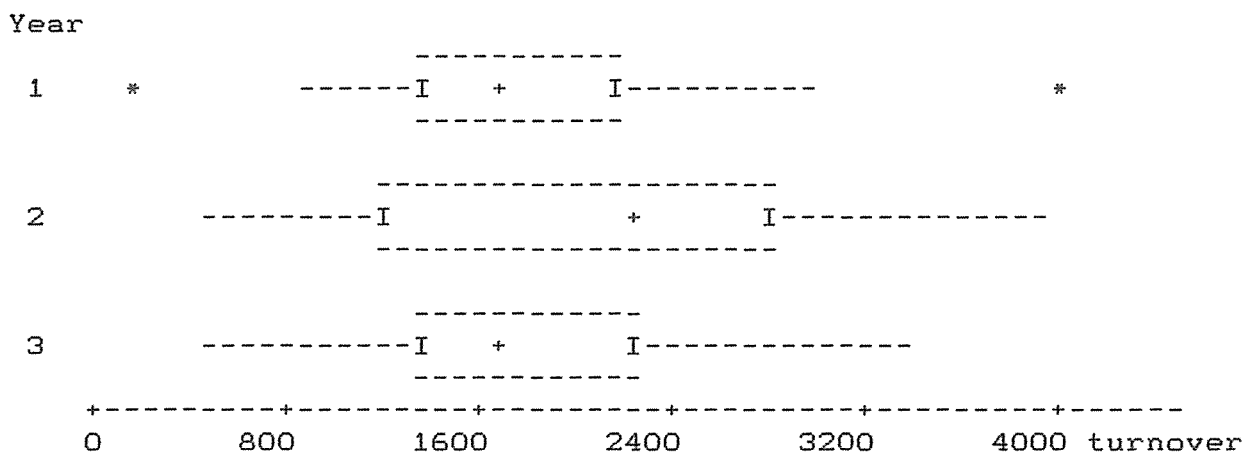


For the entire series weekly volume was right skewed about a median of 131 cases. The lowest weekly volume was 36 cases, and the highest 287 cases.

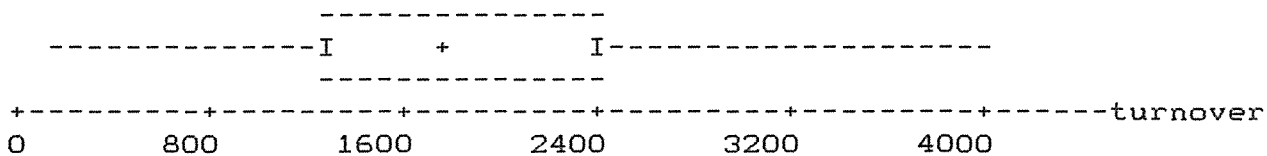


Turnover was 12% higher in year 2 than in year 1 and about 15% lower in year 3 than in year 2. See table 15.

Median weekly turnover rose in year 2 and then fell back to about the same level as year 1 in year 3.



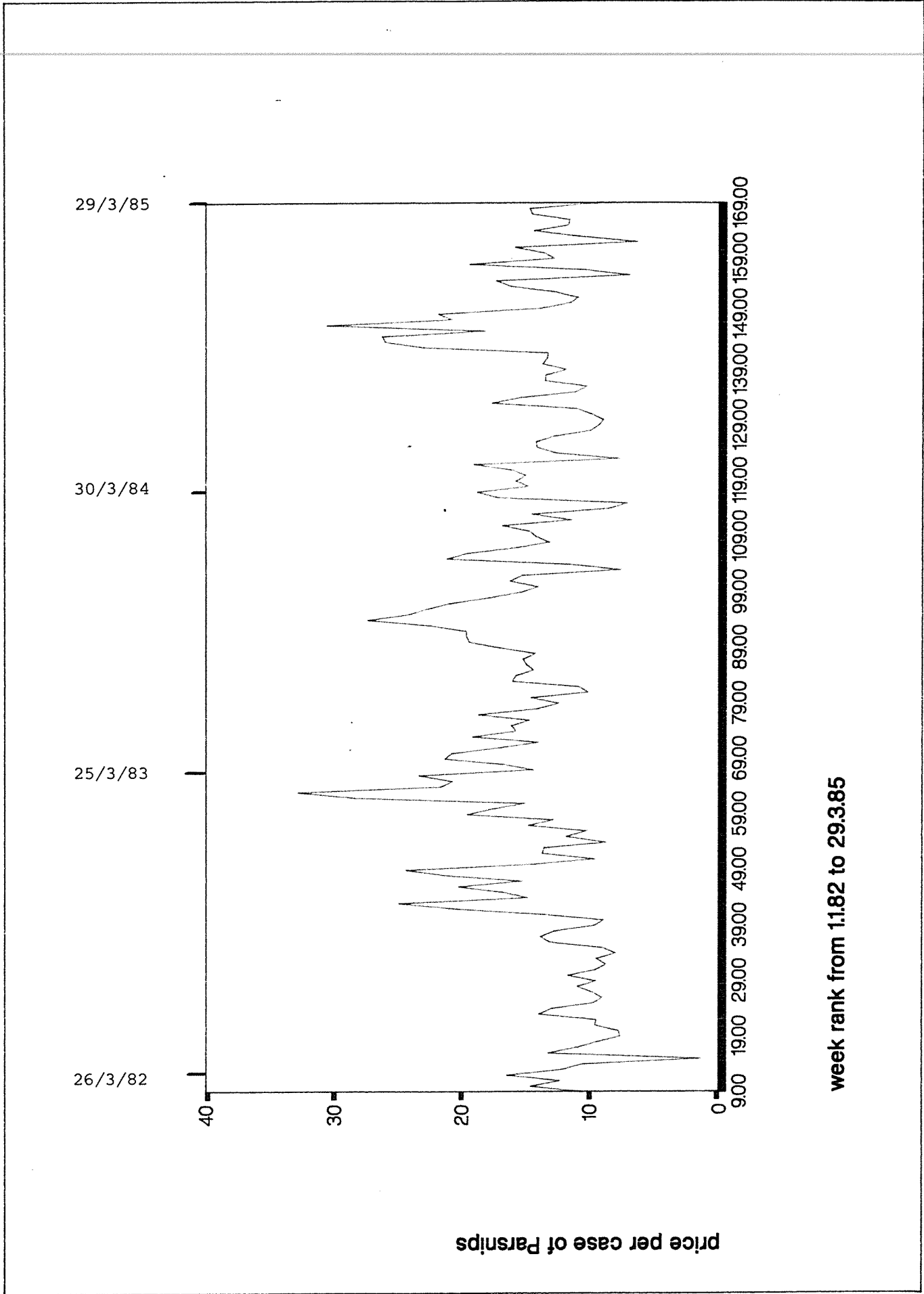
For the entire series weekly turnover was quite symmetrically distributed about a median of \$1766. The lowest weekly turnover was \$129, and the highest was \$4021.



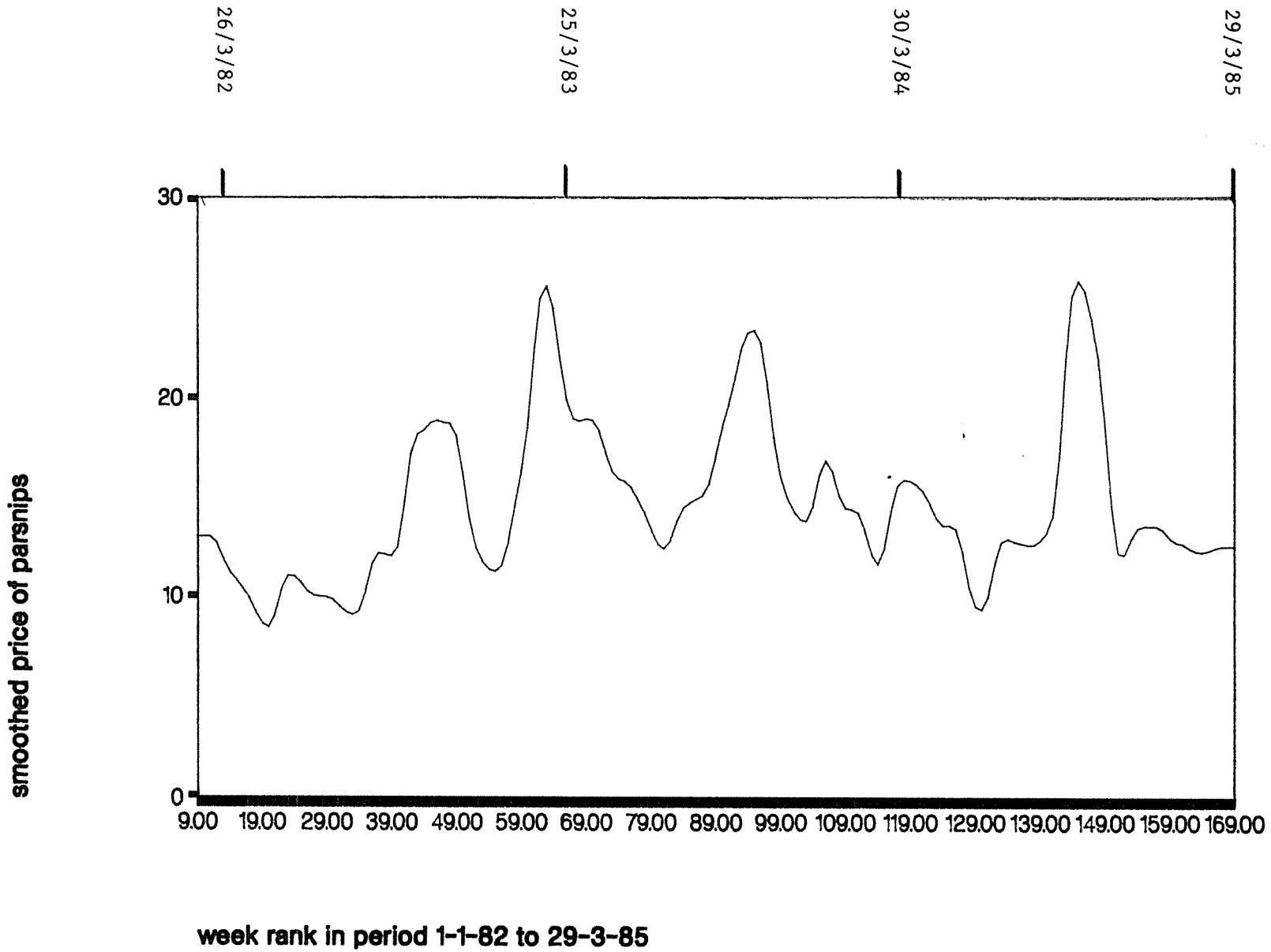
Volume was more variable than price for the three years under study.

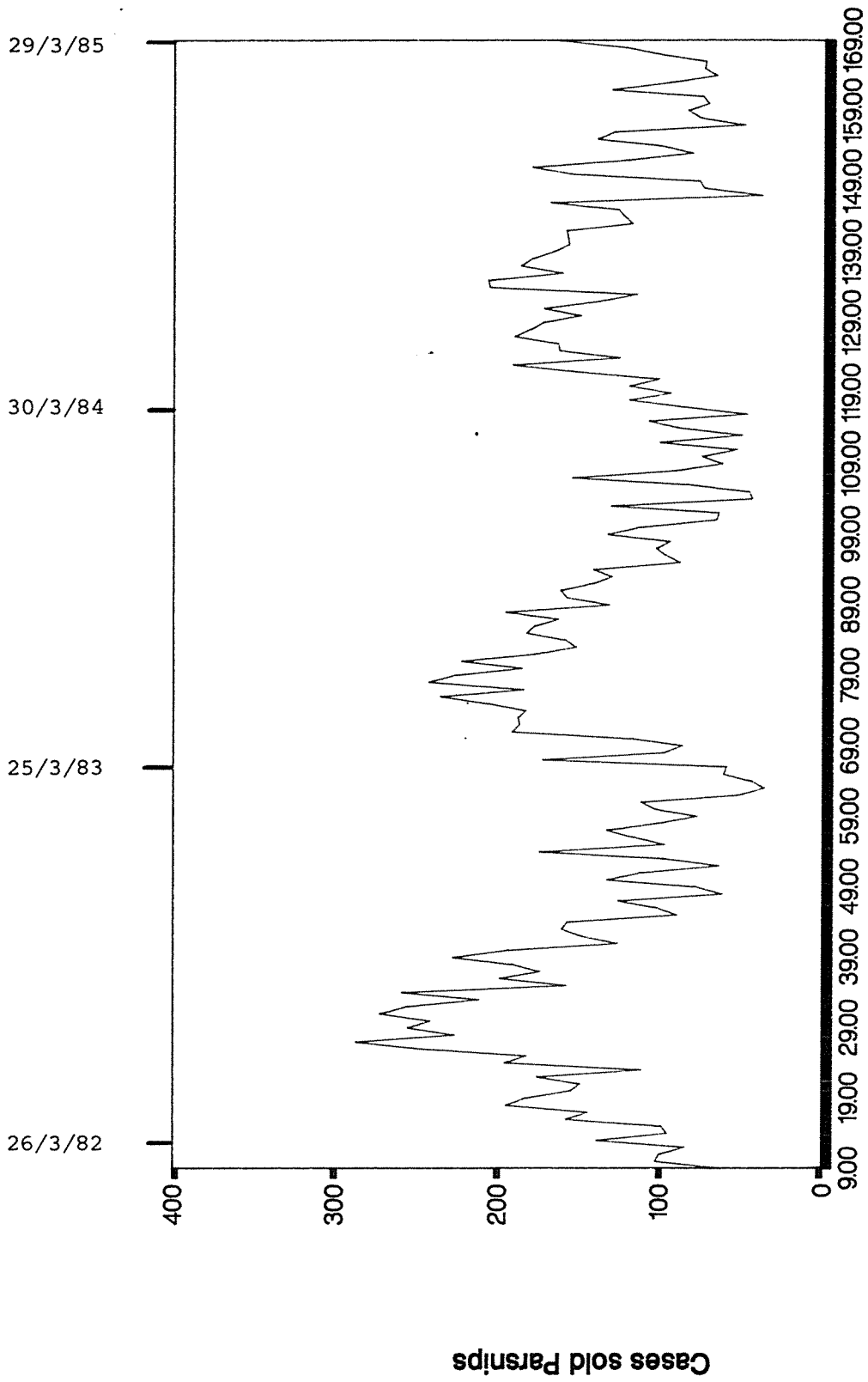
coefficient of variation

price	.34
volume	.41
turnover	.41



week rank from 1.182 to 29.3.85





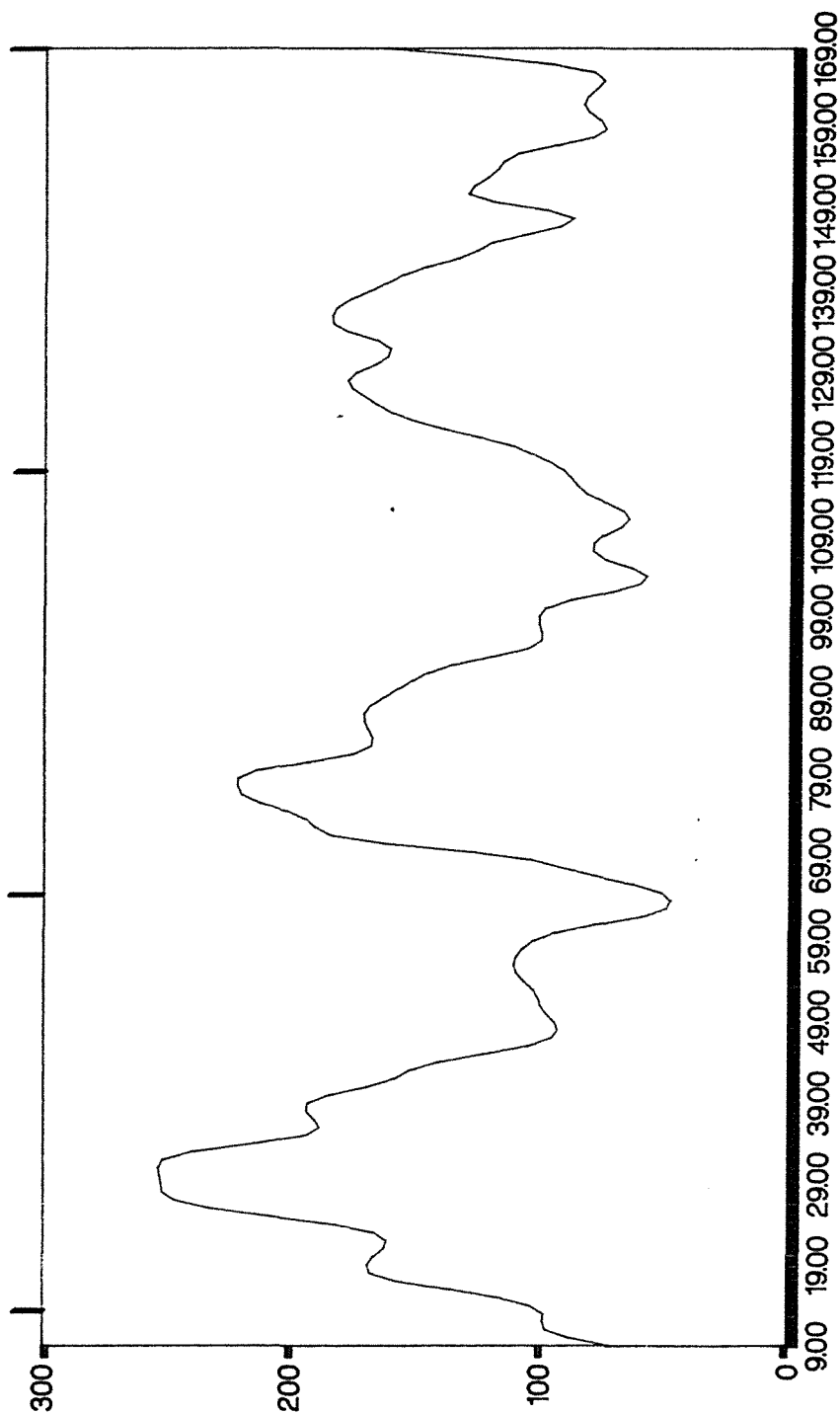
week rank from 1.1.82 to 29.3.85

29/3/85

30/3/84

25/3/83

26/3/82



smoothed volume of parsnips

week rank in period 1-1-82 to 29-3-85

It appears there is one season in the smoothed price series. ~~With the exception of the peak at the end of year 1, prices were~~ highest in October and March. Lowest prices were usually in July.

The smoothed volume series reveals one season only. Volume was greatest in about July and fell away to be lowest in February and March.

Lowest prices often occurred just before or after highest supply.

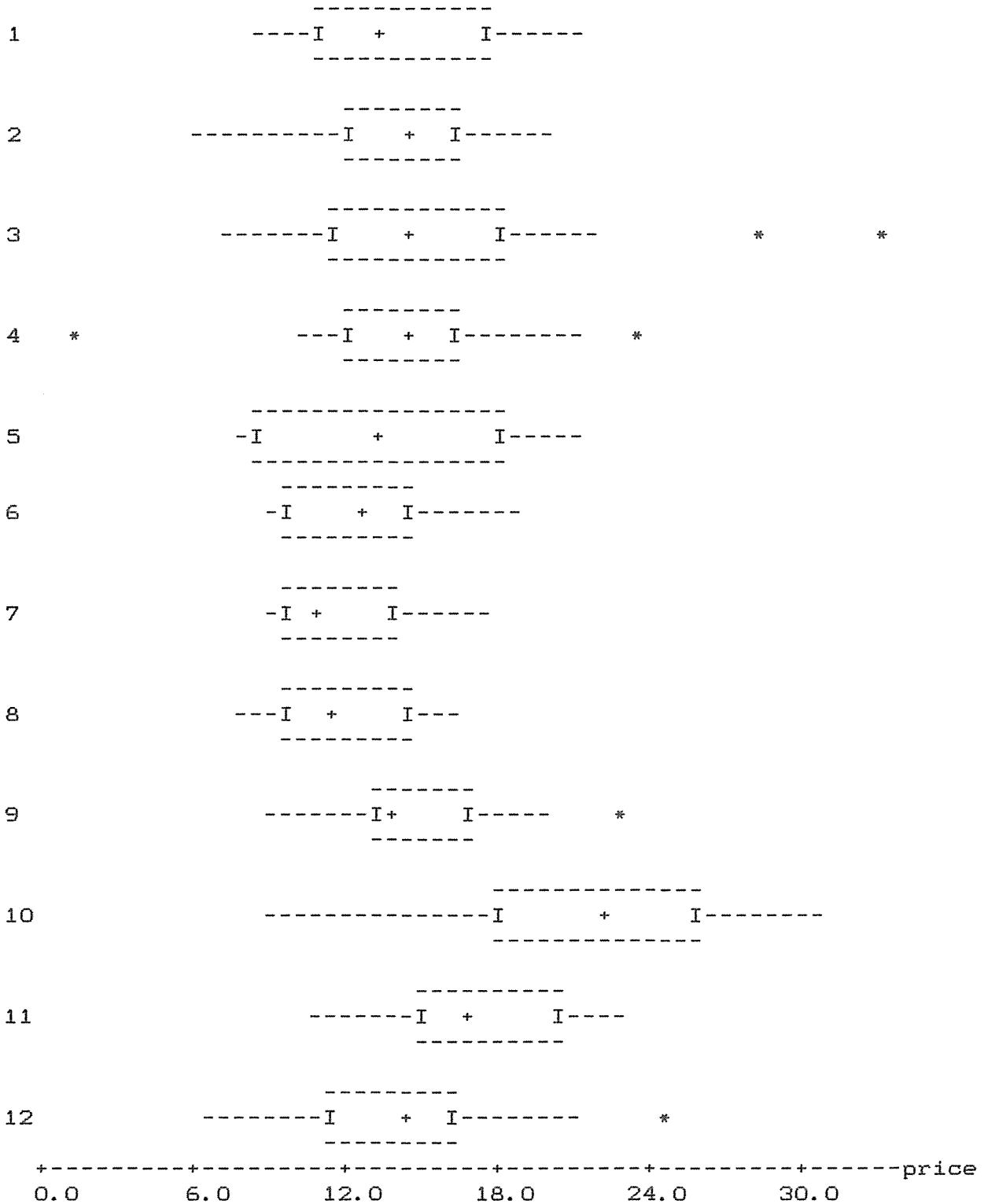
The boxplots of prices by month indicate one season for parsnips. The times of generally low prices corresponded to the times of maximum supply and the month of minimum price did correspond to the month of maximum supply.

October was the month of highest prices, and it did not correspond to the month of minimum volumes. There was one instance of very low supply in October and this may have disrupted the reaction of buyers to volumes. Perhaps this suggested that less volume was available and would be available than was actually the case and this caused prices to be bid up.

In general though, prices began rising some time after volumes had been declining.

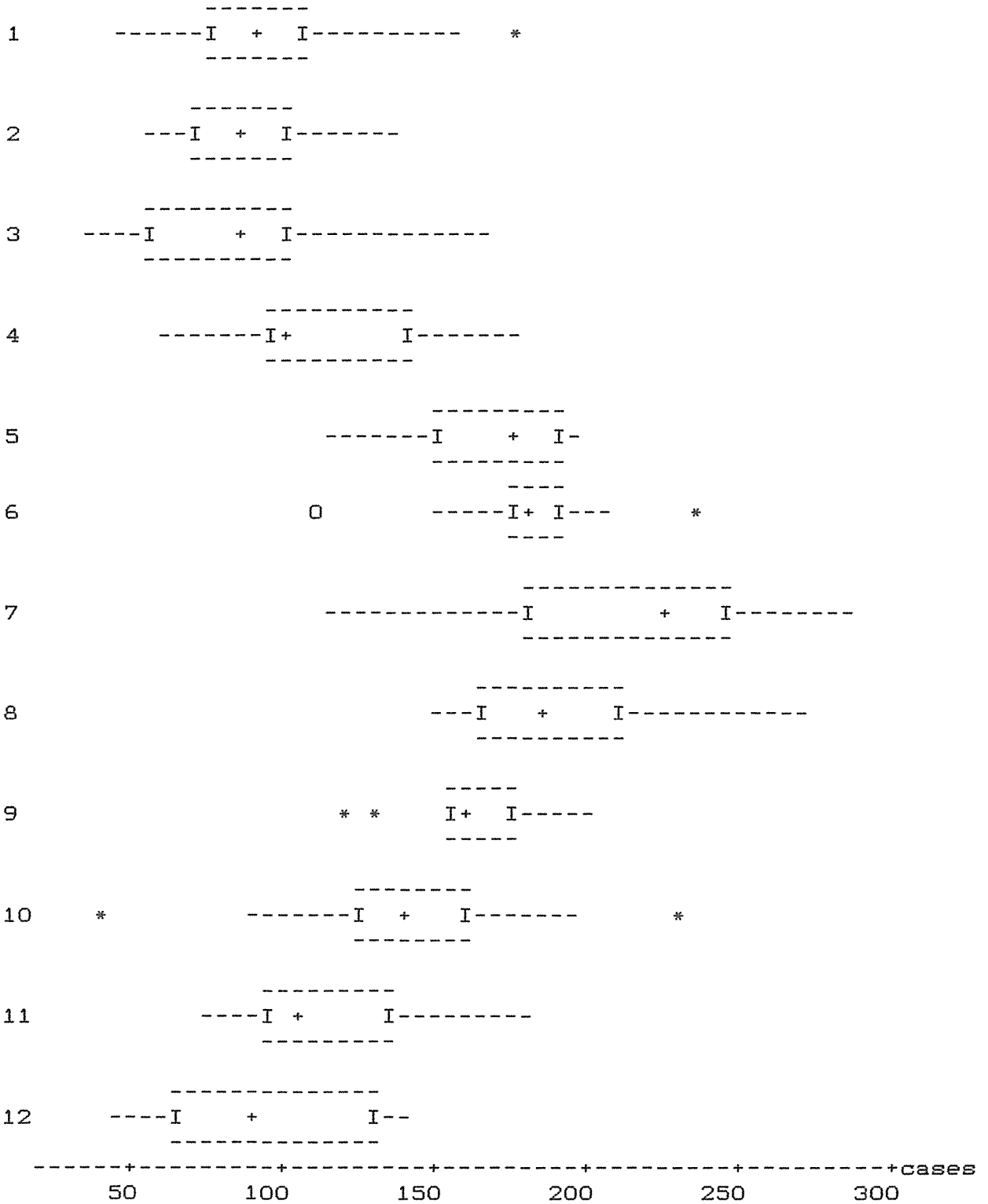
Median price was reasonably constant from month to month from ~~December to July, though it did fall in June and was lowest in~~ July. In August median price began rising and peaked in October. The general level of prices seems lowest in June, July, and August.

Month



~~Volume was reasonably constant from December to March, began rising in April, peaked in July, and began declining in August.~~

Month



14 PUMPKINS

According to the Yates seed catalogue pumpkins require warm and sheltered growing conditions. They are sensitive to frosts, needing a minimum soil temperature of 15 degrees C and air temperatures during the day over 20 degrees C. Good soil drainage is important and plants can easily be damaged by wind. If the water supply fluctuates yields will suffer. Maturity from seed takes about 110 to 125 days for crops for the early market and about 140 to 160 days for crops for the winter market. All varieties have good storage properties.

Seed is sown when the danger of frost is passed in late October and early November, Ballinger (1980).

According to Thompson and Kelly (1957) pumpkins subjected to hard frosts will not keep, so harvesting should be completed before any hard frosts.

In use, pumpkins are primarily a winter vegetable.

1 The expected behaviour of prices

Pumpkins are harvested in February and March which is when we would expect prices to be lowest. For the rest of the year we would expect prices to steadily rise as markets were supplied out of storage.

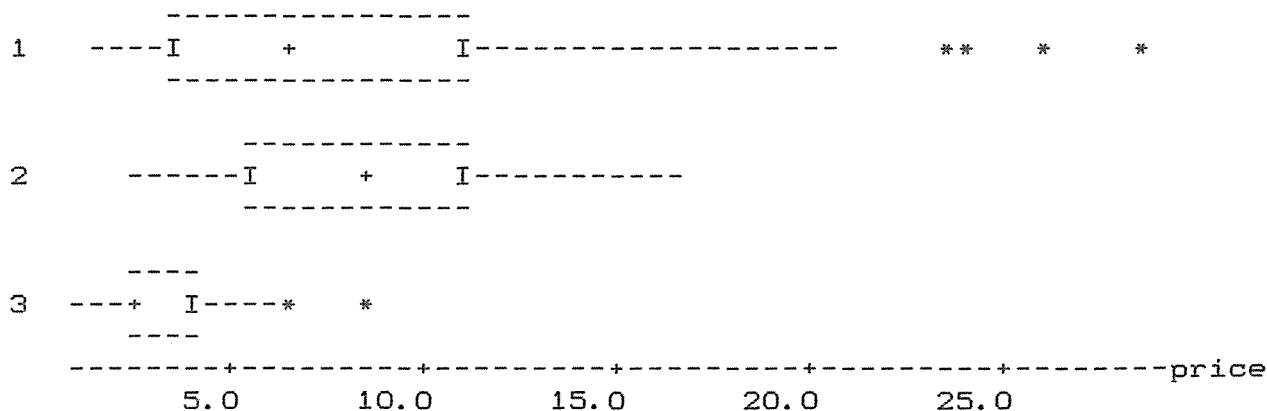
2 The behaviour of pumpkins at auction

Pumpkins were supplied continuously throughout the period under study.

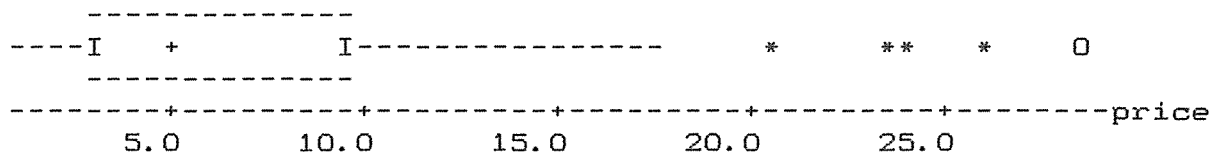
The mean weekly price of pumpkins fell by close to 1% in year 2 and then fell by about 61% in year 3. See table 13.

In each year mean price fell. Median price however, first increased and then fell. By year 3 median weekly price was considerably lower and the variation in price had declined greatly.

Year



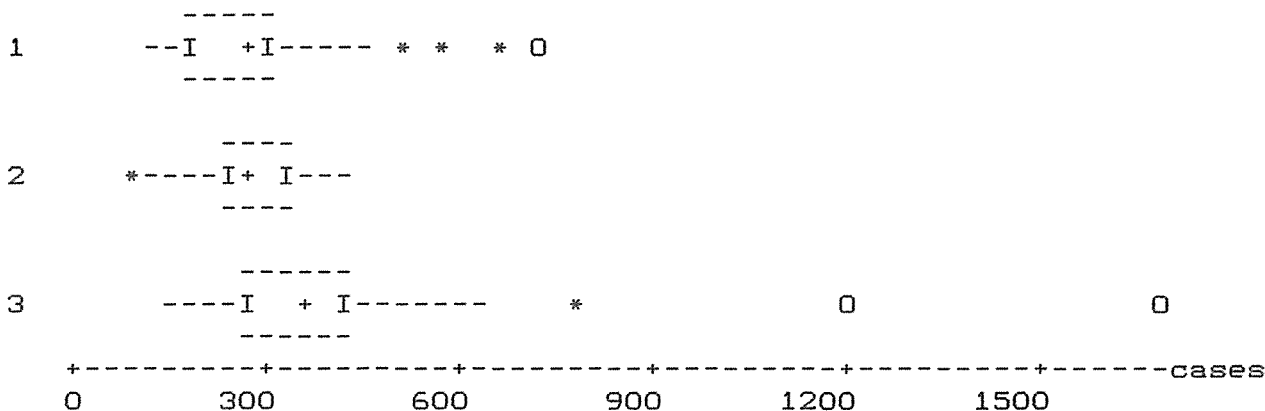
For the entire series weekly price was right skewed about a median of \$5.07, with the lowest price being \$1.12, and the highest price being \$28.50.



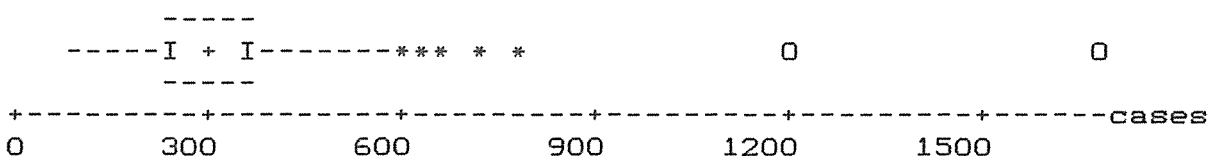
Volume fell by about 2% in year 2 and then increased in year 3 by about 36%. See table 14.

Median volume increased from year 2 to year 3 and there were two occasions of far outside values.

Year



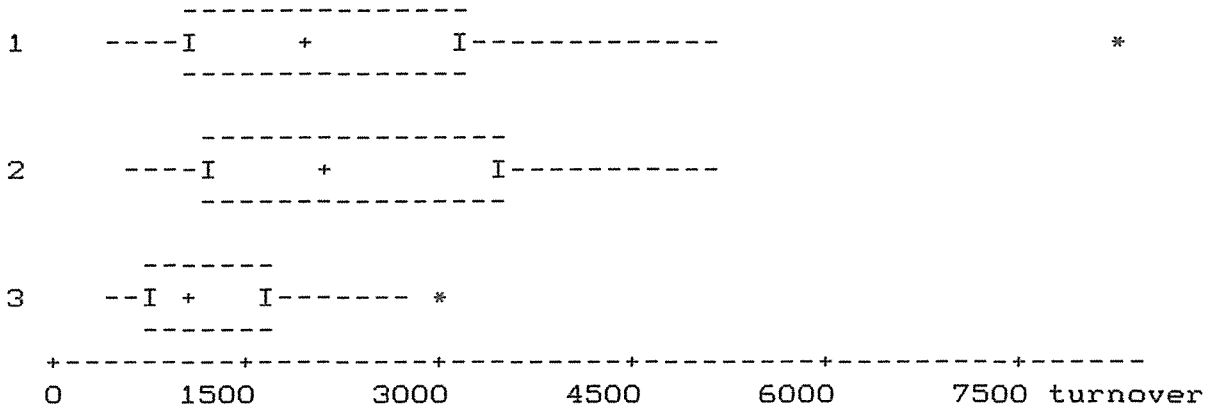
For the entire series weekly volume was right skewed about a median of 297 cases. The smallest weekly volume was 92 cases, and the highest was 1676 cases.



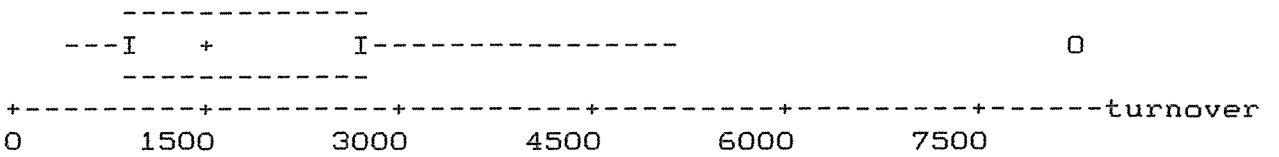
Total turnover increased by about 7% in year 2 and then fell by nearly 52% in year 3. See table 15.

Median weekly turnover has declined in the three years under study.

Year

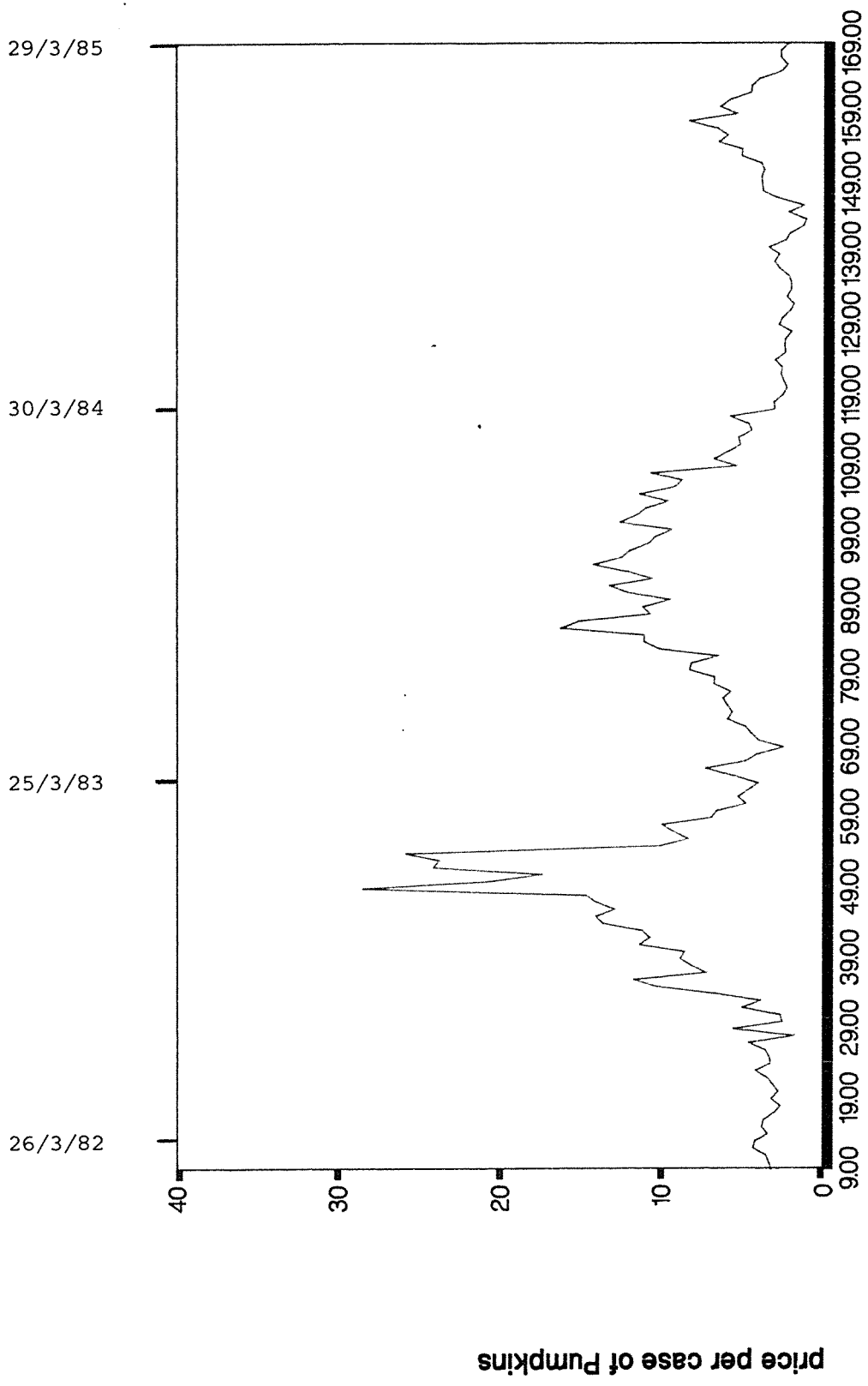


For the entire series weekly turnover was right skewed about a median of \$1506.00, with a minimum of \$385.00, and a maximum of \$8215.00.



Price exhibited considerably more variance than volume over the three years.

	coefficient of variation
price	.74
volume	.54
turnover	.69



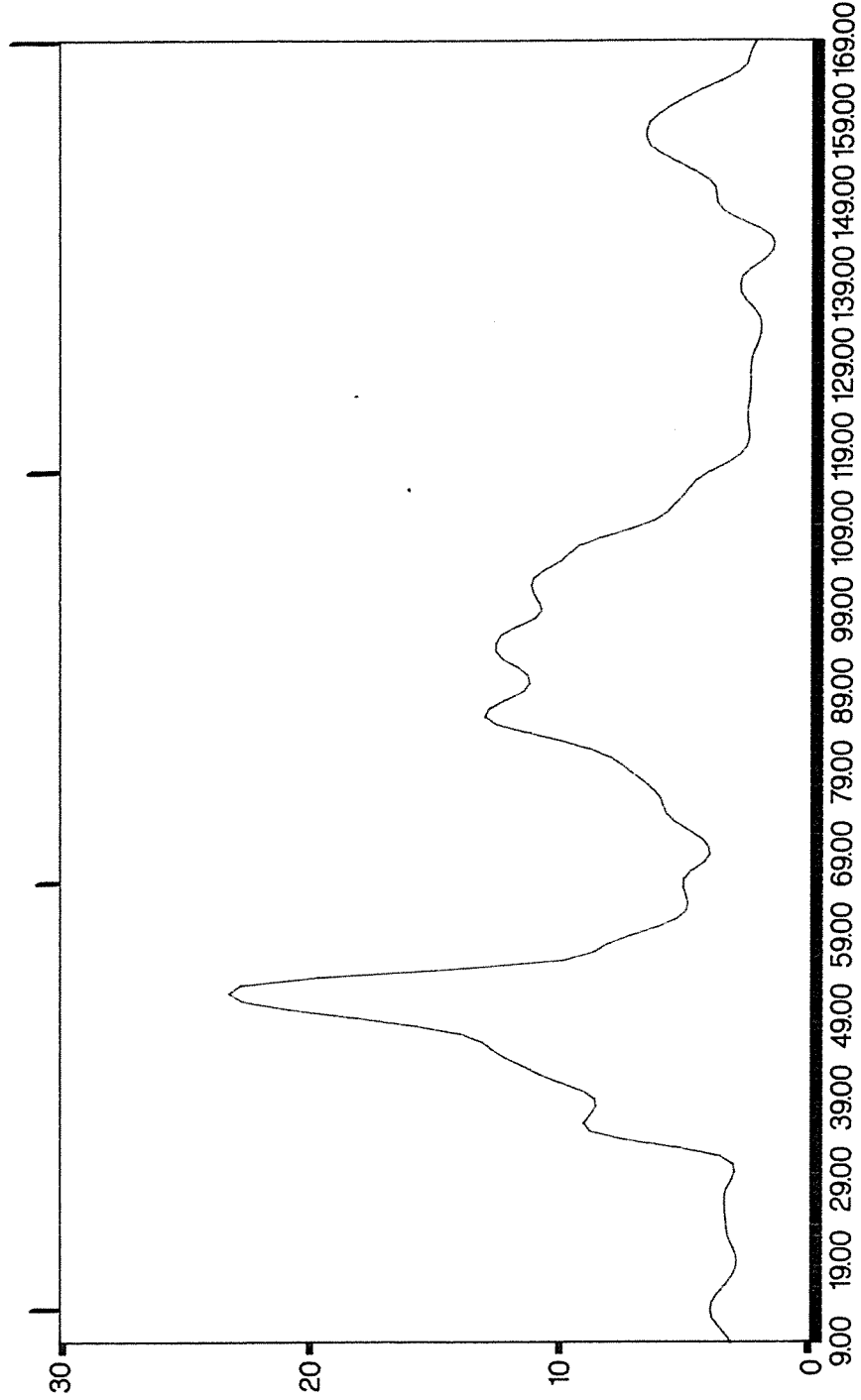
week rank from 1.82 to 29.385

29/3/85

30/3/84

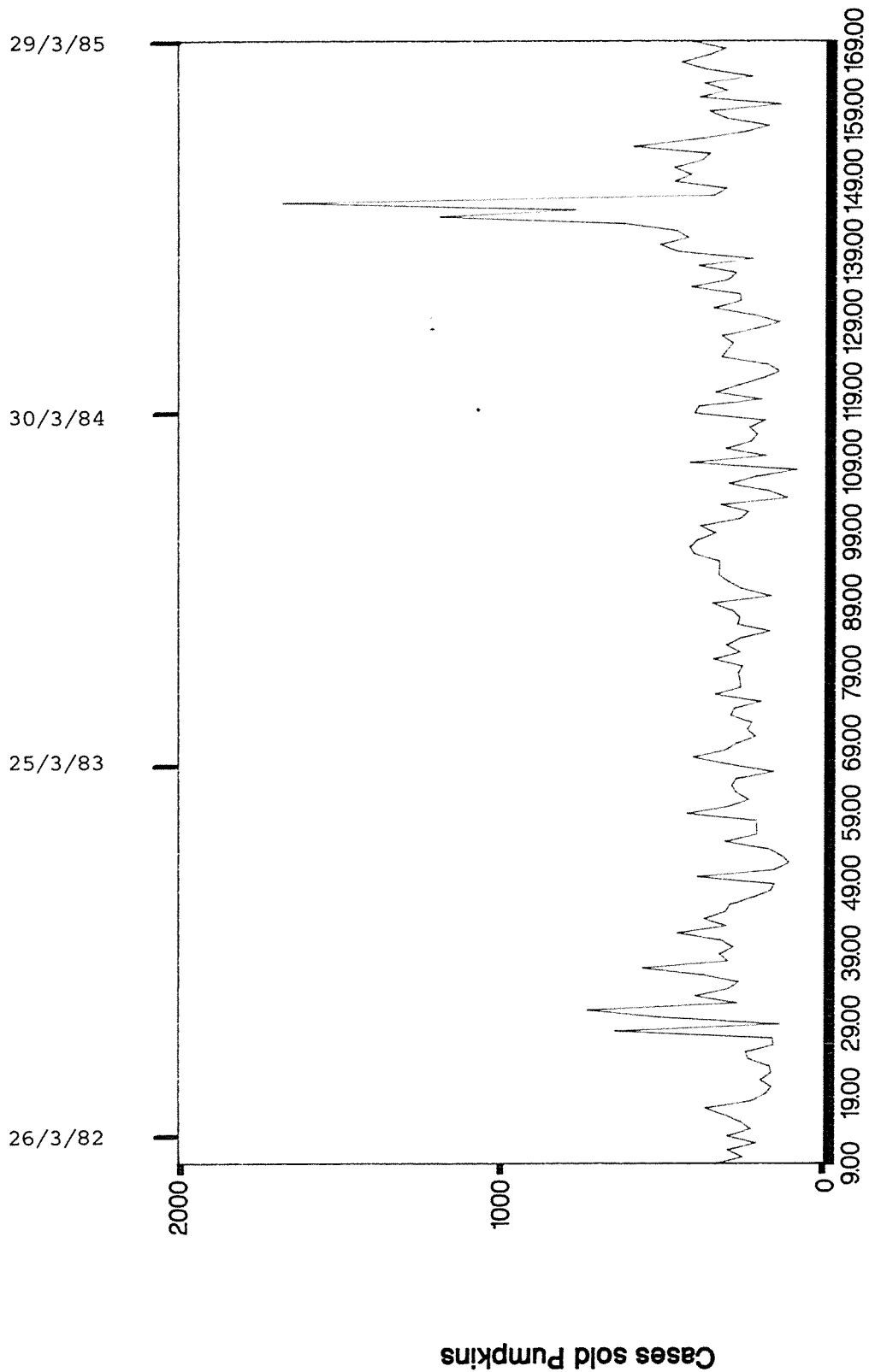
25/3/83

26/3/82



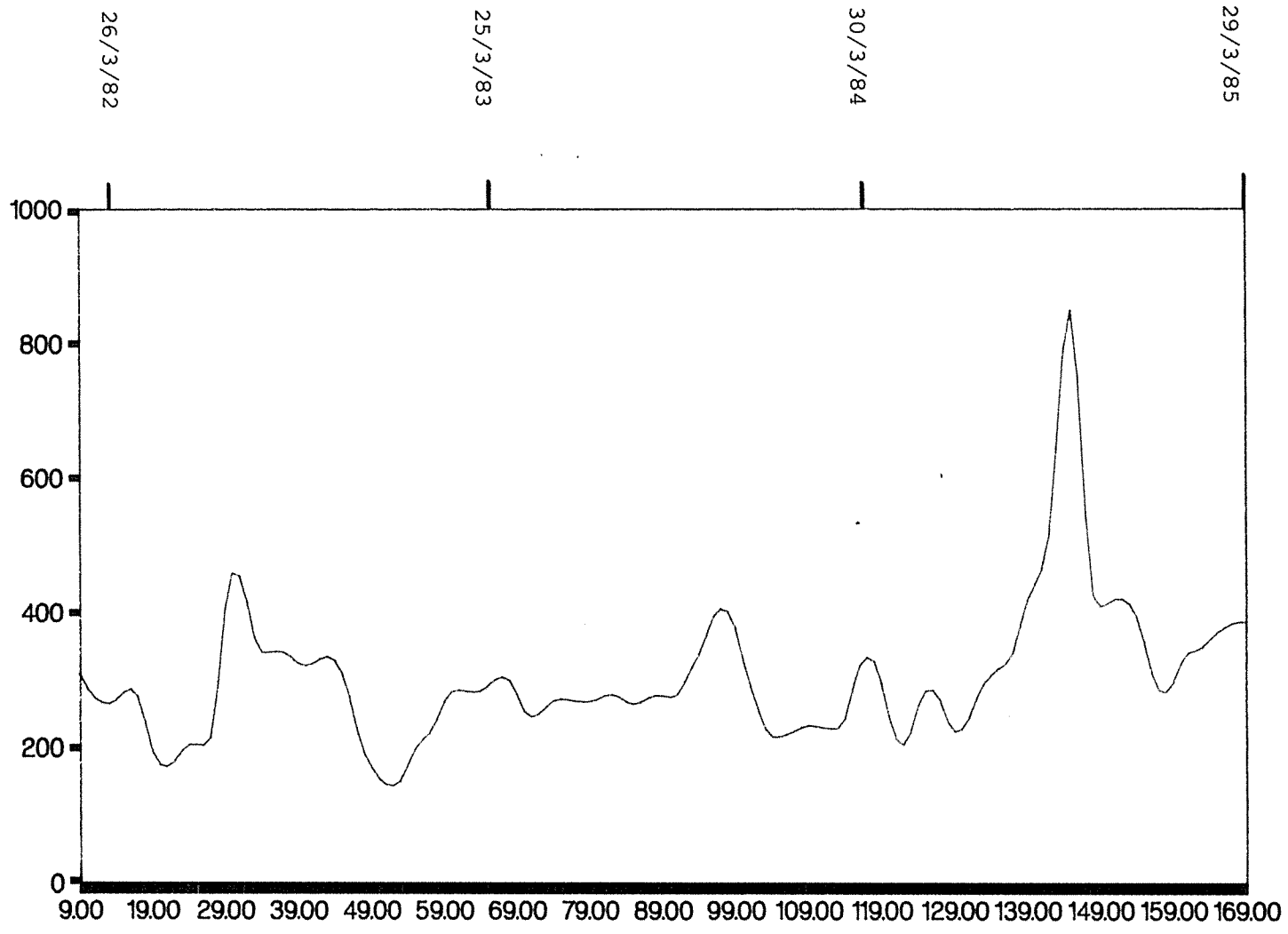
smoothed price of pumpkins

week rank in period 1-1-82 to 29-3-85



week rank from 1.182 to 29.385

smoothed volume of pumpkins



week rank in period 1-1-82 to 29-3-85

The amplitude and duration of peaks varied over the three years. However, the plot suggests that pumpkins have one season a year.

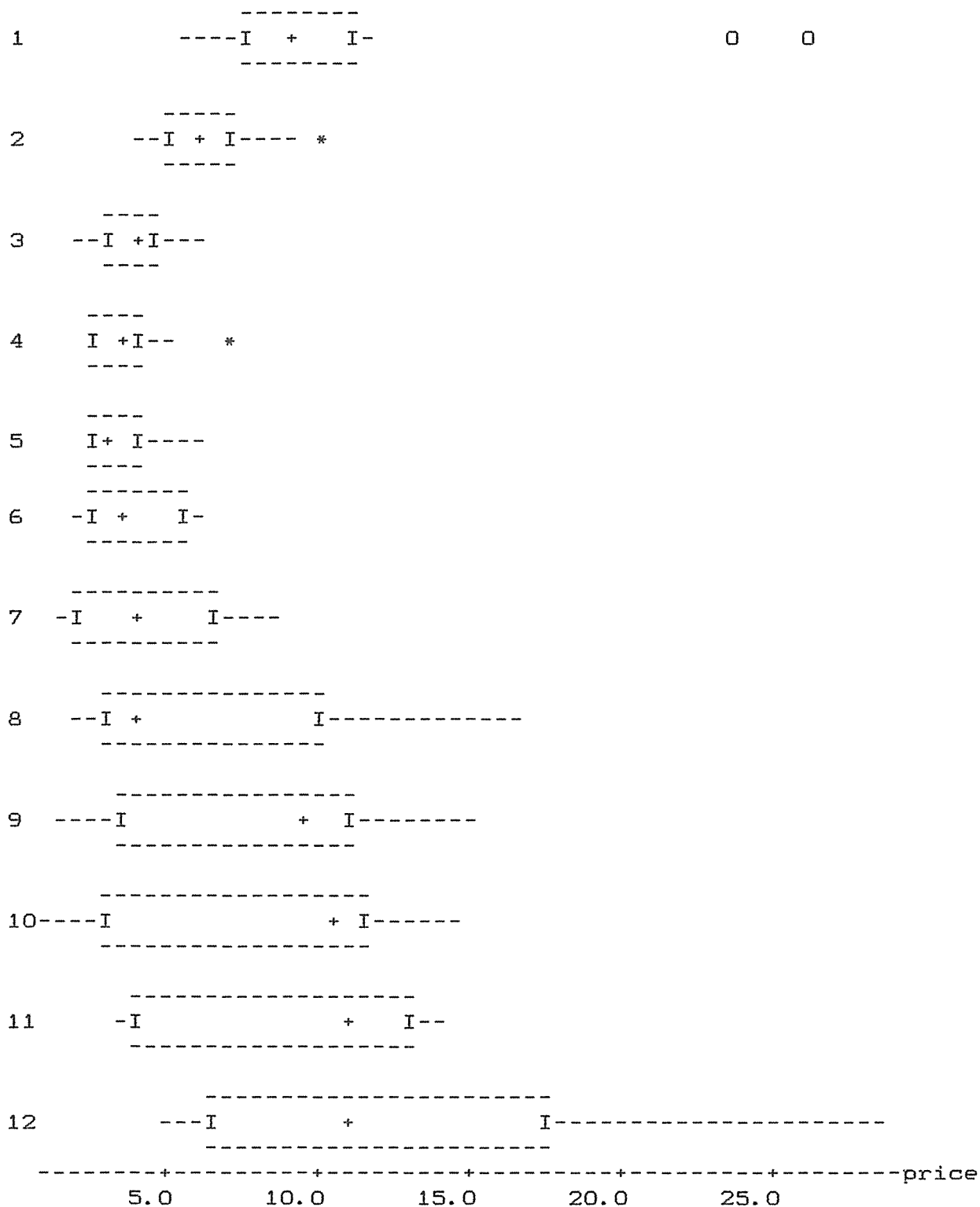
Prices were highest from the end of July and the middle of August to early to mid February. At other times prices appear to have been relatively constant.

In years 1 and 3 prices peaked in summer and in year 2 they peaked in late spring. Prices were lowest in winter.

Volume appears to have one season a year with quantities increasing from about the middle of July and falling away to a relatively constant low from January to the middle of July.

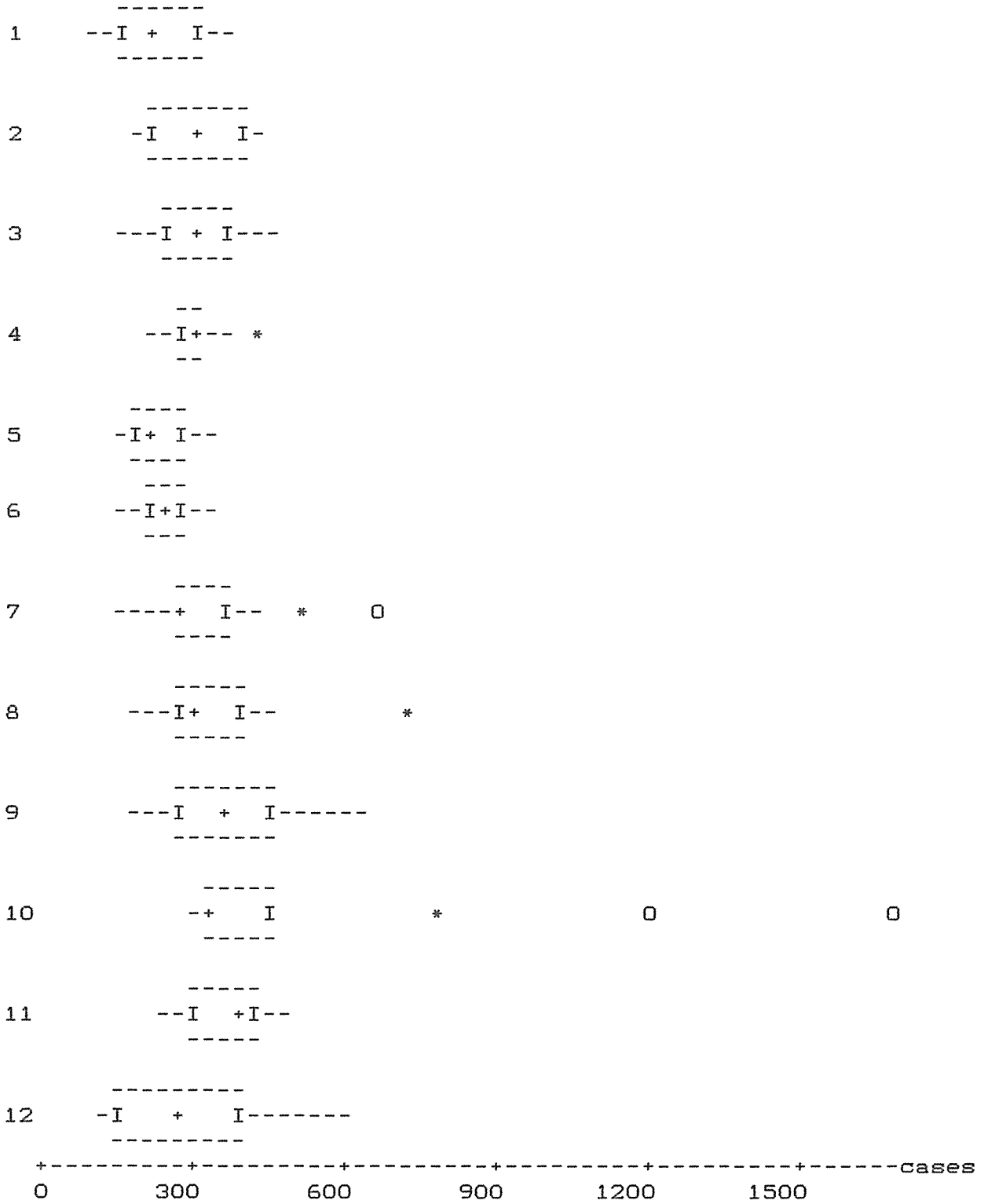
The price boxplots illustrate that median price was lowest in May and highest in November and December. Prices and volumes were low in the first half of the year and were high in the second half of the year. Prices were high in December and January, and May and June which was when volumes were lowest.

Month



Volume varied in a smooth fashion. It was lowest in May and June, and December and January and quite similar for the rest of the year.

Month



15 SILVERBEET

The Yates seed guide states that maturity takes from 65 to 70 days depending on the variety, and that it is sensitive to low temperatures which can cause bolting.

Ballinger (1980) and Tannock (1914) note that seed can be sown from the beginning of spring into March and that this will provide a supply through winter. To ensure winter supply, plants must become established before any frosts.

1 The expected behaviour of prices

Silverbeet is not planted when frosts can be expected so two and a half months after the time of frosts we can expect volumes to be low. This will be in about January and February, when we would expect prices to be highest. Volumes should begin rising after February peaking prior to frosts. Prices would be expected to decline from the end of February starting to rise after frosts when volumes have fallen.

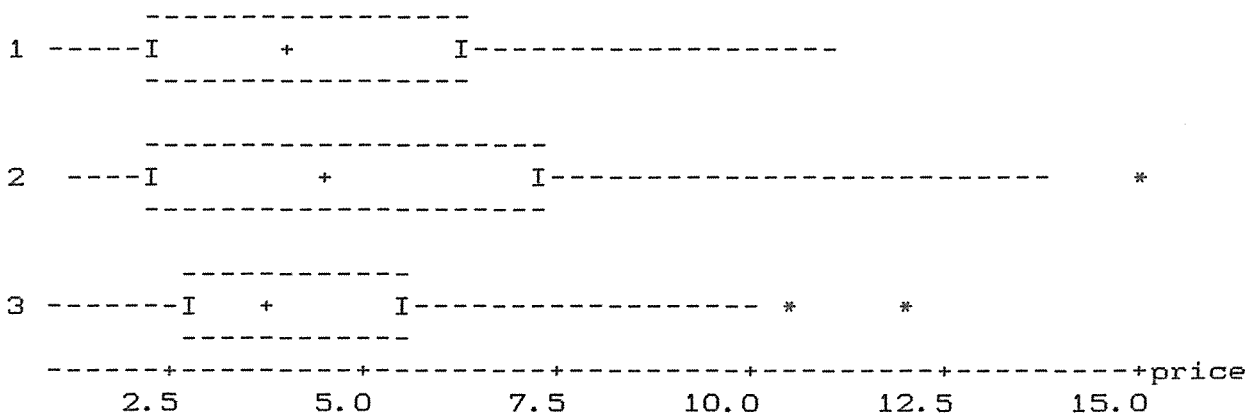
2 The behaviour of silverbeet at auction

Silverbeet was supplied in all weeks under study.

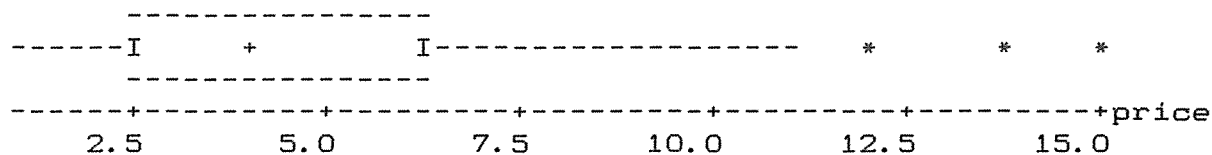
Mean weekly price rose by about 12% to March 31 1984 and then fell by nearly 13% to March 31 1985. See table 13.

This is also illustrated by reviewing the boxplots for each March year. In year 2 median price rose and prices became more variable. In year 3 median price fell to below the year 1 median with the range of prices falling also.

Year



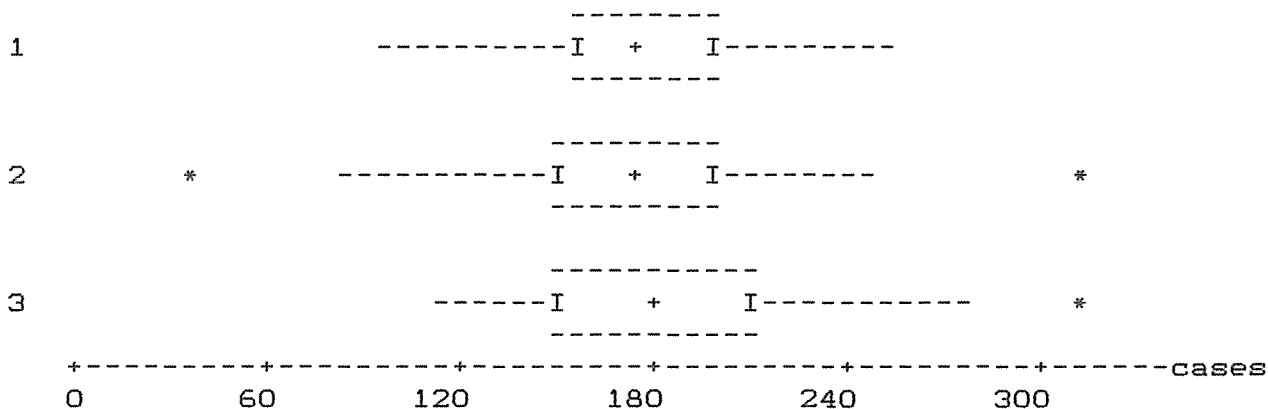
For the entire series price was right skewed about a median of \$4.04. The lowest price was \$1.04 and the highest was \$14.93.



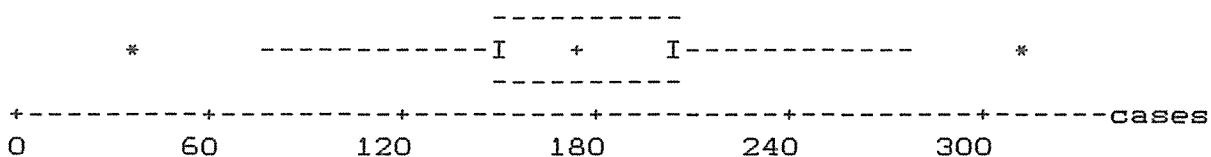
Total volume fell by about 3% in year 2 and then increased by about 2% in year 3. See table 14.

Median weekly volume remained about the same in each of the three years. The greater variation in price in year 2 can be traced to the two outliers in year 2 volume.

Year



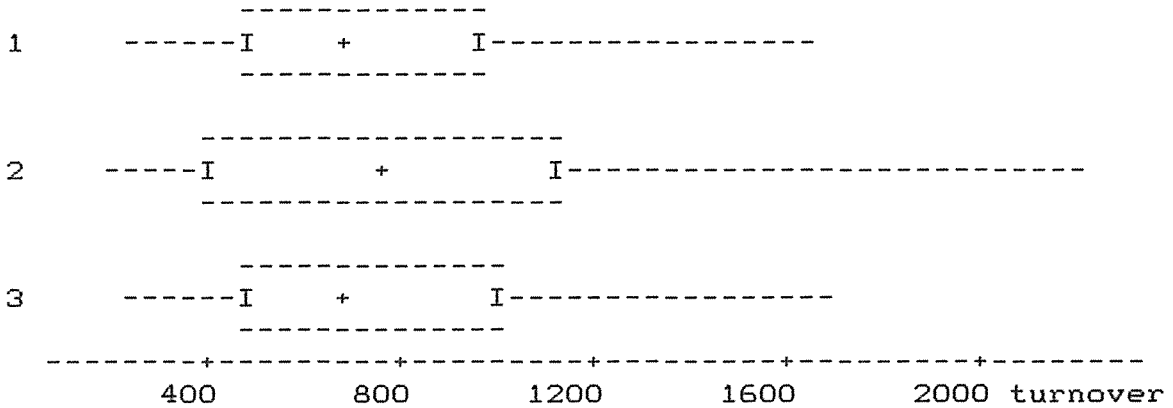
For the entire series volume was quite symmetrically distributed about a median of 174 cases. Minimum volume was 34 cases and maximum volume was 314 cases.



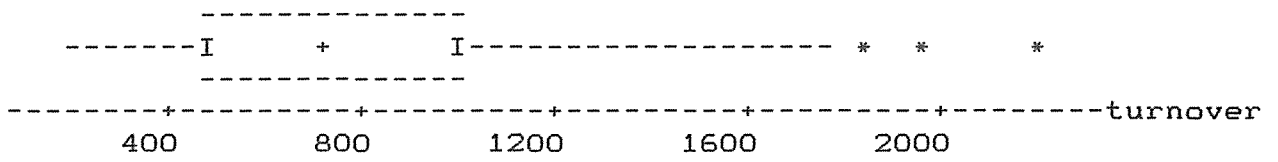
Turnover increased by about 8% in the year to March 31 1984, and then fell by about 10% in the year to March 31 1985. See table 15.

The boxplots for turnover are virtually identical for year 1 and year 3. Year 2 was the year with lower volume and this is evidenced in the higher median weekly turnover and greater range in year 2.

Year



For the entire series, weekly turnover was right skewed about a median of \$706.00, with a low value of \$218.00, and a high value of \$2195.00.

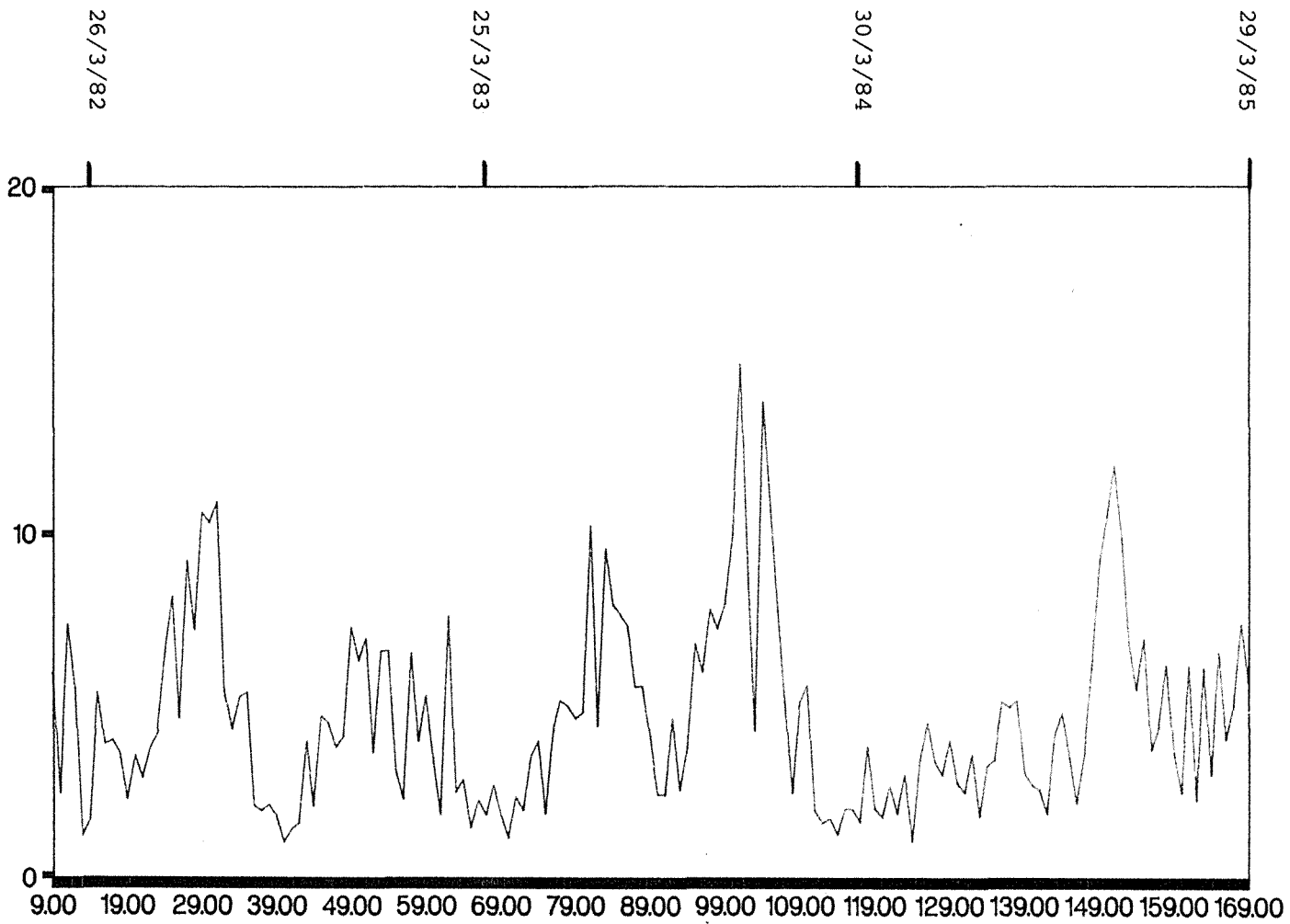


For the three years price was considerably more variable than volume.

coefficient of variation

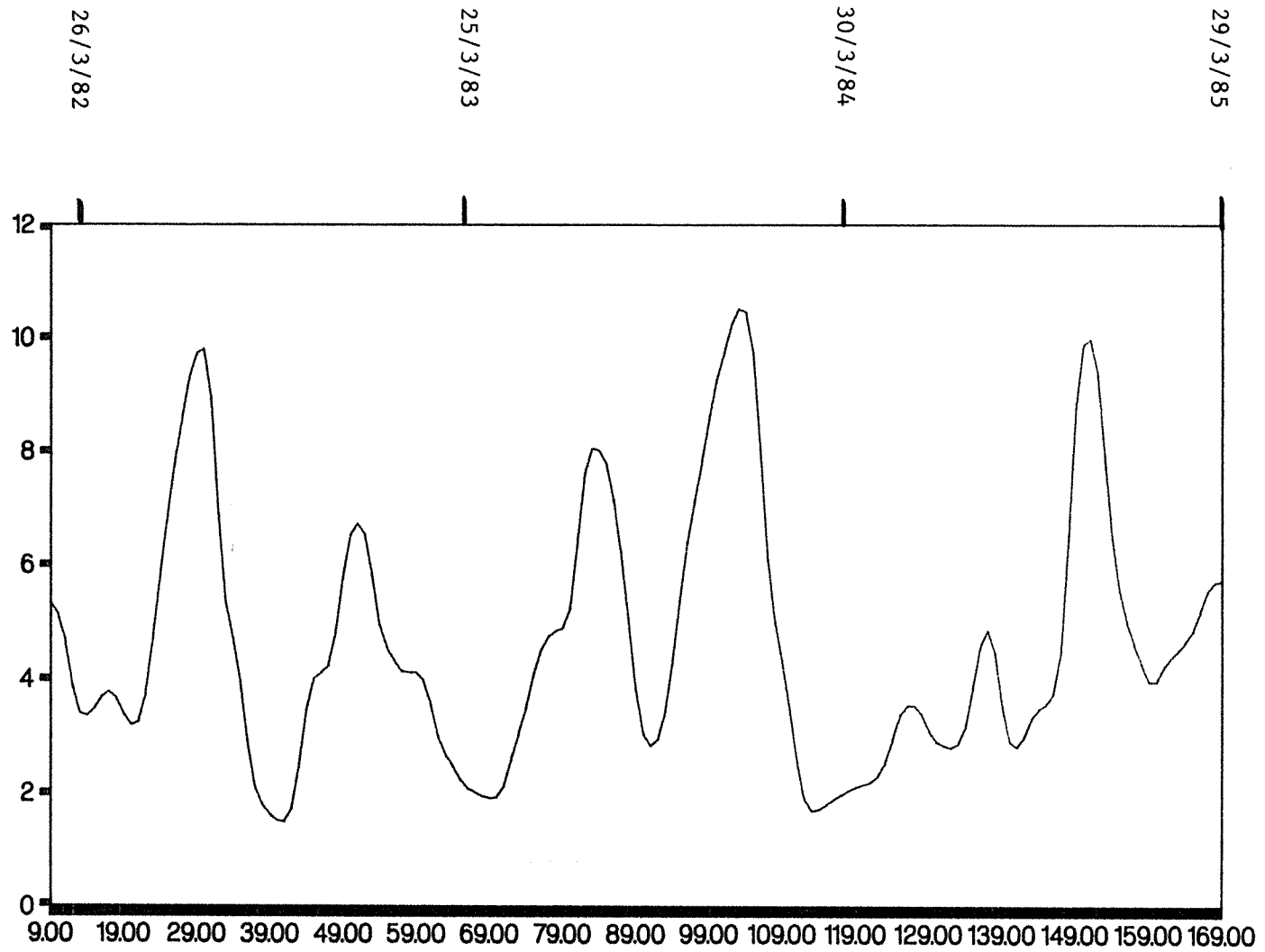
price	.58
volume	.23
turnover	.51

price per case of Silverbeet

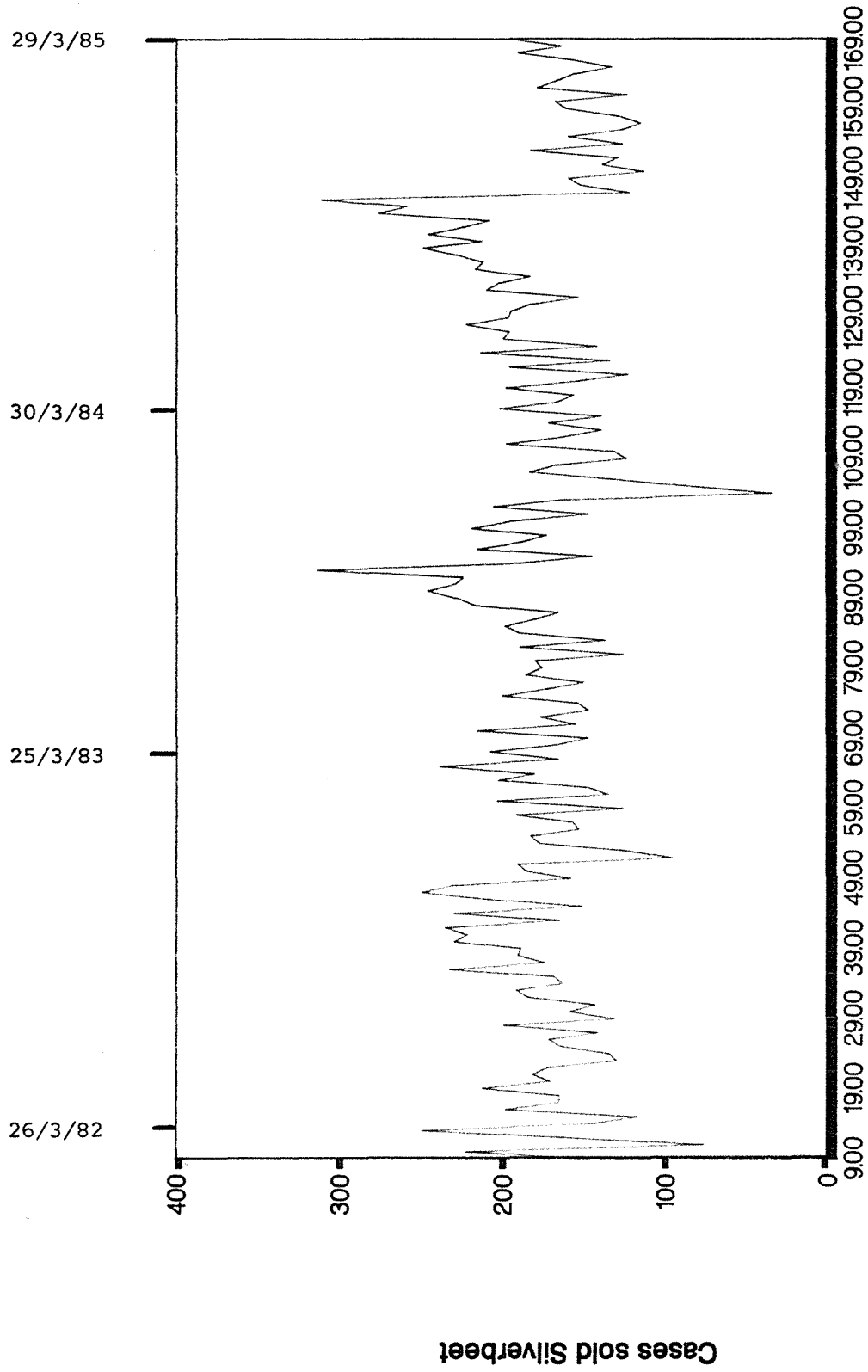


week rank from 1.182 to 29.385

smoothed price of silverbeet



week rank in period 1-1-82 to 29-3-85



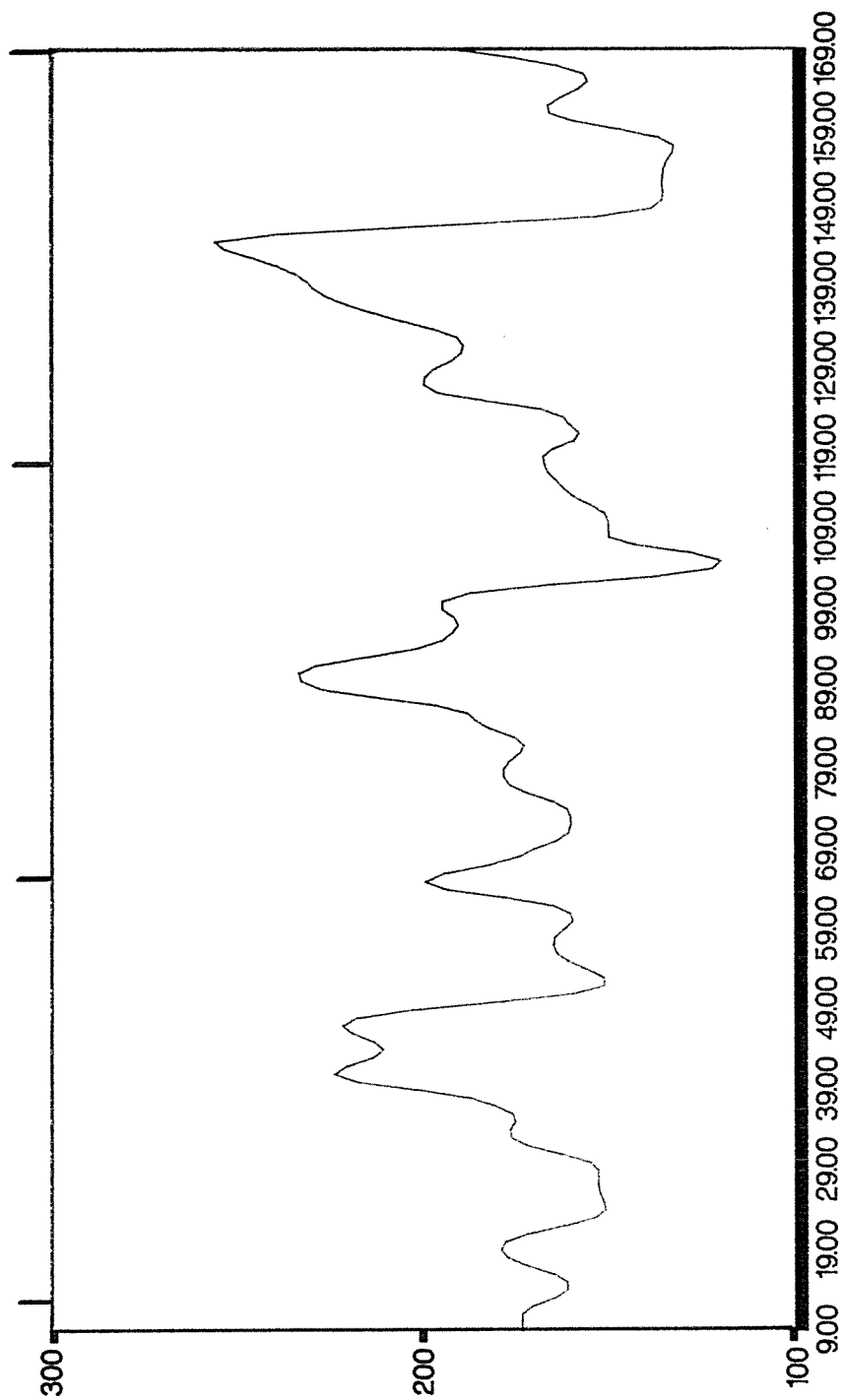
week rank from 1.182 to 29.3.85

29/3/85

30/3/84

25/3/83

26/3/82



smoothed volume of silverbeet

week rank in period 1-1-82 to 29-3-85

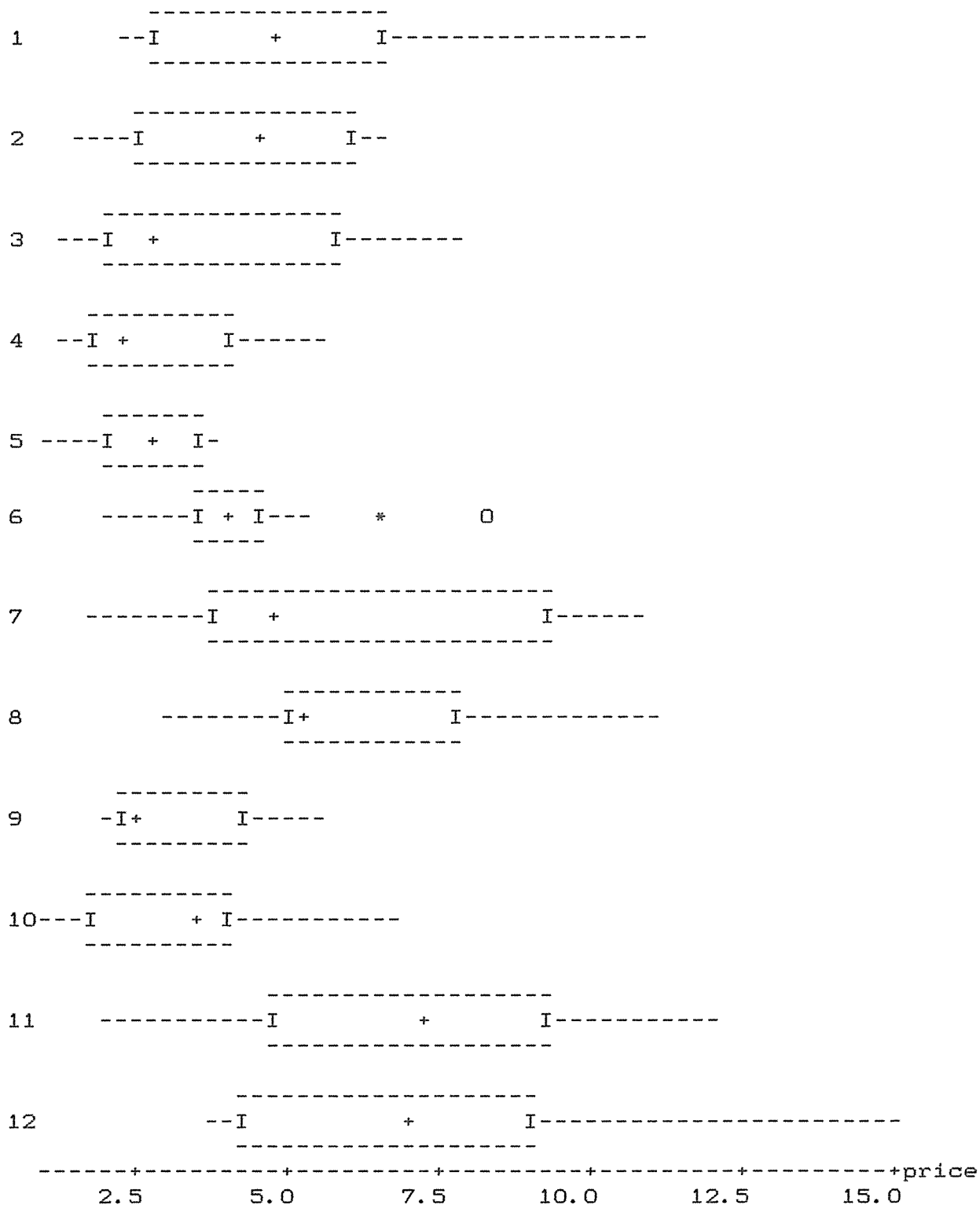
From the smoothed price series it seems that there are two seasons for silverbeet. In successive years prices peaked first in mid July, late July, and early August and then in mid to late December, and mid November. These peaks correspond to periods of low supply.

Peak supply was mid October to the end of November in year 1, mid September to mid October in year 2, and the end of September to the middle of October in year 3.

The high prices in July and August occurred when volumes were beginning to increase which is surprising. Some factor other than volume must have been causing prices to peak at this time. This pattern occurred in each of the three years.

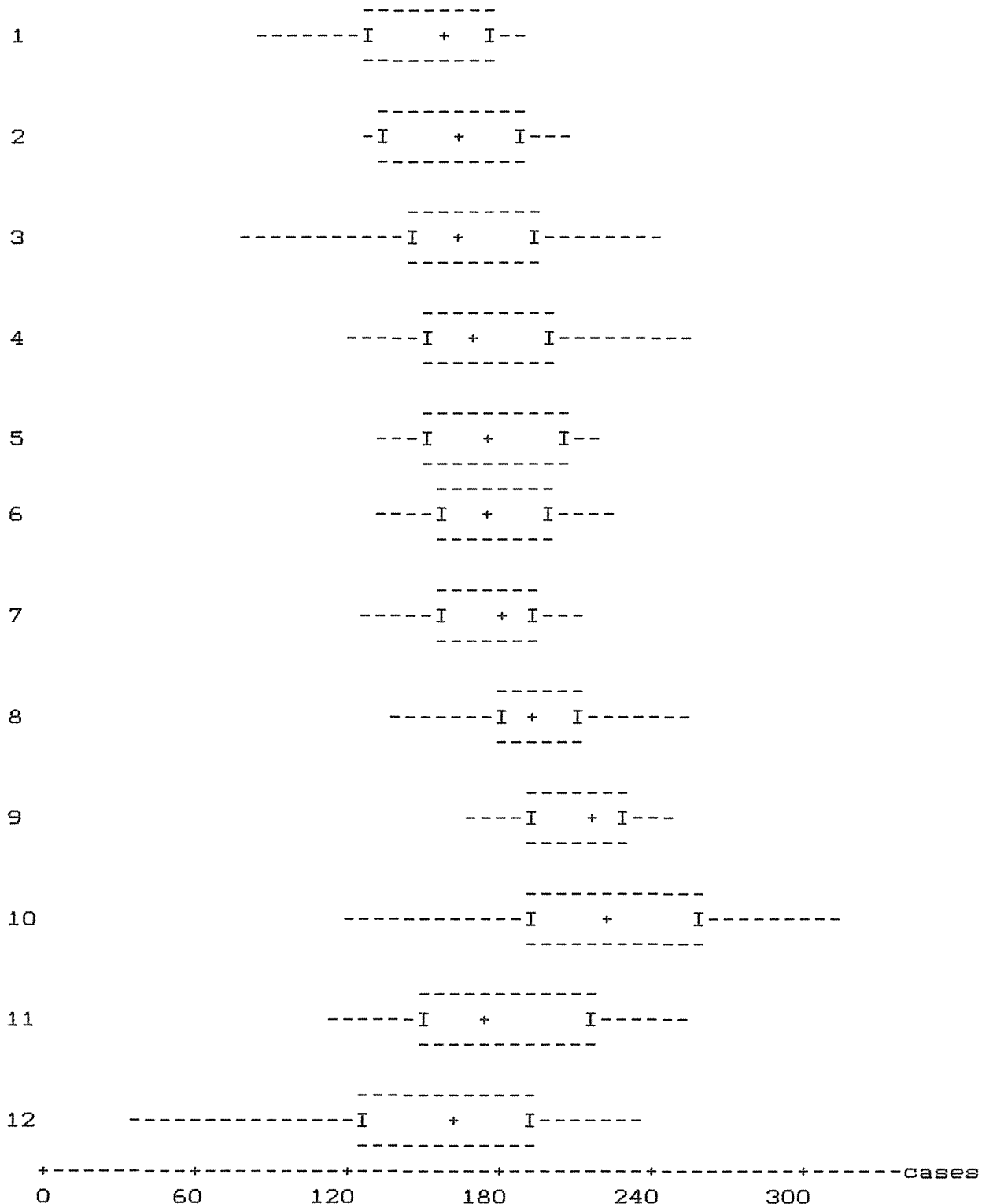
The boxplots below indicate that there are two seasons in a year. Prices were highest in the middle of winter and in the middle of summer. The lowest prices were in March, April, May, and October.

Month



Silverbeet volumes were lowest in January and rose steadily from February to peak in October. The turning points were January and October. The volume series suggests only one season for silverbeet.

Month



16 SPINACH

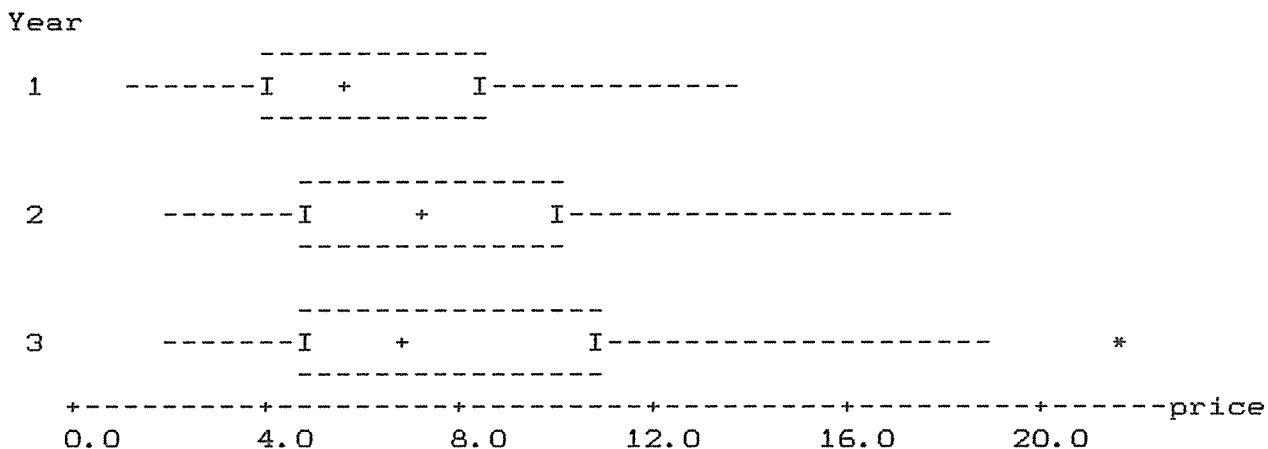
Depending on the cultivar, spinach may be sown in early spring or in February, and plants take 50 days to reach maturity (Ballinger 1980).

1 The behaviour of spinach at auction

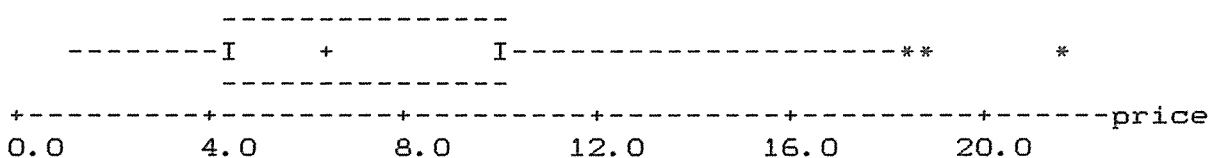
Spinach was not supplied continuously but the number of weeks in which it was supplied increased from year to year perhaps indicating greater consumer acceptance.

The mean weekly price increased by 31% in year 2 and by 0.5% in year 3. See table 13.

The change in median weekly price and range of prices for each year is given below. Median price increased in year 2 and then fell in year 3. The variation in price increased in year 2 and prices remained as variable in year 3 as in year 2.



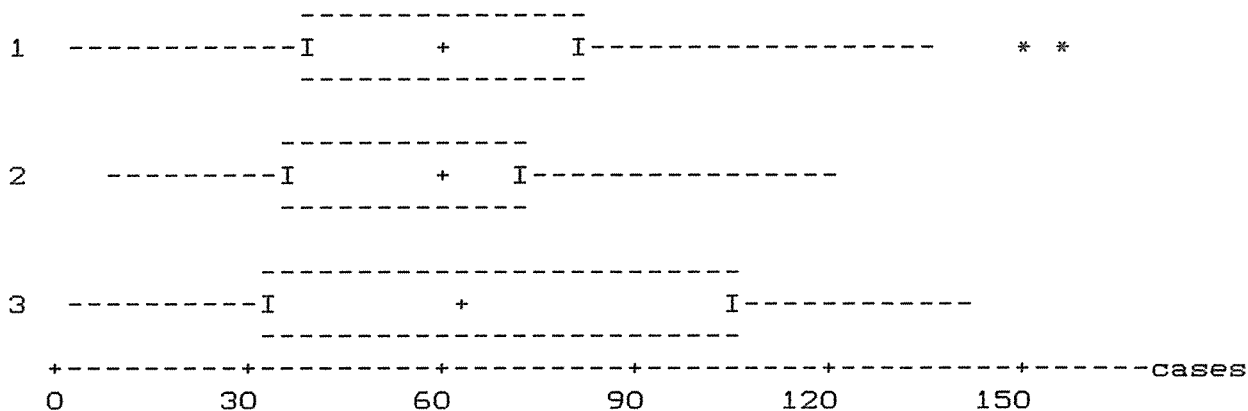
For the entire series prices were right skewed about a median of \$6.60; the lowest price was \$1.22, and the highest was \$21.63.



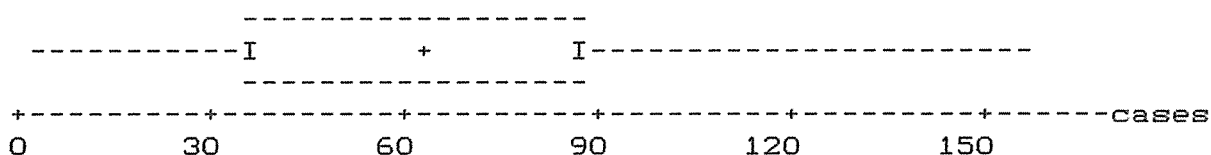
Volume fell by nearly 9% in year 2 and then increased by 25% in year 3. See table 14.

The range of weekly volume remained about the same throughout the three years but in year 3 there was a greater prevalence of higher weekly volumes than in the other two years. This is illustrated by the hinges containing greater values.

Year



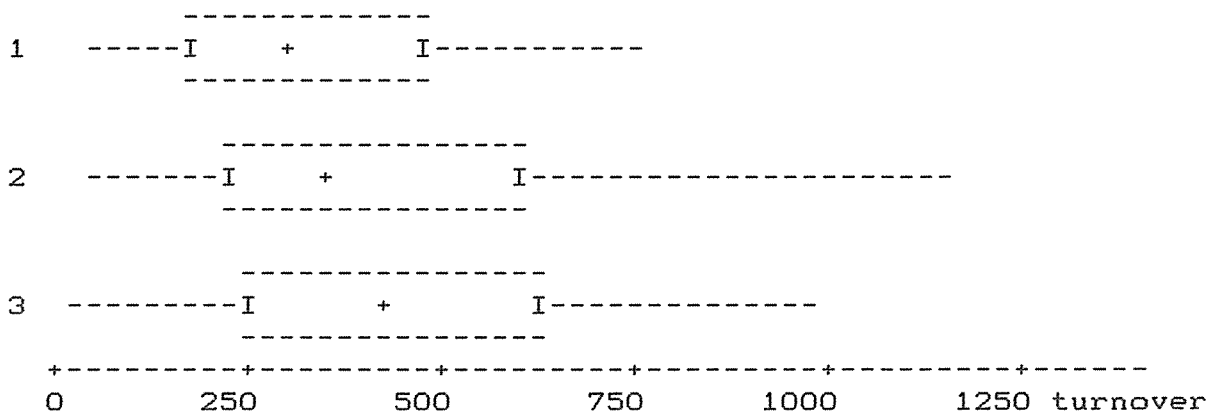
For the entire series weekly volume was slightly right skewed about a median of 62 cases. The lowest weekly volume was 4 cases and the highest was 156 cases.



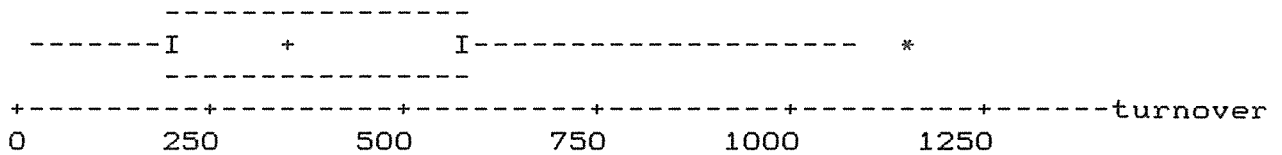
Annual turnover increased by 37% in year 2 and then by about 5% in year 3. See table 15.

Median weekly turnover has increased in successive years.

Year



For the entire series, weekly turnover was right skewed about a median of \$348.00; the lowest weekly turnover was \$36.00 and the highest was \$1140.00.



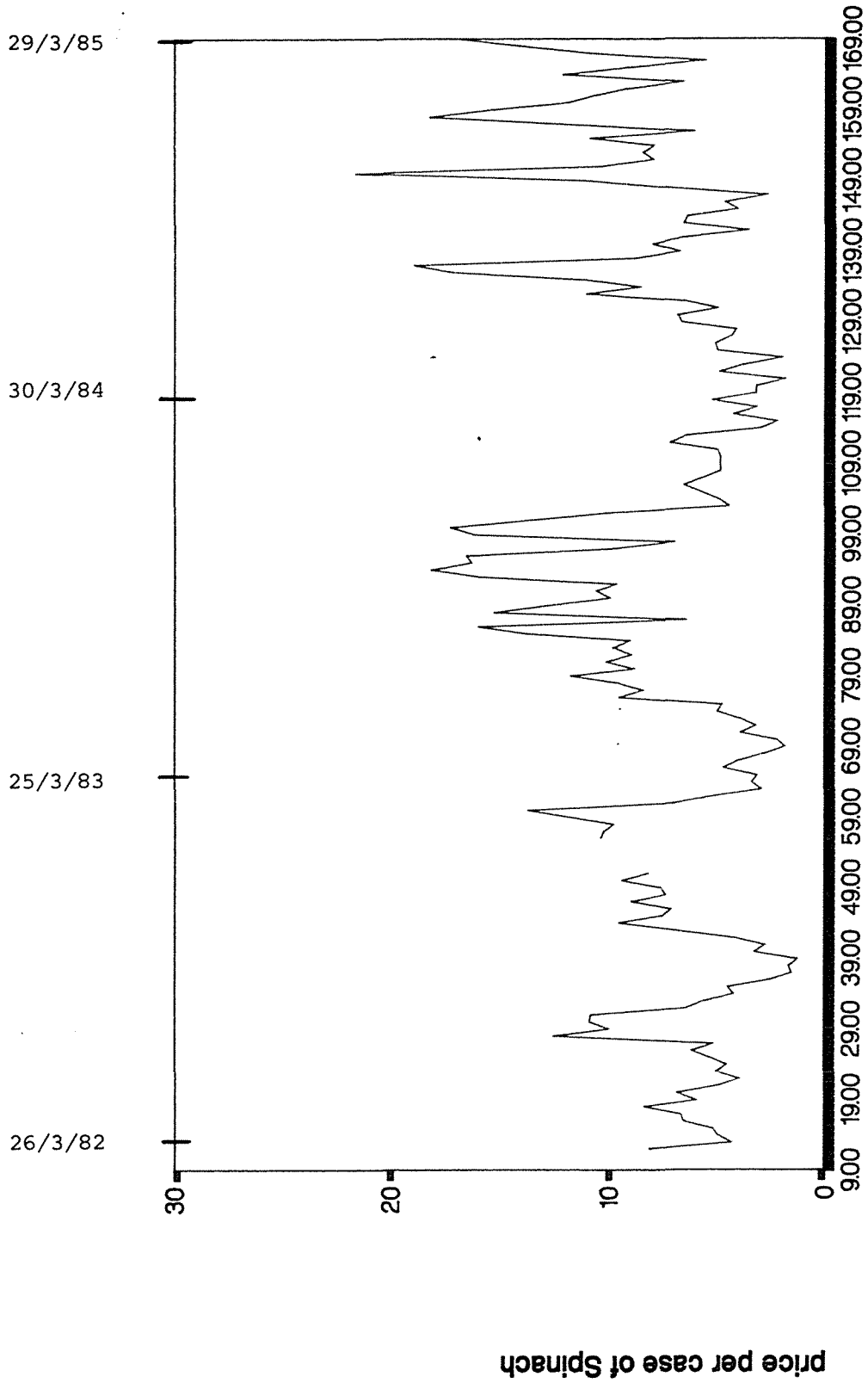
Price and volume were both quite variable.

coefficient of variation

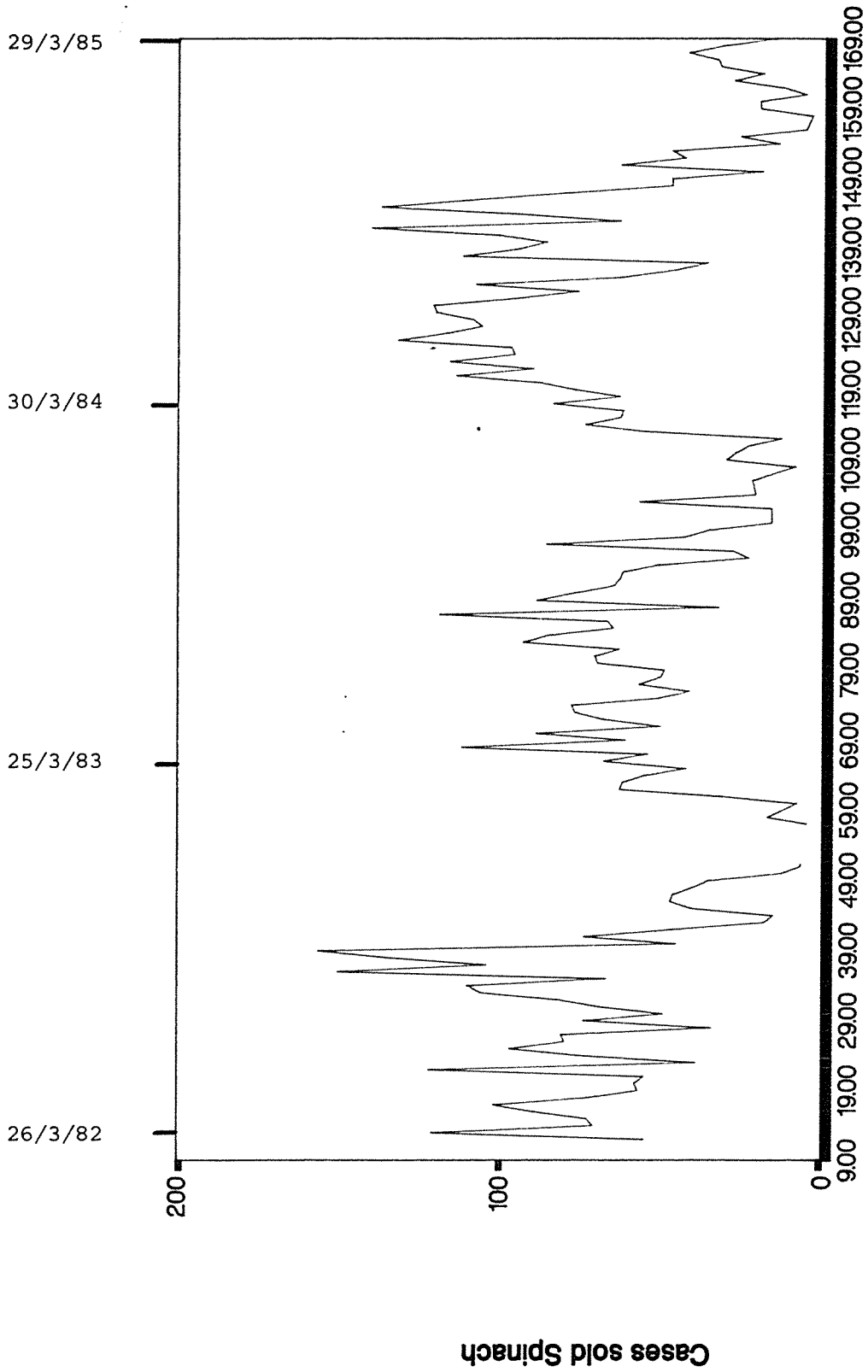
price	.56
volume	.56
turnover	.61

It seems, from the time series plot of price which follows, that there is one season in each year. It is not clear whether there is a consistent seasonal pattern. Prices were, in general, highest in July and lowest in March and April.

Spinach was a relatively recent addition to the market and perhaps its volatility was due to buyers discovering its price level, and growers learning to produce it.



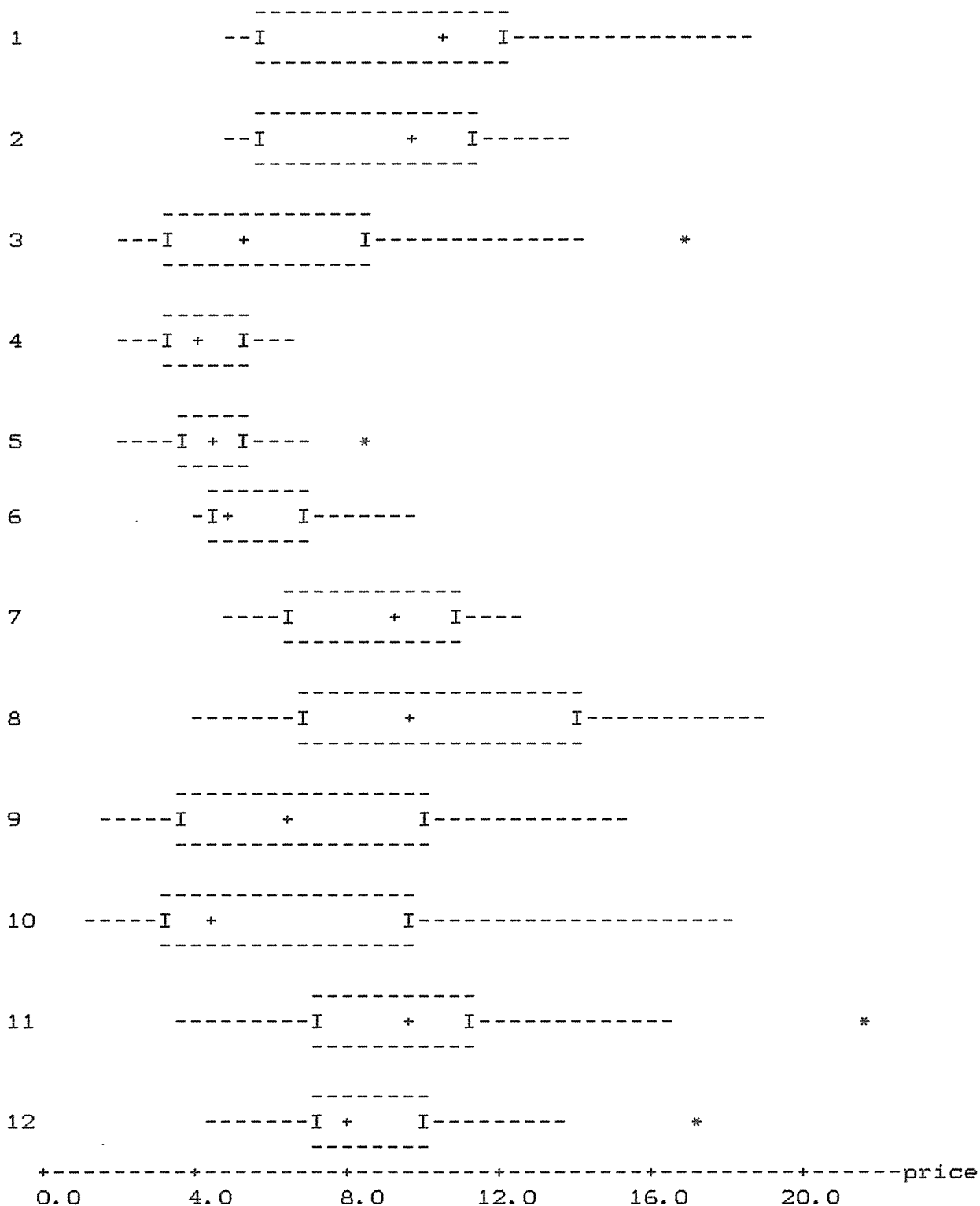
week rank from 1.182 to 29.385



week rank from 1.1.82 to 29.3.85

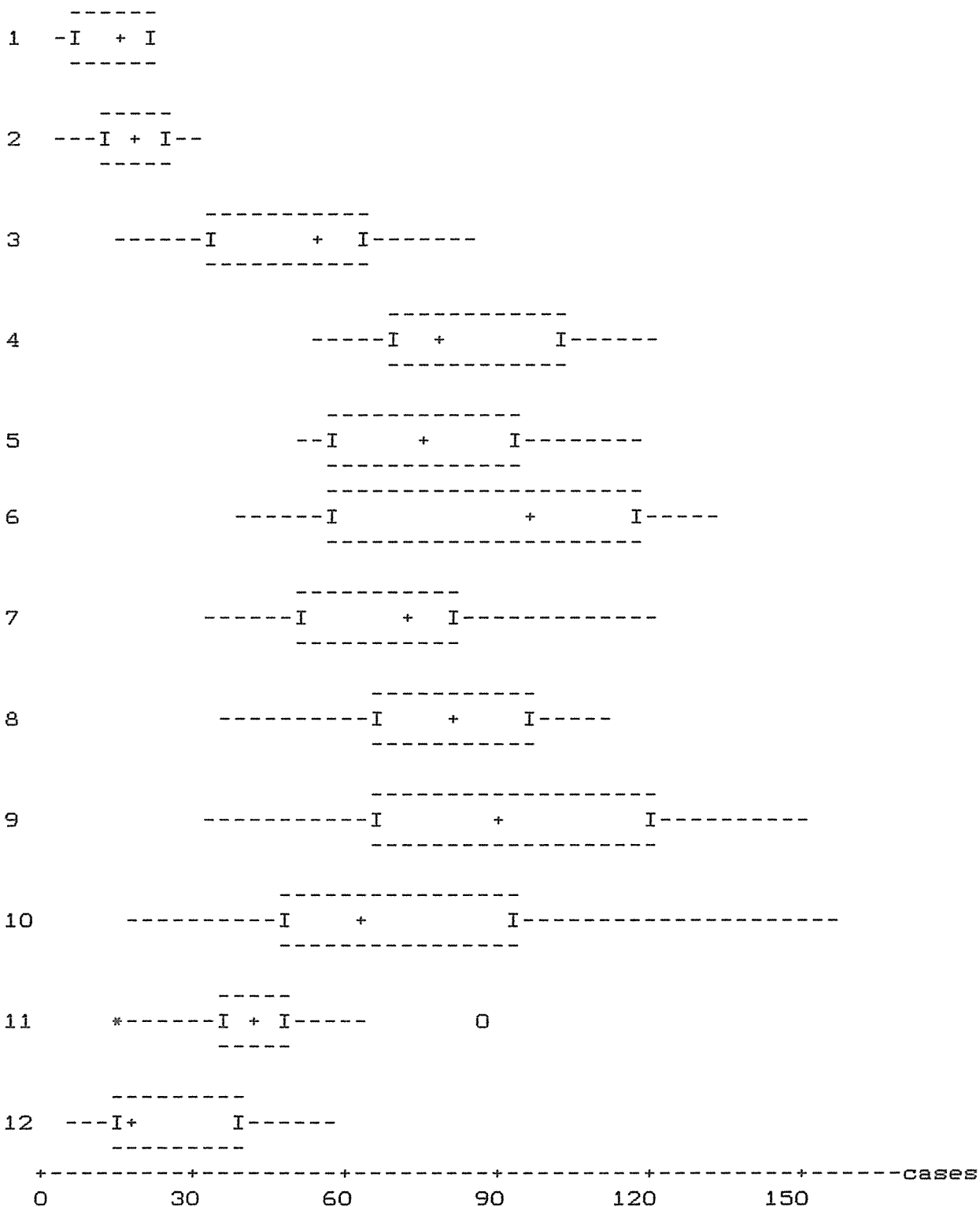
The boxplots below indicate that spinach prices were seasonal. The overall pattern was for prices to be lowest in April May, and June, and relatively high from August to February.

Month



The volume pattern depicts volumes as being high throughout the winter and lowest in the summer months of December, January, and February.

Month



17 SPRING ONIONS

The Yates seed catalogue describes two varieties of spring onions. Both mature early and cannot be stored.

Spring onions are planted out in autumn, which should result in bulbs which would be mature in December, Ballinger (1980).

1 The expected behaviour of prices

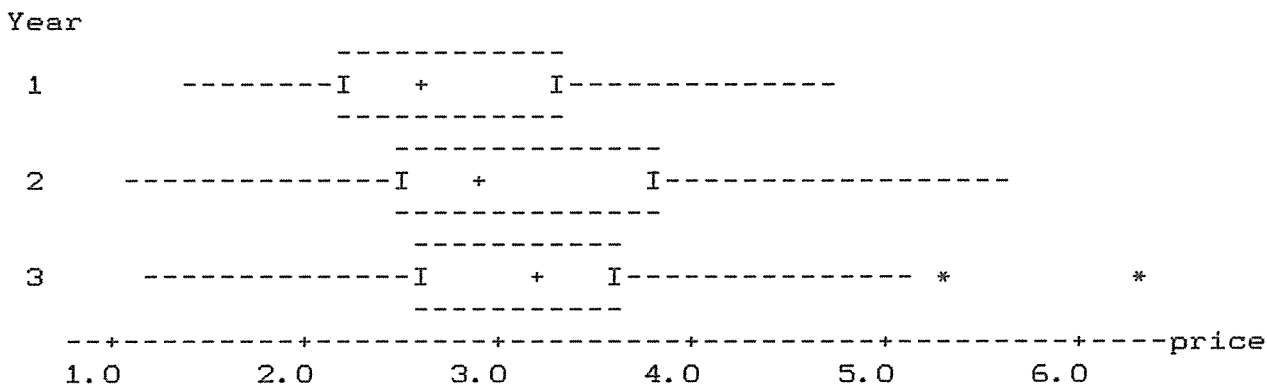
This vegetable cannot be stored to maintain levels of supply. We would expect volumes to be highest in early summer and falling away towards the end of summer. Consequently prices will be expected to be lowest in early summer and rising at the end of summer. The period of lowest supply will probably be mid winter when photoperiod is shortest. We would expect this to be the time of highest price. As photoperiod started increasing so should supply. Prices should also begin falling.

2 The behaviour of spring onions at auction

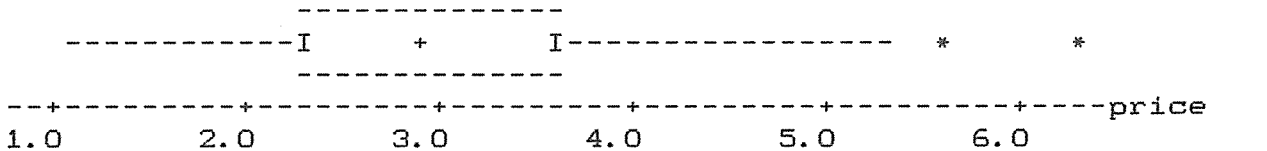
Spring onions were supplied for the full period of time under study.

The mean yearly price rose by about 14% in year 2 and then by about 2% in year 3. See table 13.

Median weekly price increased in successive years. The range of prices in successive years remained about the same with two outliers observed in year 3.



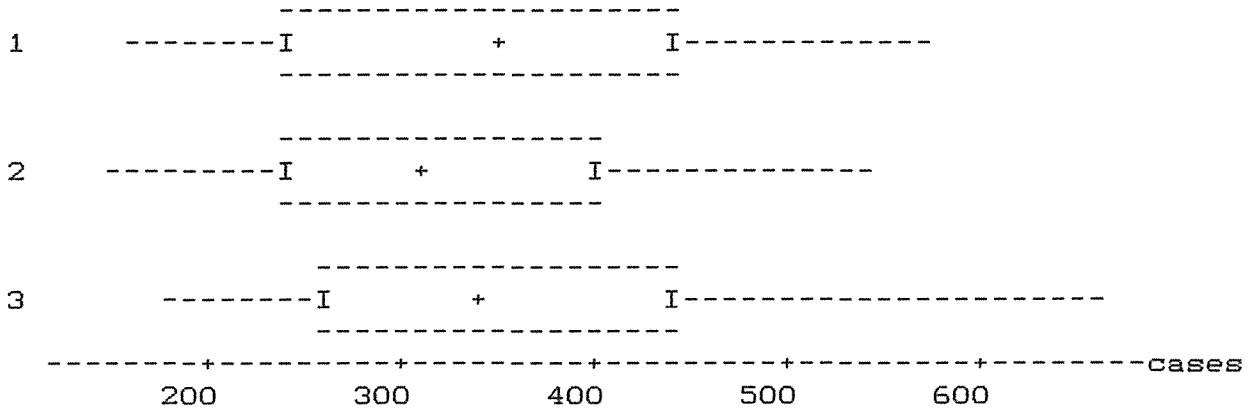
For the entire series price was quite symmetrical about a median of \$2.87. The lowest price received was \$1.06, and the highest was \$6.29.



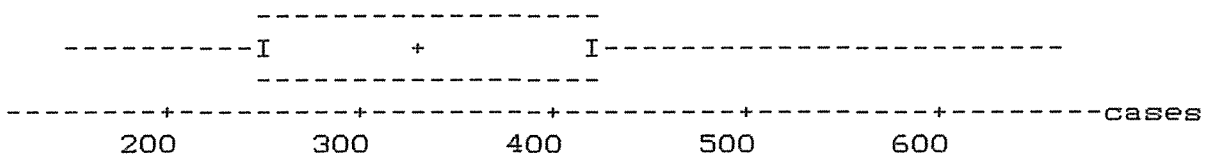
Volume declined by about 6% in year 2 and then increased by about 14% in year 3. See table 14.

Median weekly volume fell in year two and then increased in year 3 to slightly below the year 1 level. The variability in weekly volume was greater in year 3 than in years 1 and 2.

Year



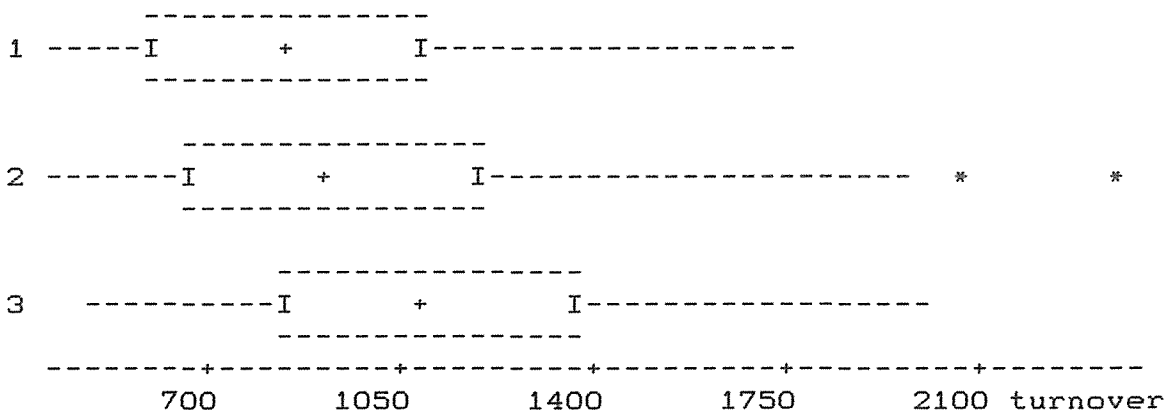
For the entire series, volume was right skewed about a median of 334 cases. The smallest weekly volume was 154 cases, and the greatest, 568 cases.



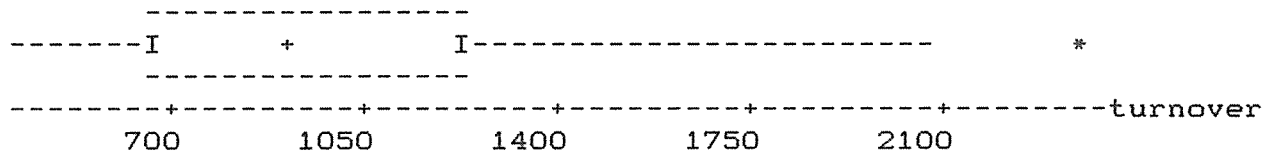
Yearly turnover increased in successive years. In year 2 it increased by about 11% and in year 3 it increased by about 10%. See table 15.

Median weekly turnover increased in successive years, becoming slightly more variable.

Year



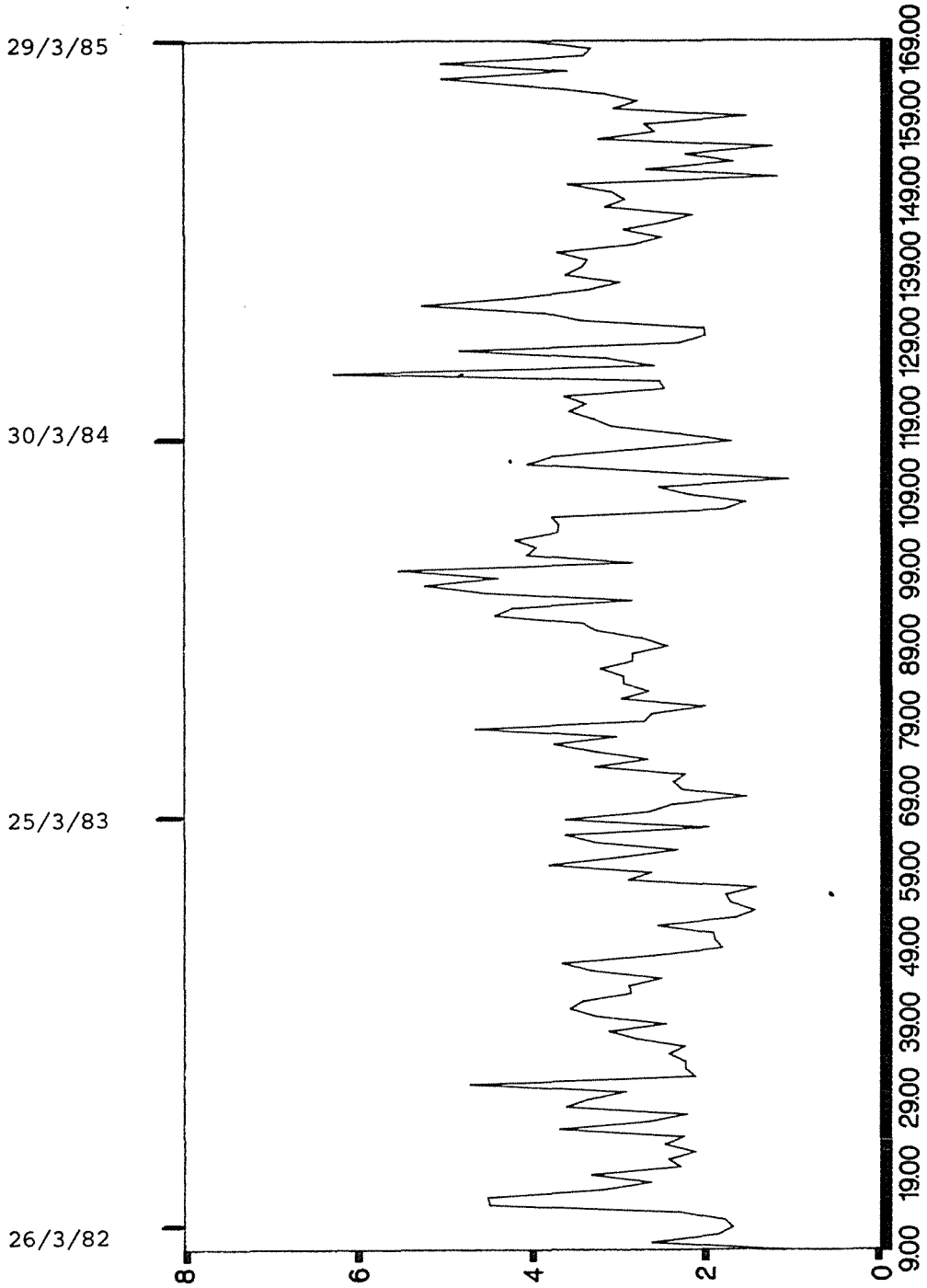
For the entire series, weekly turnover was right skewed about a median of \$923.00, with a low value of \$426.00 and a high value of \$2335.00.



Price was slightly more variable than volume.

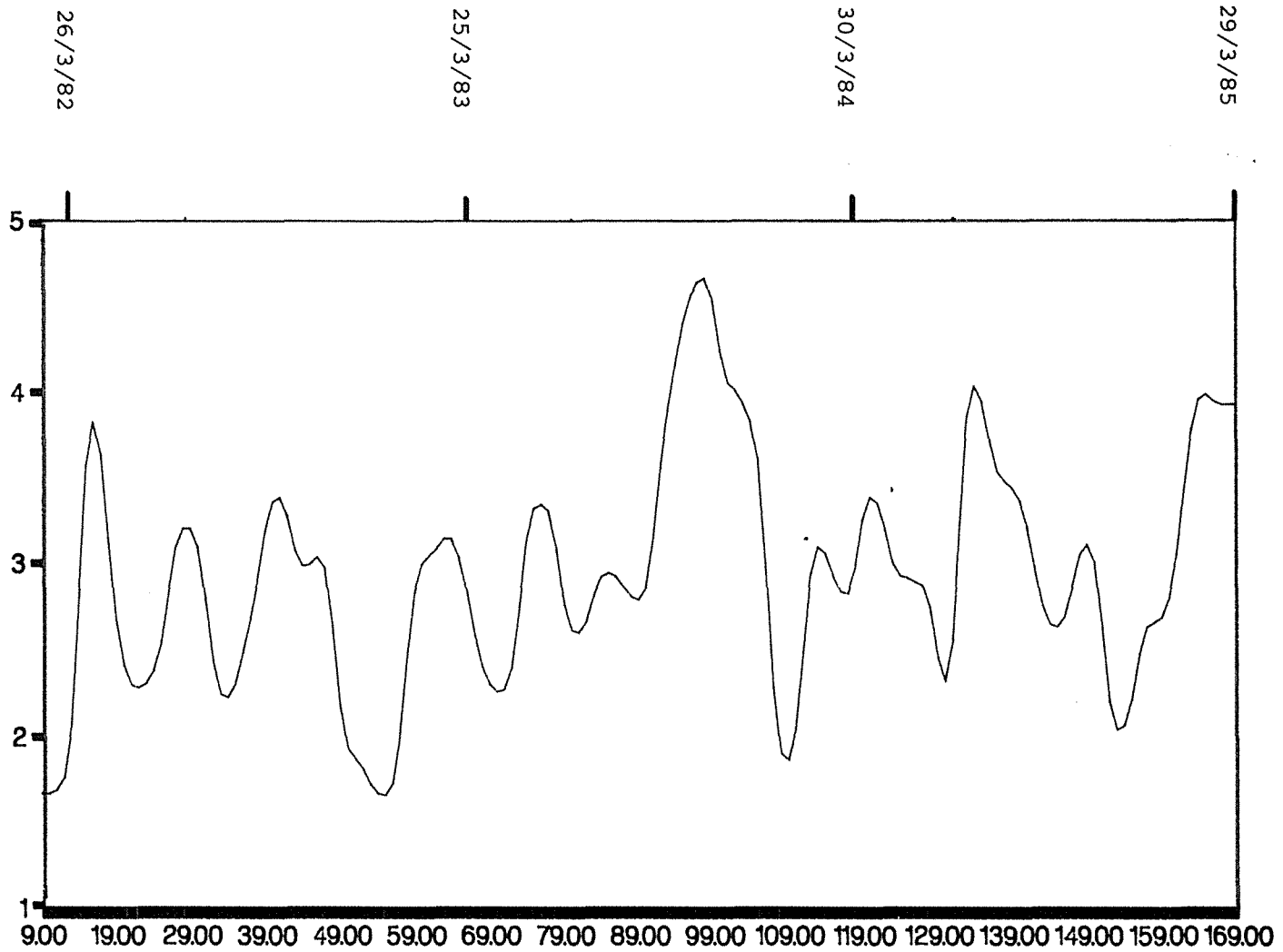
coefficient of variation

price	.37
volume	.33
turnover	.40



week rank from 1.1.82 to 29.3.85

smoothed price of spring onions



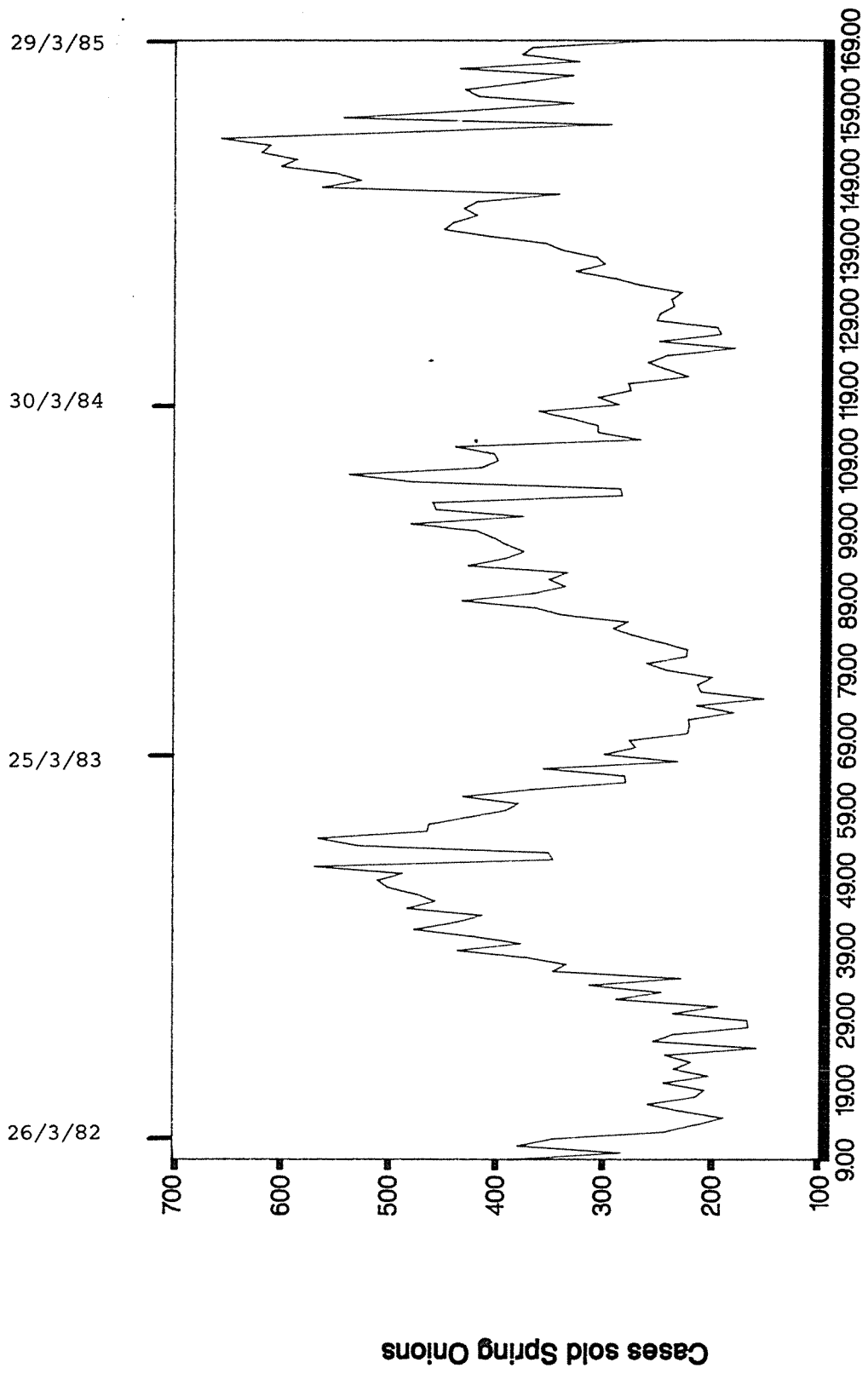
week rank in period 1-1-82 to 29-3-85

26/3/82

25/3/83

30/3/84

29/3/85



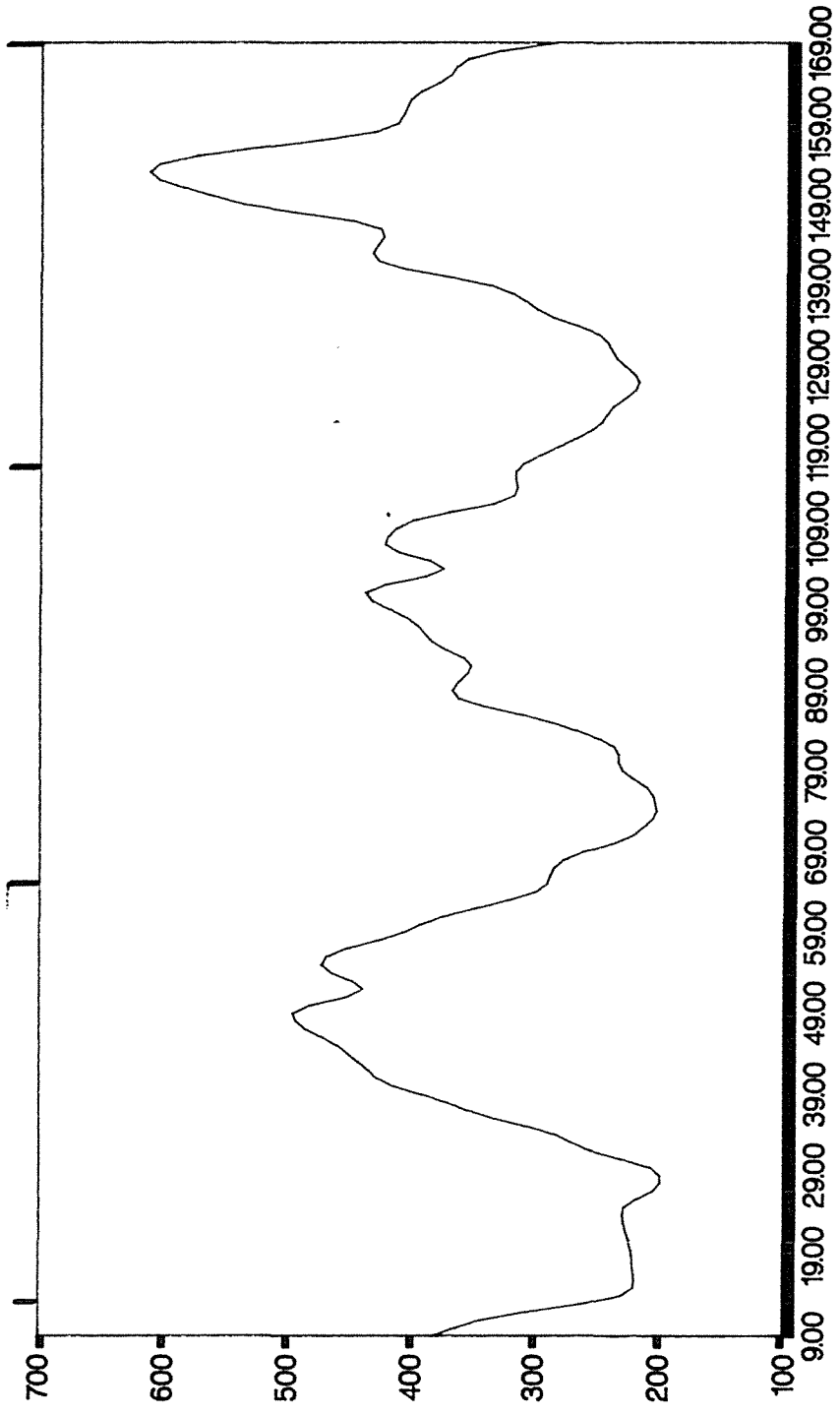
week rank from 1.182 to 29.3.85

29/3/85

30/3/84

25/3/83

26/3/82



smoothed volume of spring onions

week rank in period 1-1-82 to 29-3-85

Reviewing the smoothed price series reveals about four peaks in each year. They do not occur at the same time and they are not of constant amplitude. These peaks occur most frequently in the months of March, April, July, and November.

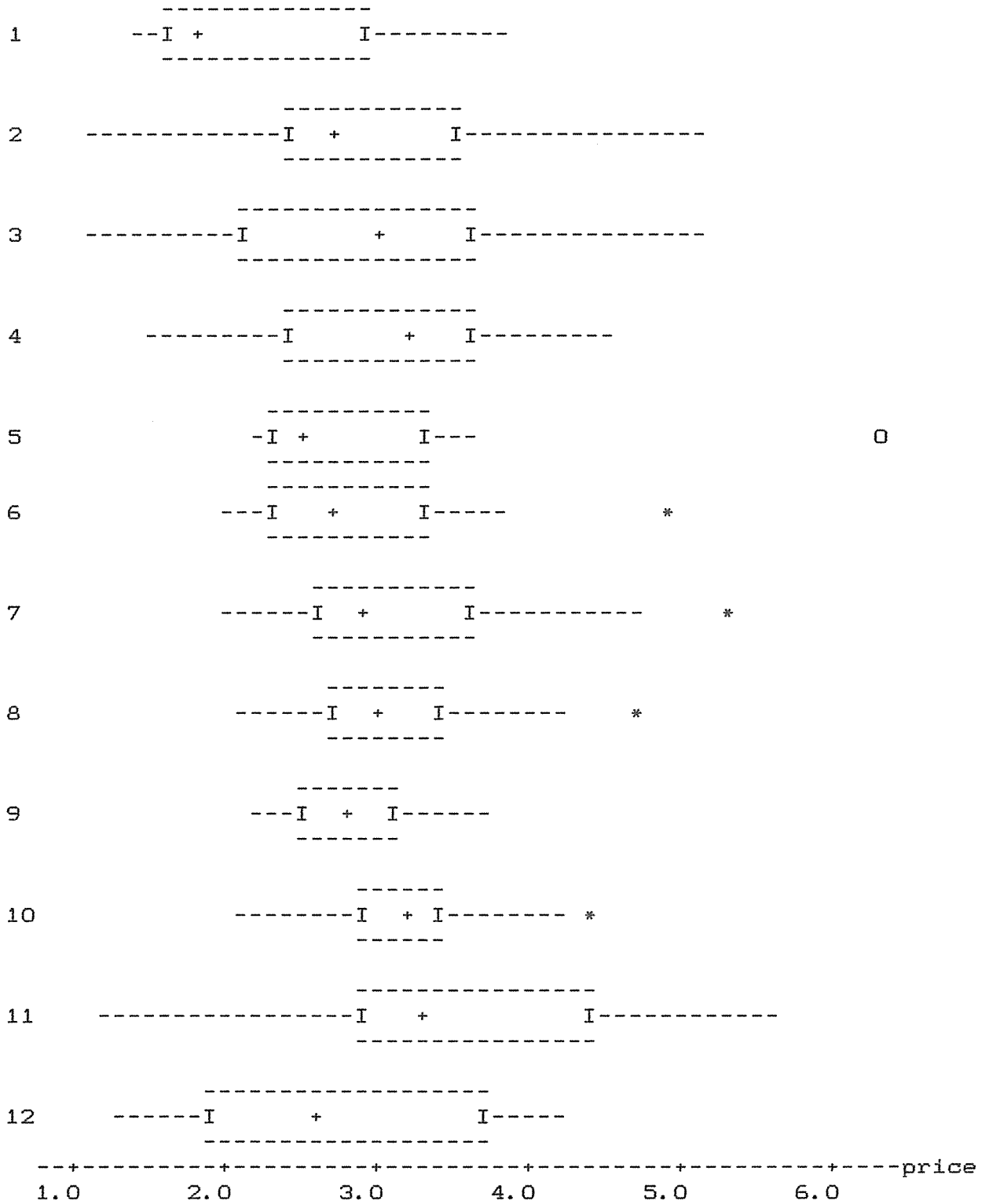
The smoothed volume series reveals one supply peak. In the first two years quantities brought to market were quite constant from the beginning of April to about the end of July. At the beginning of August volume increased. It peaked in the beginning to middle of December and then fell away to the off-season low at about the end of March.

In year 3, the low volume part of the season was shorter than for years 1 and 2. Volume started to rise at the beginning of July, about a month earlier than in the preceding two years.

The following boxplots indicate that the time of lowest price was generally the time of highest supply.

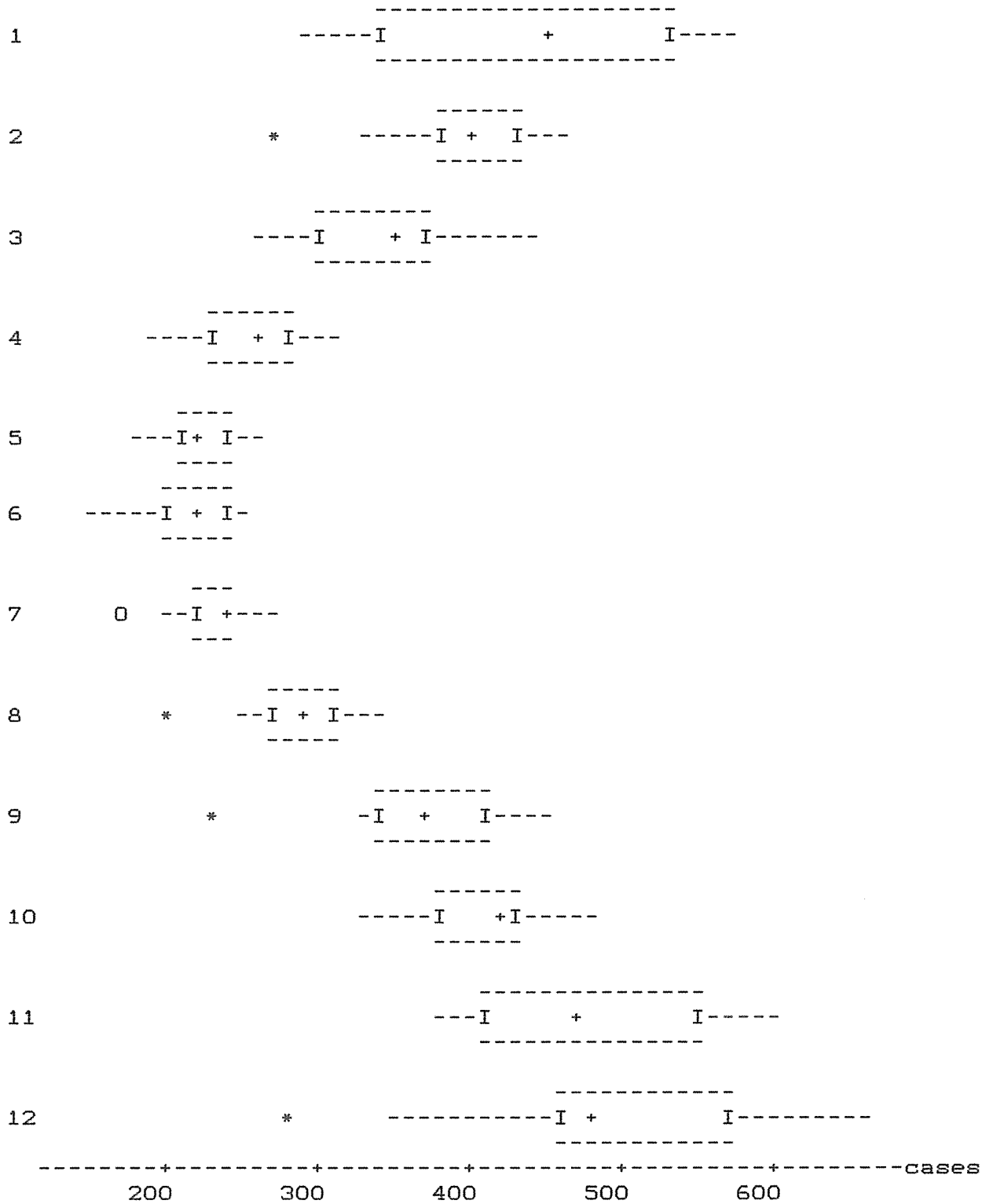
The boxplots of price by month fluctuate a great deal, but in general prices were lowest in summer and highest in winter.

Month



The volume boxplots indicate that volumes were lowest in May, June and July, and were highest in November, December, and January. The month of highest volumes was December.

Month



18 TOMATOES

Tomatoes are grown all year round. The crop is grown in glass houses in winter and outdoors in summer. It was noted earlier in this report that about two thirds of annual tomato volumes are grown under glass.

The Yates seed catalogue describes many varieties whose maturity ranges from extra-early to medium.

According to Ballinger (1980) seedlings are planted out when the danger of frost has passed. This is at the end of October or early November. Earlier plantings are made in warmer regions and with the aid of protection.

During growth tomatoes require constant attention. They must be weeded, watered and sprayed and mature in about 100 days.

Thompson and Kelly (1957) comment that market quality is adversely affected by both high and low temperatures. Chemical treatments can be used to improve the setting of fruit when weather conditions are adverse.

Supply can be manipulated by picking at the mature-green stage and artificially ripening.

1 The expected behaviour of prices

Volumes and yield peak at the end of summer. Depending on the particular weather experienced, this could be in about late February or early March. Prices would be expected to be lowest at this time. Because this vegetable is grown under glass in winter we would expect prices and volumes to be relatively constant during this time, but with prices probably being highest in the middle of winter. Prices will be relatively high and should start falling as volumes begin rising with early outdoor varieties at the beginning of summer. We can expect summer demand to be higher than winter demand and this might offset some of the effect greater supply at summer.

Tomatoes are irrigated in summer. We would expect lack of rainfall to have little effect on quantities. Excessive rainfall might cause yields to be lower and of lower quality.

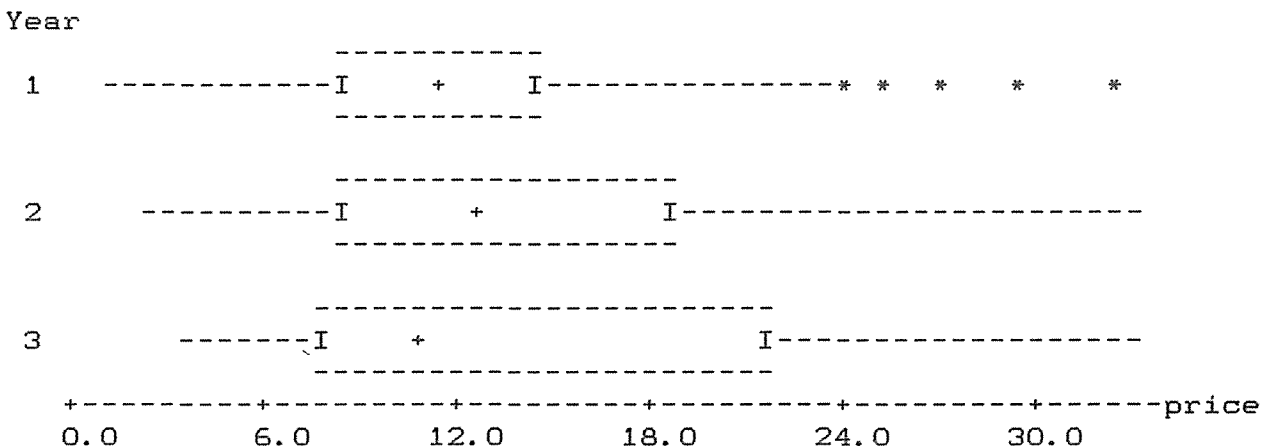
We would expect weather to have no influence on yields in winter because the crop is grown under glass. Low temperatures will occur at the time of low supply but any change in winter temperatures are not likely to cause changes in production. They may however cause changes in demand. Fresh tomatoes are primarily a salad vegetable and in the very cold winter months demand for tomatoes will probably be lowest.

2 The behaviour of tomatoes at auction

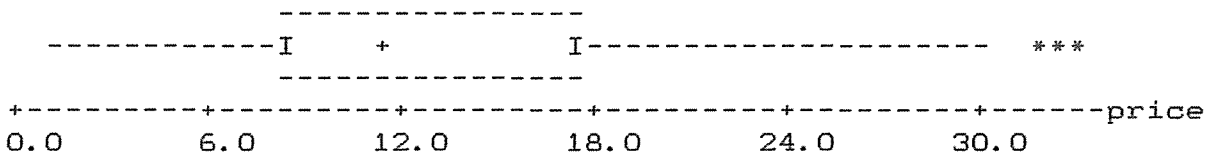
Tomatoes were supplied in all weeks under study and had the largest turnover of all of the vegetables studied.

The mean yearly price has risen in each year. In 1984 it was about 11% higher than in 1983. In 1985 it was about 1% higher than in 1984. See table 13.

The boxplots below indicate that median weekly price has in fact fallen. In years 2 and 3 prices have bunched at the lower end of the scale. This means that for at least 50% of the time, prices were lower than the median. The range of prices received was about the same in each year.



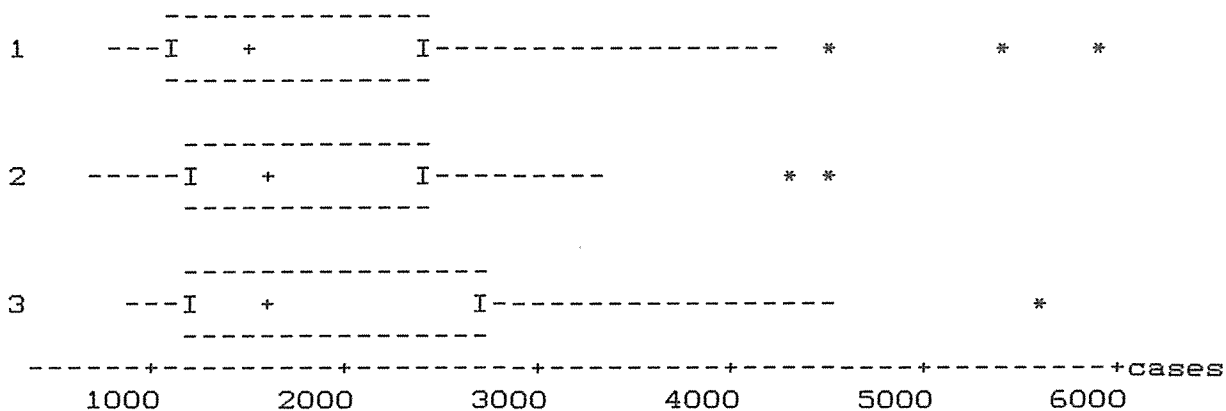
For the entire series price was right skewed about a median of \$11.10 with a low price of \$1.23, and a high price of \$33.16.



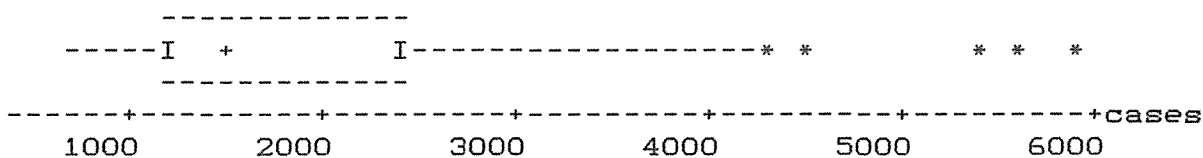
Volume fell by about 4% in year 2 and then increased by about 9% in year 3. See table 14.

In each year, median weekly volume has remained about the same. Variation in weekly volume was almost identical for years 1 and 3. Less variation was experienced in year 2 than in the other two years.

Year



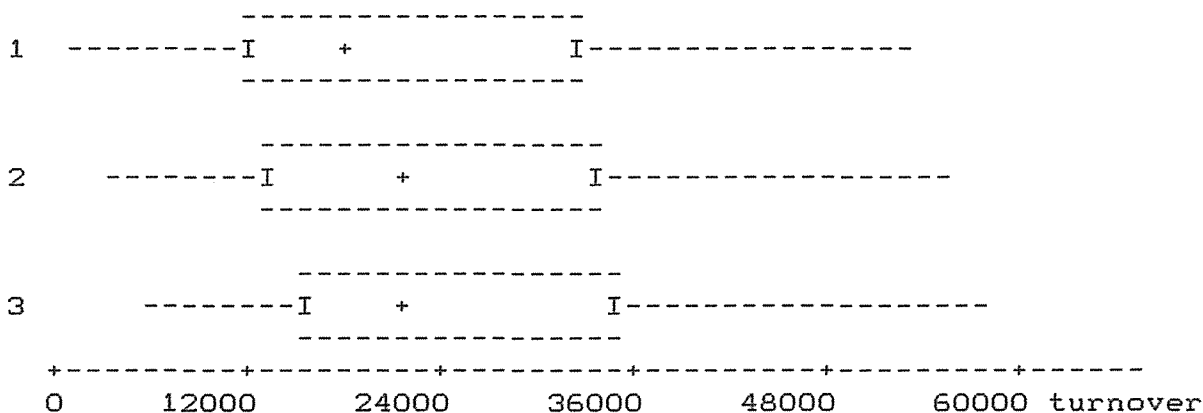
For the entire series weekly volume was right skewed about a median of 1549 cases. The minimum weekly volume for the three years in the study was 700 cases and the maximum was 5896 cases.



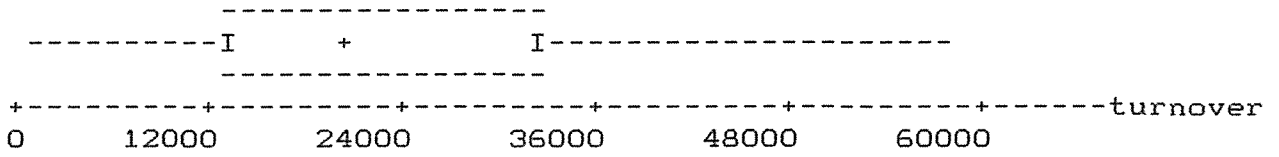
Turnover increased by about 7% in year 2 and then fell by about 3% in year 3. See table 15.

The distribution of weekly turnover has moved to the right in successive years and the variation has remained about the same. Median turnover has increased in successive years.

Year



For the entire series turnover was right skewed about a median of \$20333.00. Lowest weekly turnover was \$1271.00 and highest was \$57089.00.

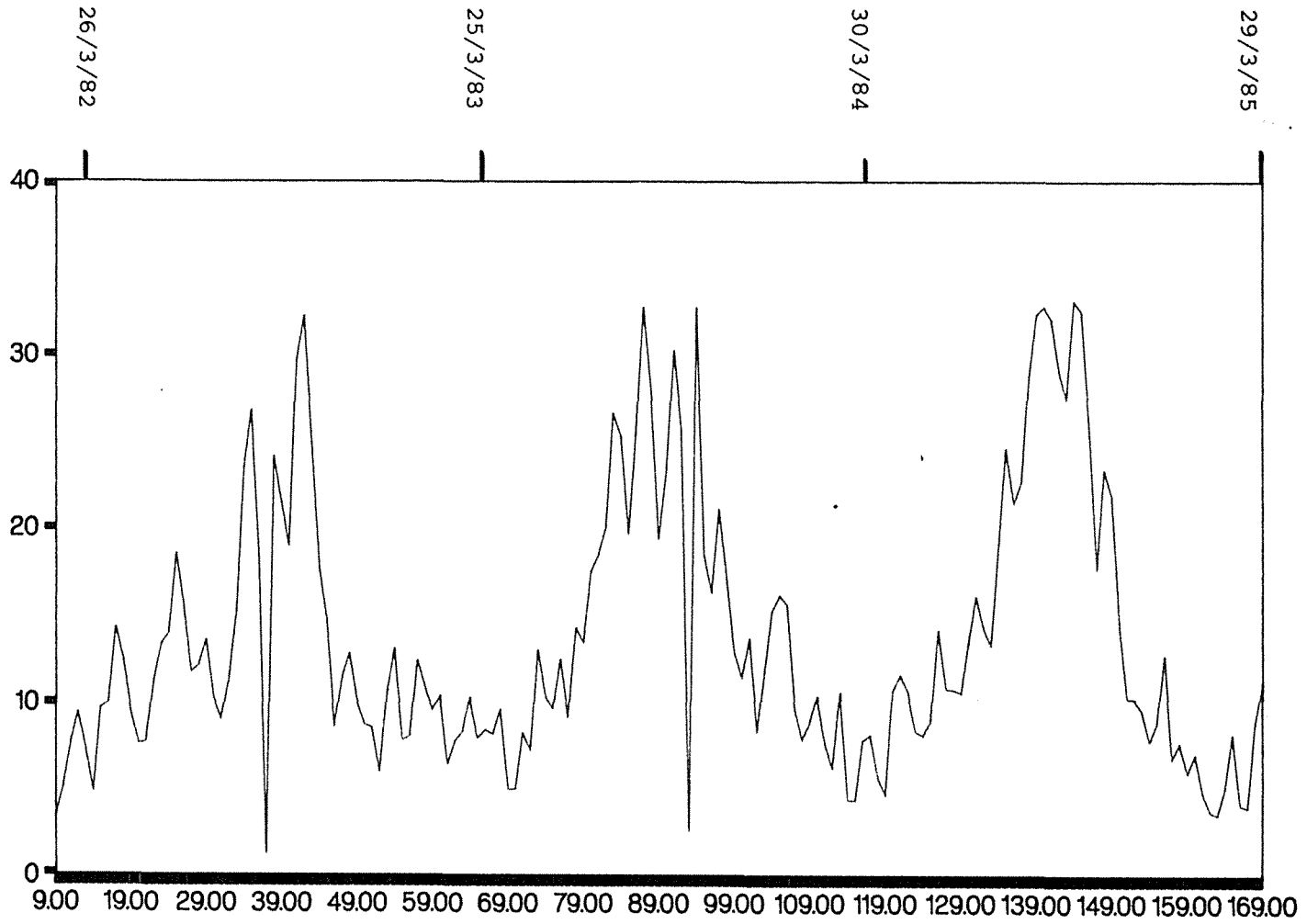


Both price and volume were quite variable with prices being a little more variable than the volume.

coefficient of variation

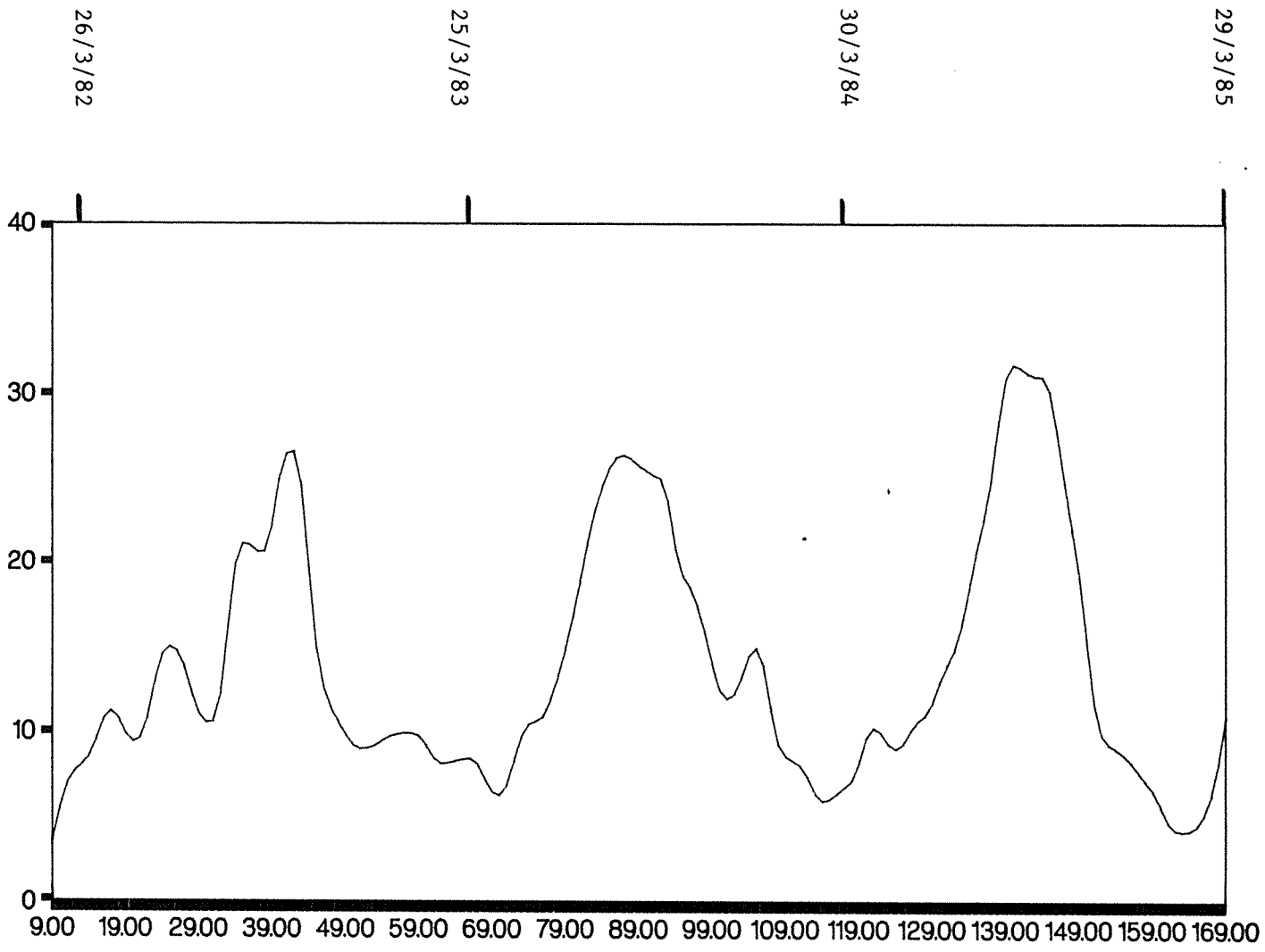
price	.57
volume	.53
turnover	.54

price per case of Tomatoes



week rank from 1.182 to 29.385

smoothed price of tomatoes



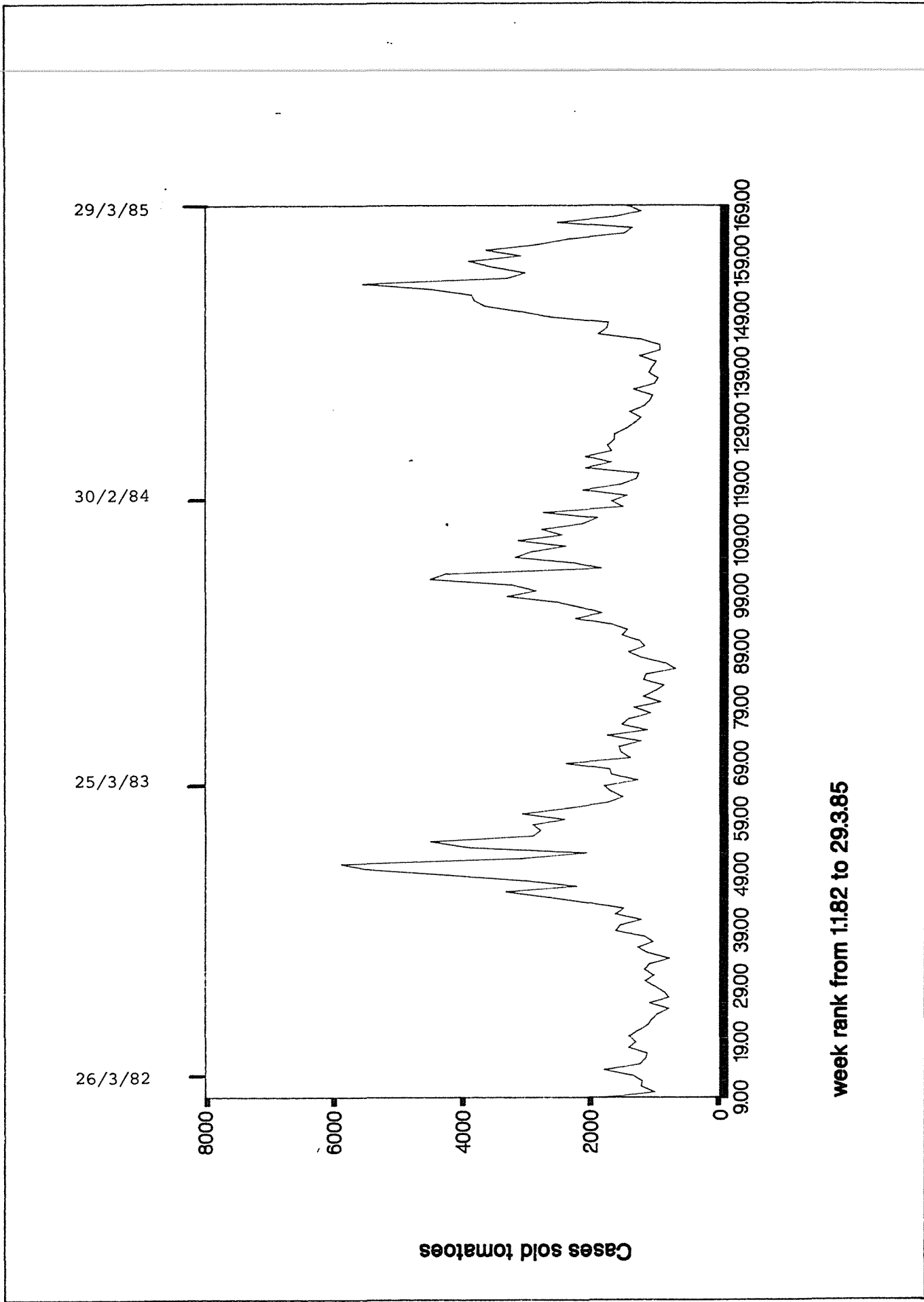
week rank in period 1-1-82 to 29-3-85

26/3/82

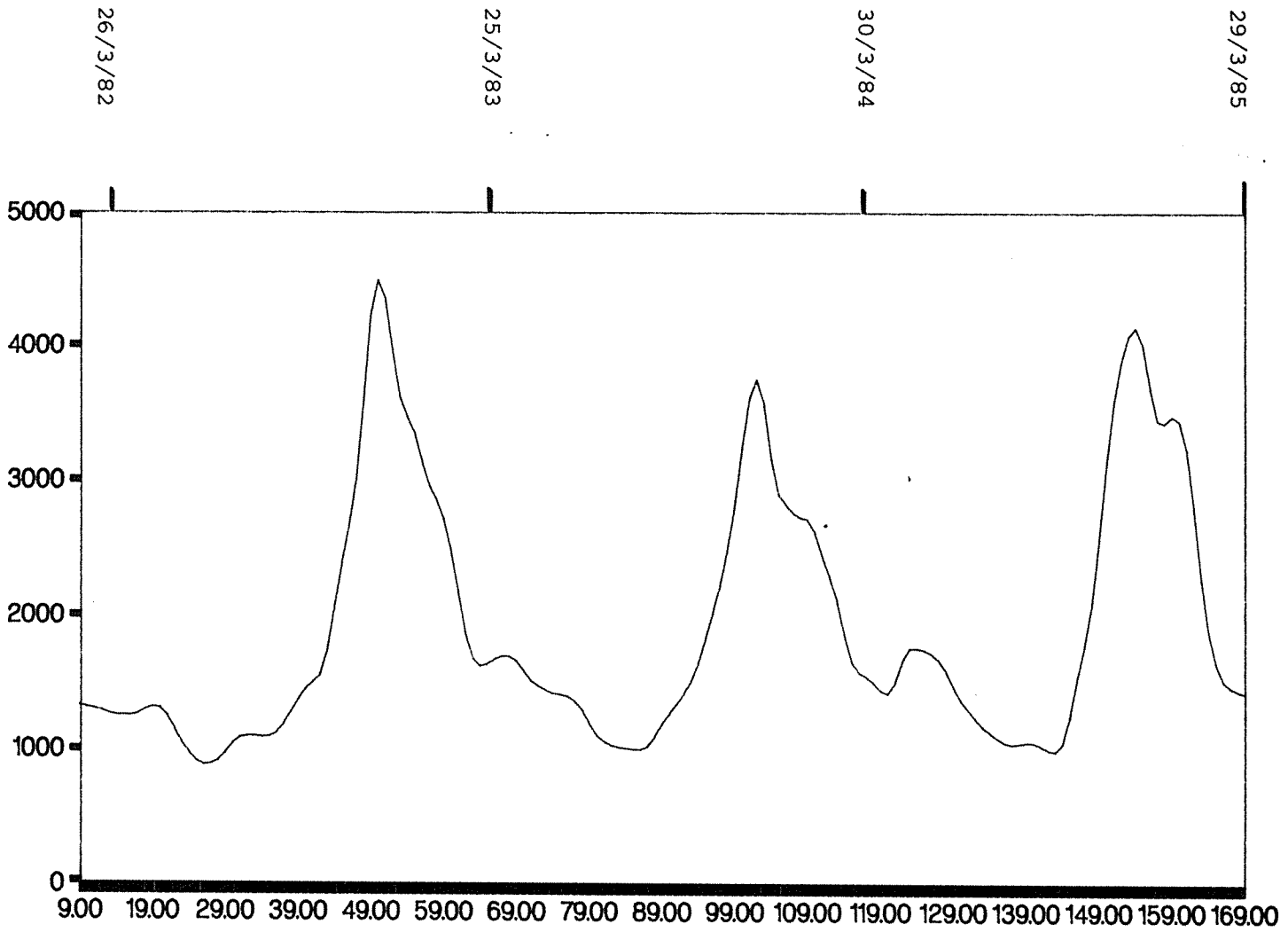
25/3/83

30/3/84

29/3/85



smoothed volume of tomatoes



week rank in period 1-1-82 to 29-3-85

Reviewing the smoothed price series reveals three peaks in year 1, two peaks in year 2, and 1 peak in year 3. The major peaks occurred in October in year 1 and mid August to mid October in years 2 and 3.

Reviewing the smoothed volume series indicates that the secondary peaks in the smoothed price series were not due to changes in volume.

The smoothed volume series reveals 29 or 30 weeks when volumes are fairly constant followed by a period where volumes peak and then fall back to the relatively constant off-season position.

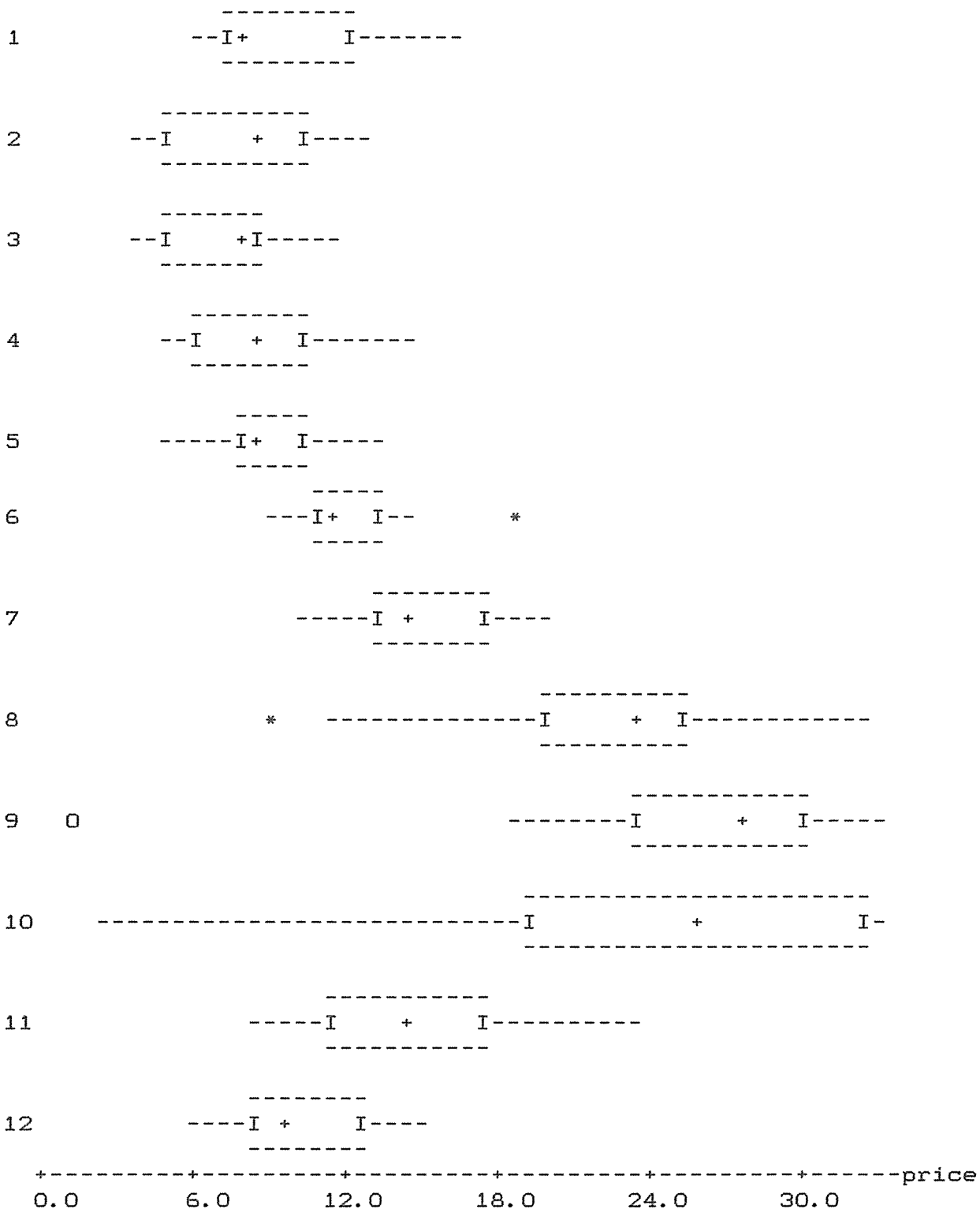
The low volume period is from early March to the end of September.

Volumes consistently peaked in mid December. The time of lowest supply was not as consistent as the time of highest supply.

Lowest volumes were from mid June to mid September in year 1; mid July to mid September in year 2; and early August to early October in year 3.

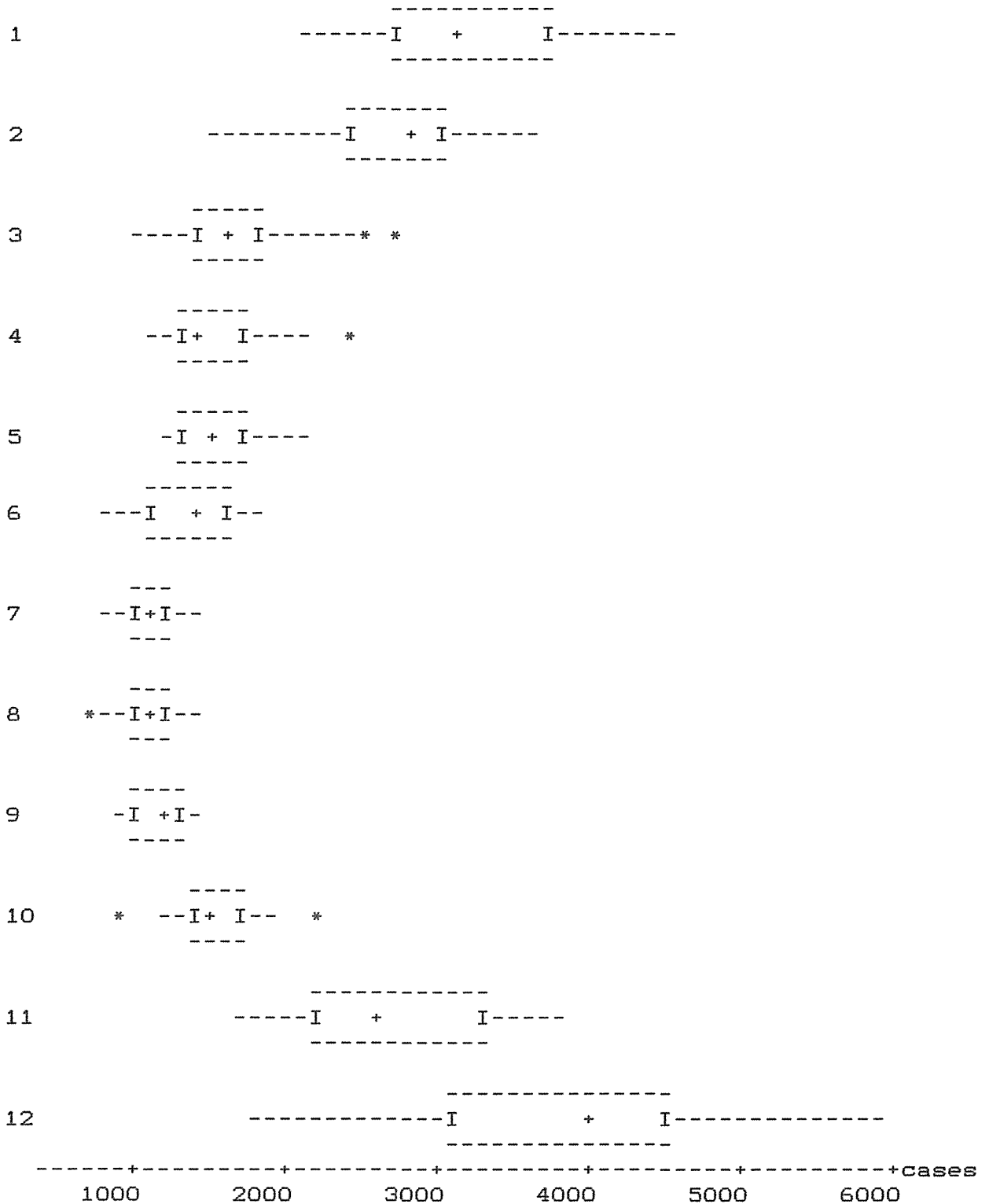
Tomato prices peak in September and October and then decline to be lowest in summer and early autumn, in March. One season each year is indicated. The long left whisker in October is probably due to an increase in volume on the floor.

Month



Tomato volumes were lowest during winter, especially in July, August, and September. Volumes were highest in summer and peaked in December. The time of highest supply corresponds to the time of lowest price. The time of highest price was a little later than the time of lowest supply.

Month



19 Descriptive statistics

A comparison of price for each vegetable for the three years ending March 31 is given below.

Table 13 Average price of each vegetable in the years ending 31 March 1983, 1984, & 1985 (nominal \$)

VEGETABLE	MEAN PRICE	% CHANGE	STD DEV	MINIMUM PRICE	MAXIMUM PRICE	VALID N
Broccoli						
1983	6.041		2.332	2.58	11.96	53
1984	7.256	+20.1	3.758	1.10	17.23	52
1985	7.913	+ 9.1	2.856	1.85	14.47	52
Brussel sprouts						
1983	12.685		2.884	5.31	20.22	37
1984	14.045	+10.7	3.628	7.52	23.90	34
1985	14.116	+ 0.5	3.338	7.82	20.44	37
Cabbage						
1983	4.487		2.013	1.52	8.97	53
1984	5.617	+25.2	2.916	1.52	11.75	52
1985	5.104	- 9.1	2.952	2.11	17.16	52
Capsicum						
1983	12.844		6.579	3.40	26.39	53
1984	11.762	- 8.4	6.415	3.51	27.77	52
1985	9.368	-20.4	5.778	2.33	24.71	52
Cauliflower						
1983	6.026		2.304	1.62	11.40	53
1984	7.490	+24.3	2.306	3.00	14.82	52
1985	8.392	+11.2	2.288	4.05	13.47	52
Celery						
1983	9.060		5.571	2.50	25.84	53
1984	9.153	+ 1.0	7.047	1.99	26.29	52
1985	9.979	+ 9.0	4.932	3.72	24.78	52
Garlic						
1983	6.588		2.937	2.03	20.94	52
1984	3.277	-50.3	1.255	1.80	7.67	51
1985	2.754	-16.0	1.277	.74	8.06	52
Kumara						
1983	22.489		10.336	9.00	54.97	53
1984	19.945	-11.3	6.007	6.32	36.15	52
1985	15.066	-24.5	5.579	2.10	30.47	52

VEGETABLE	MEAN PRICE	% CHANGE	STD DEV	MINIMUM PRICE	MAXIMUM PRICE	VALID N

Leeks						
1983	9.519		2.506	.85	15.86	44
1984	8.447	-11.3	3.400	4.23	18.54	41
1985	10.790	+27.7	2.707	6.08	18.13	37
Lettuce						
1983	4.399		2.783	.65	12.62	53
1984	6.189	+40.7	2.839	1.33	11.44	52
1985	6.619	+ 7.0	2.226	1.97	10.74	52
Mushrooms						
1983	12.779		1.919	8.69	16.13	53
1984	11.183	-12.5	2.522	4.94	15.19	52
1985	11.982	+ 7.1	2.454	7.43	18.51	52
Onions						
1983	5.526		1.515	3.16	8.66	53
1984	6.759	+22.3	3.953	2.44	15.13	52
1985	10.203	+51.0	3.227	4.38	18.04	52
Parsnips						
1983	13.520		5.776	1.30	32.78	53
1984	16.263	+20.3	4.174	6.98	27.39	52
1985	14.275	-12.2	4.888	6.20	30.58	52
Pumpkins						
1983	8.532		6.517	1.70	28.50	53
1984	8.472	- 0.7	3.375	2.43	16.27	52
1985	3.289	-61.2	1.541	1.12	8.34	52
Silverbeet						
1983	4.504		2.508	1.04	10.92	53
1984	5.058	+12.3	3.247	1.17	14.93	52
1985	4.423	-12.6	2.345	1.05	12.02	52
Spinach						
1983	6.305		2.955	1.22	13.75	48
1984	8.258	+31.0	4.699	1.82	18.14	49
1985	8.292	+ 0.4	4.629	1.82	21.63	51
Spring onions						
1983	2.725		.778	1.43	4.72	53
1984	3.103	+13.9	.959	1.06	5.56	52
1985	3.174	+ 2.3	.991	1.19	6.29	52
Tomatoes						
1983	12.884		6.347	1.23	32.23	53
1984	14.346	+11.3	7.715	2.56	32.80	52
1985	14.455	+ 0.8	9.068	3.59	33.16	52

A comparison of total cases sold and total turnover for each vegetable for the three years ending 31 March 1983, 1984, and 1985 is given respectively in tables 14 and 15 below.

 Table 14 Total Volume year ended 31 March

	1983	% CHANGE	1984	% CHANGE	1985
Broccoli	11571	+ 4.9	12136	+ 0.9	12247
Brussel Sprouts	5585	-16.3	4675	+ 8.3	5064
Cabbage	49063	-12.3	43023	-13.1	37393
Capsicum	4848	+11.5	5475	+43.9	7878
Cauli	57341	-23	44151	- 9.2	40088
Celery	17266	-38.4	12473	+19.8	14943
Garlic	3010	- 7.1	2796	+ 9.4	3059
Kumara	9344	+29.2	12011	+ 6.6	12800
Leeks	8198	-10	7381	-18.8	5992
Lettuce	60788	+ 5.1	57664	+12.2	64674
Mushrooms	15641	+24.7	19510	+ 2.3	19961
Onions	18871	- 0.2	18830	+33.8	25188
Parsnips	7899	-13.4	6837	- 1.3	6746
Pumpkins	15097	- 2.4	14731	+36.2	20063
Silverbeet	9426	- 3.1	9136	+ 2.4	9355
Spinach	3032	- 8.8	2764	+25.4	3465
Spring Onions	17928	- 6.3	16795	+13.7	19102
Tomatoes	101738	- 3.7	97991	+ 8.7	106483

 Table 15 Total turnover for the year ended 31 March

	1983	% CHANGE	1984	% CHANGE	1985
Broccoli	64187	+28.7	82596	+10.8	91485
Brussel Sprouts	70810	-13.2	61449	+ 7.7	66156
Cabbage	218072	+ 6.6	232450	-24.6	175330
Capsicum	45568	+13.3	51639	+ 4.4	53895
Cauli	315293	- 0.7	313245	+ 2.3	320333
Celery	133223	-38.0	82655	+61.1	133183
Garlic	17635	-49.9	8932	+ 2.4	8953
Kumara	190205	+21.5	231048	-17.7	190152
Leeks	77566	-32.7	52214	+16.8	60991
Lettuce	242287	+34.2	325128	+28.9	419073
Mushrooms	199750	+ 6.8	213299	+10.5	235687
Onions	93342	+28.8	120201	+91.9	230683
Parsnips	97225	+12.0	108894	-15.2	92340
Pumpkins	117708	+ 6.5	125341	-51.8	60401
Silverbeet	40090	+ 8.3	43400	- 9.7	39205
Spinach	15735	+36.9	21537	+ 4.6	22519
Spring Onions	47172	+11.3	52514	+ 9.6	57559
Tomatoes	1230734	+ 6.6	1312761	- 2.6	1278108

The percentages in tables 13, 14, and 15 were calculated as follows:

$$\% \text{ change} = [(X_n + 1)/X_n] - 1$$

20. Summary

In conclusion, we see that variation in price does not follow variation in quantity as closely as might be expected. Furthermore, highest prices do not necessarily occur at the time of lowest supply. Lowest prices also do not always occur at the time of highest supply. Infact, for some vegetables high prices follow lowest supply. That is, prices are often lowest in the month following the month of highest supply.

This may have something to do with buyers not being sure about the available supply. Their bidding may reflect a lack of information about future supply and when supply starts to fall they perhaps over-react. On the other hand, growers may, in response to a high price, bring more produce to market and buyers perhaps miscalculate the quantity on the floor.

It is clear from the boxplots and summary statistics that for most vegetables weekly prices and volumes vary considerably within and between years. Weekly prices in general varied more than weekly volumes.

For some vegetables average year's price and volume changed in opposite directions while for others changes were in the same direction.

For some vegetables when both median price and volume increased, the increase in one of the variables was considerably less in percentage terms than the other.

The following table presents the coefficient of variation for weekly price and volume for each vegetable over the full three year period.

A coefficient close to zero means that the standard error is small relative to the mean. Thus the variable has small variance.

 Table 17 Coefficient of variation

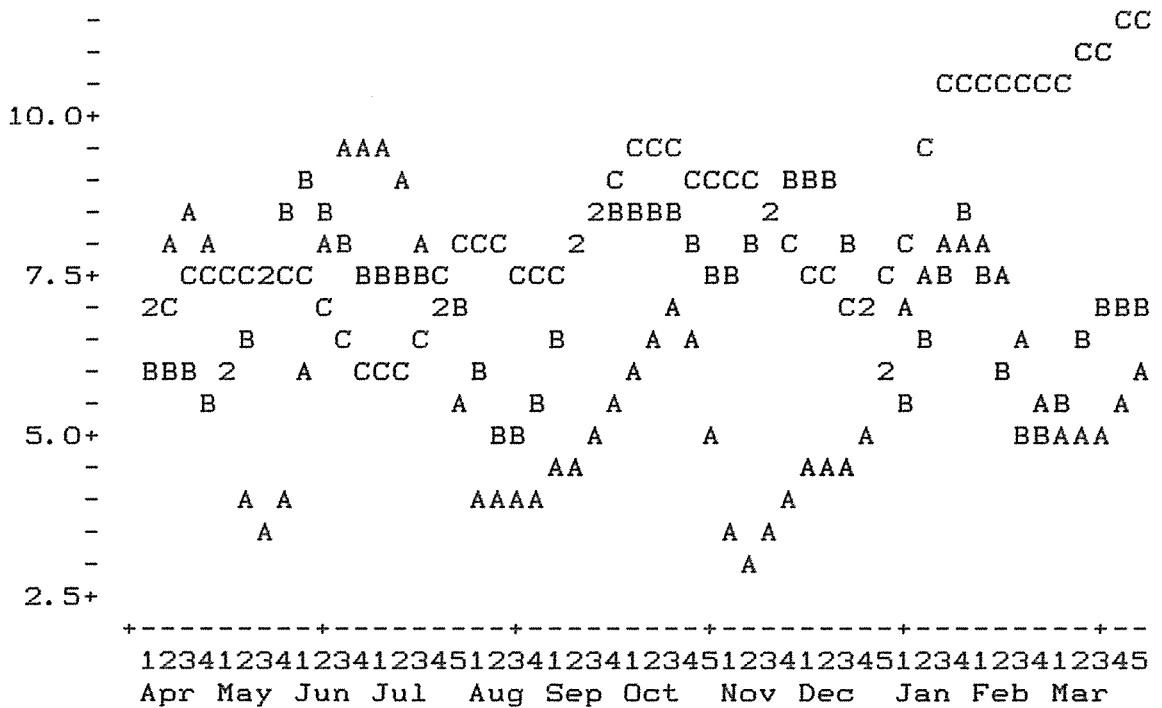
	price	volume
broccoli	.44	.42
brussels sprouts	.63	.24
cabbage	.52	.31
capsicum	.57	.69
cauliflower	.34	.37
celery	.65	.51
garlic	.62	.64
kumaras	.43	.34
leeks	.31	.70
lettuce	.50	.36
mushrooms	.20	.20
onions	.48	.53
parsnips	.34	.41
pumpkins	.74	.54
silverbeet	.58	.23
spinach	.56	.56
spring onions	.37	.33
tomatoes	.57	.53

Mushroom prices had the lowest variance and pumpkin prices the greatest variance. Mushroom volumes had the lowest variance and leek volumes the highest variance.

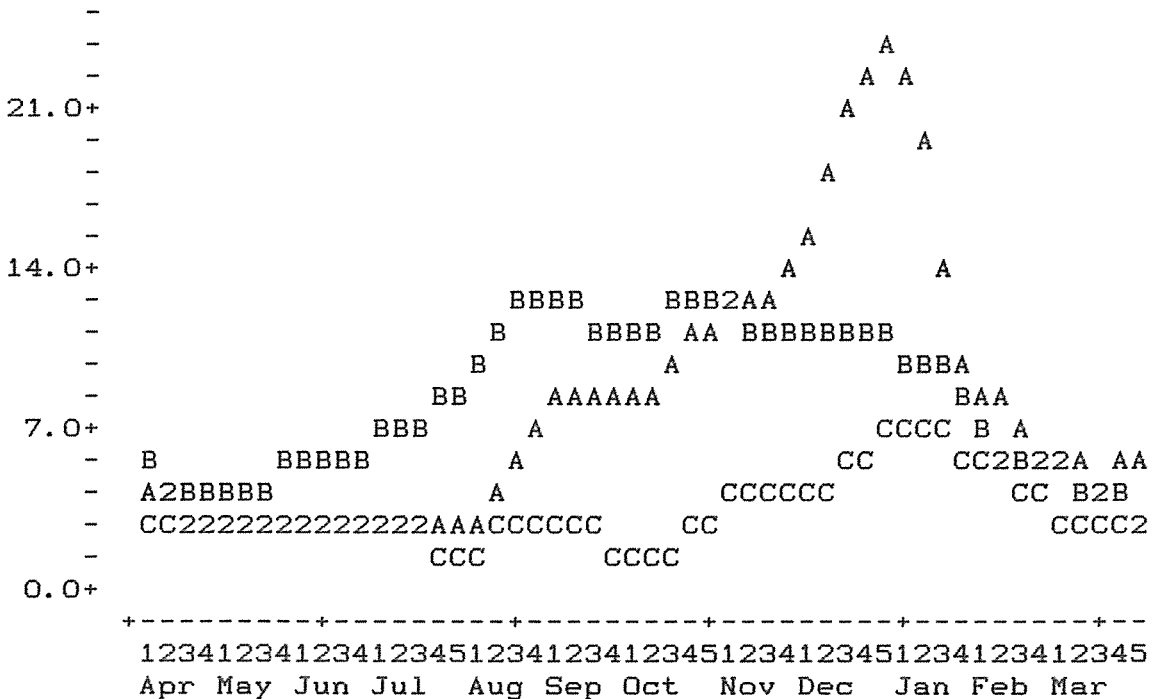
3. Vegetables with similar price patterns

Other vegetables exhibited similar patterns from year to year, but these patterns were displaced. These vegetables were cauliflower, pumpkins, parsnips, and spring onions, and their patterns are plotted below.

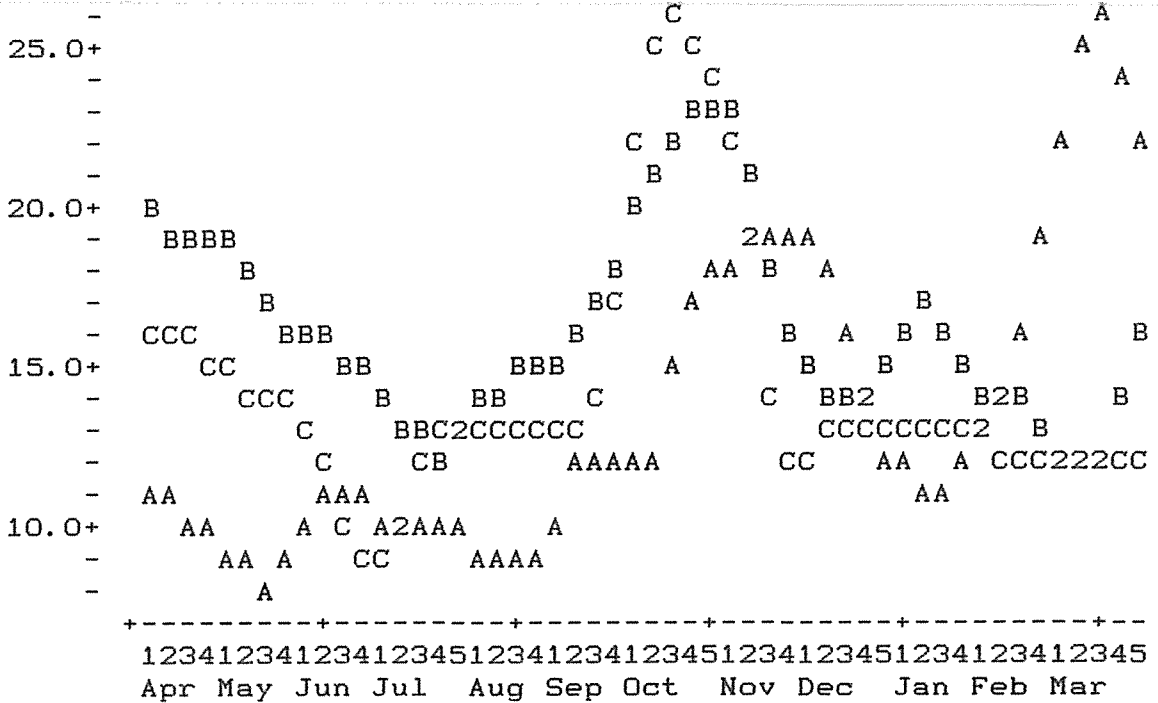
Cauliflower



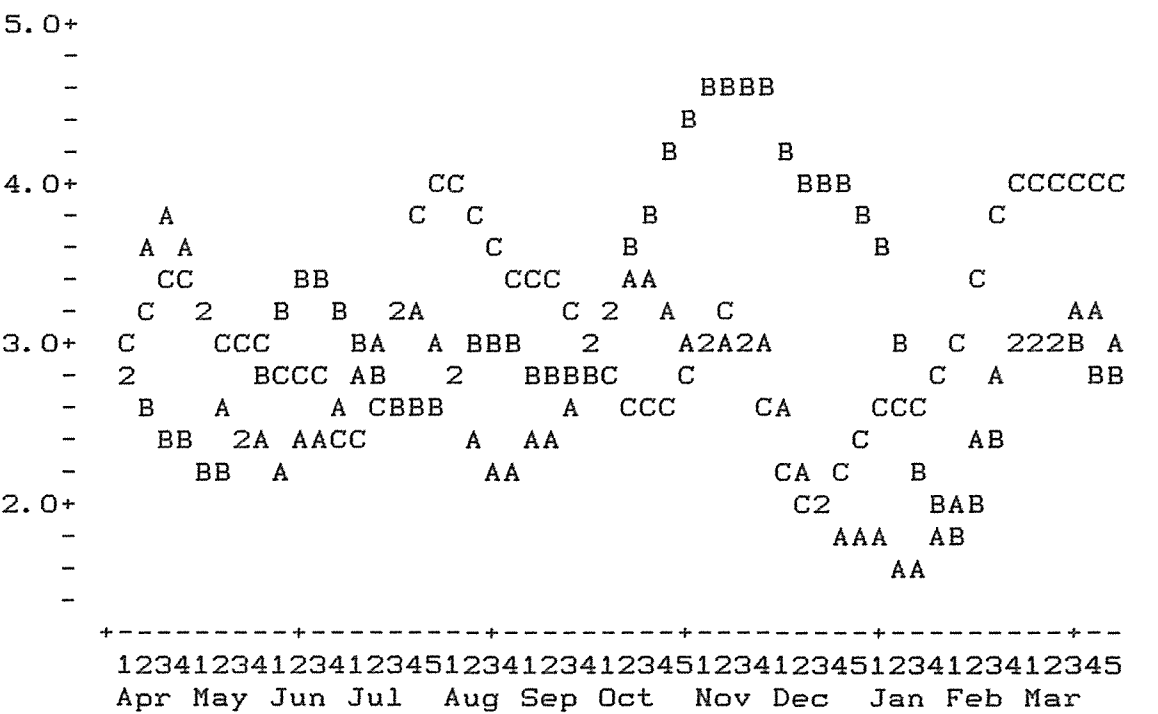
Pumpkin



Parsnip



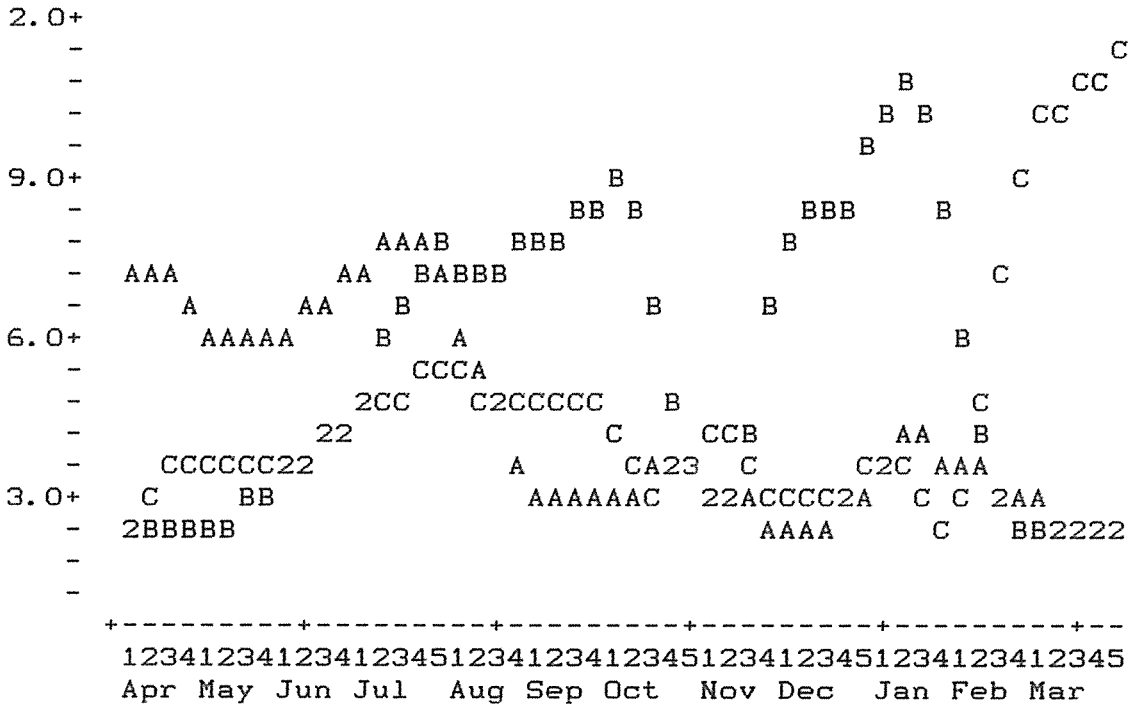
Spring onions



4. Vegetables with no consistent price pattern

The remaining vegetables exhibited smoothed price series whose behaviour did not have a constant pattern. Forecasts of the prices of these vegetables using time series methods would probably have large forecast errors. The vegetables are garlic, onions, lettuce, mushrooms, and cabbage. Their price series are plotted below.

Cabbage



Each year exhibits at least one period of time when the behaviour of price differs markedly from the previous year, but parts of the year are similar. It seems that year 1 and year 3 prices are similar for part of the year, that year 1 and year 2 prices are similar for part of the year, and that year 2 and year 3 prices are similar for part of the year.

5. Summary

Some vegetables had regular price patterns in that they were virtually identical from year to year. These were broccoli, capsicums, celery, silverbeet, kumaras, and tomatoes. Capsicums and a considerable volume of tomatoes are grown under glass, and kumaras are mostly supplied from the north. This may cause their prices to be more stable.

Others had patterns which were similar but were displaced from year to year. This may have been the result of different weather conditions in each year, or perhaps the existence of a weather cycle. These were cauliflower, pumpkins, parsnips, and spring onions.

The remaining vegetables did not have discernable price patterns. Their price behaviour differed markedly from year to year. These were cabbages, garlic, lettuces, mushrooms and onions. Some of these vegetables seemed to have cyclical price patterns. Garlic could be included with the first group of vegetables and it is only the effect of one very different year which complicated its behaviour.

CHAPTER 8 PRICE AND VOLUME RELATIONSHIPS

1. Introduction

In static supply analysis, price and supply are simultaneously determined.

In recursive systems, current price is largely determined by current supply and current supply is largely determined by some past price.

In this chapter attention is focussed on the relationship between current marketed quantity, current price, and lagged prices.

We expect that when the quantity marketed rises the price will fall, and that when the quantity marketed falls prices will rise, all other things being equal.

Given that supply in any week is relatively fixed, we are interested in establishing how price responds to changes in quantity from week to week. Knowing this would enable us to make estimates of prices likely to be received for certain quantities.

1. Hypothesis : price in week t is a linear function of the quantity marketed in week t . ie $p_t = f(q_t)$

This hypothesis was tested by regressing current price on current quantity for each vegetable. The results are presented below.

 Table 18 Current price as a function of current volume

price of:	rsq	arsq	F	sig	D	constant	coefficient
broccoli	.13	.12	22.98	0.000	0.63	9.747	-.012
cabbage	.08	.07	13.85	0.0003	0.45	7.549	-.003
capsicum	.45	.44	128.54	0.000	0.87	17.343	-.053
cauli	.42	.42	116.80	0.000	1.17	11.698	-.005
celery	.26	.26	56.83	0.000	0.44	15.286	-.021
garlic	.02	.02	3.46	0.065	0.75	4.866	-.011
kumara	.24	.24	50.46	0.000	0.47	30.874	-.055
lettuce	.16	.15	29.28	0.000	0.68	9.107	-.003
mushroom	.22	.22	45.82	0.000	1.05	17.640	-.016
onions	.05	.04	7.82	0.006	0.16	8.925	-.004
parsnips	.17	.17	33.18	0.000	0.76	19.798	-.038
pumpkins	.06	.06	10.83	0.001	0.26	9.000	-.007
silverbeet	.19	.19	37.65	0.000	0.70	9.757	-.029
springons	.07	.06	11.06	0.001	1.15	3.704	-.002
tomatoes	.13	.13	24.78	0.000	0.56	19.043	-.003

For the vegetables in this study the evidence does not support the presumption that there is a strong causal relationship between price and current quantity marketed. The statistical relationships indicate that for most of the vegetables current price depends on current quantity to a

small extent when the variables are measured in their original values.

All relationships were significant with the exception of garlic.

The negative sign of the regression coefficients is what is expected, as quantity increases price decreases.

2. Price flexibility coefficients

Price flexibility coefficients are obtained directly by regressing the logarithm of price against the logarithm of quantity, (Colman and Miah 1973 p 355), and give the percentage change in price for a 1% change in quantity.

The logarithm of current price was regressed against the logarithm of current volume. The numbers in the coefficient column in table 19 are the resulting flexibility coefficients. The numbers in the column labelled seB are their standard errors.

 Table 19 Logarithm of price as a function of logarithm of quantity

logarithm price of:	rsq	arsq	F	D	constant	coeff	seB	sig
broccoli	.11	.10	18.66	0.68	1.49	-.297	.069	0.000
cabbage	.06	.06	10.87	0.47	1.808	-.401	.122	0.012
capsicum	.56	.56	204.87	0.82	2.295	-.677	.047	0.000
cauli	.44	.43	122.97	1.01	2.744	-.653	.059	0.000
celery	.37	.36	91.45	0.54	2.500	-.669	.070	0.000
garlic	.00	.00						
kumara	.20	.19	39.33	0.78	2.350	-.480	.077	0.000
lettuce	.14	.13	24.87	0.72	2.394	-.557	.112	0.000
mushroom	.21	.20	41.81	1.01	2.316	-.491	.076	0.000
onions	.05	.05	9.09	0.01	1.384	-.220	.073	0.003
parsnips	.13	.12	23.30	1.05	1.760	-.297	.062	0.000
pumpkins	.11	.10	19.41	0.18	2.060	-.542	.123	0.000
silverbeet	.18	.17	34.46	0.71	2.701	-.940	.160	0.000
springons	.07	.07	12.73	1.10	1.134	-.272	.076	0.0005
tomatoes	.13	.12	23.40	0.88	2.506	-.444	.092	0.000

All equations were significant at the 95% level; all but cabbages were significant at the 99% level.

In all cases, the flexibility coefficient is negative, and is less than 1.00. A small percentage change in the quantity marketed has resulted in a smaller percentage change in price for all of the vegetables. The standard errors associated with the coefficients are all relatively small, which suggests they have high precision.

However, the adjusted r-squared values are generally low which means that only a small proportion of the variance of each price has been explained.

It is clear that simply knowing the quantity which will be marketed is insufficient to make a good prediction of price. In general taking logarithms has not improved the fit of the model.

3. Re-expression of one or both of the price and quantity variables may result in a more linear scatterplot and thus a better linear relationship. A resistant line was estimated for the current price volume relationships for all of the vegetables.

It is possible to infer useful transformations from the half-slope ratio produced as a result of fitting a resistant line, and the resistant line itself is a way of describing the linear dependence of prices on quantities.

A resistant line is resistant to the effects of outliers. The x-axis is divided into thirds and the median of the x's and the y's in each third is established. These medians are coordinates for what is called the summary point for each third.

A line is fitted which has the same slope as a line passing through the left and right summary points and which has about half of the observations above it and half below it. This line is called a resistant line.

The slope of the line which connects the middle summary point with the right hand summary point, b_r , is given as the right half slope. The slope of the line which connects the middle summary point and the left hand summary point, b_l , is given as the left half slope. The ratio of the right half slope to the left half slope is defined as the half slope ratio.

$$\text{ie HSR} = b_r/b_l$$

The sign and magnitude of the half slope ratio is very useful in selecting transformations.

If the half slope ratio is greater than 1 b_r is greater than b_l . Linearity may be improved by increasing the values of x and, depending on whether the values of y increase or decrease with values of x, decreasing or increasing the values of y, respectively.

If the half slope ratio is less than 1, b_r is less than b_l . Linearity may be improved by decreasing the values of x and again, depending on whether values of y increase or decrease with values of x, increasing or decreasing the values of y. This is referred to as going up or down in the ladder of powers (Tukey, 1977; Velleman and Hoaglin, 1981). A reprint of their ladder of powers is given in appendix 2.

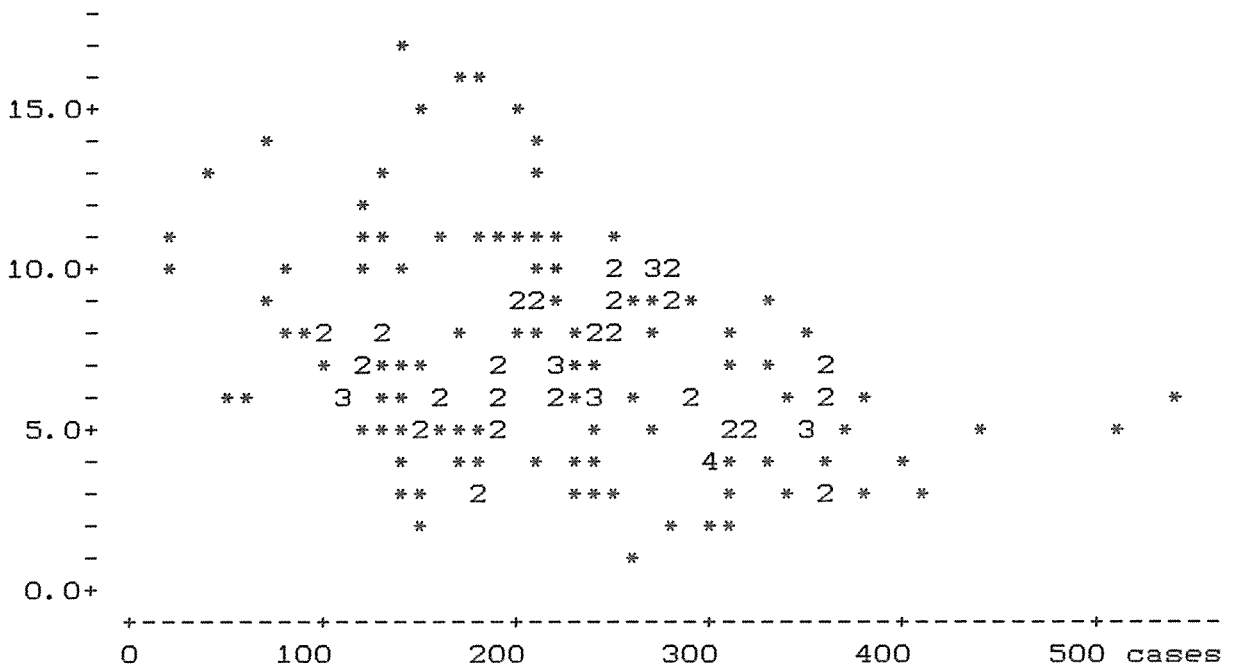
If the half slope ratio is negative, each half slope has a different sign and no benefit will be gained by re-expression.

Each of the price volume scatterplots for the vegetables is shown below. The resistant line which describes the x y relationship and the half-slope ratio are also given.

Note that the resistant line for the price of broccoli is

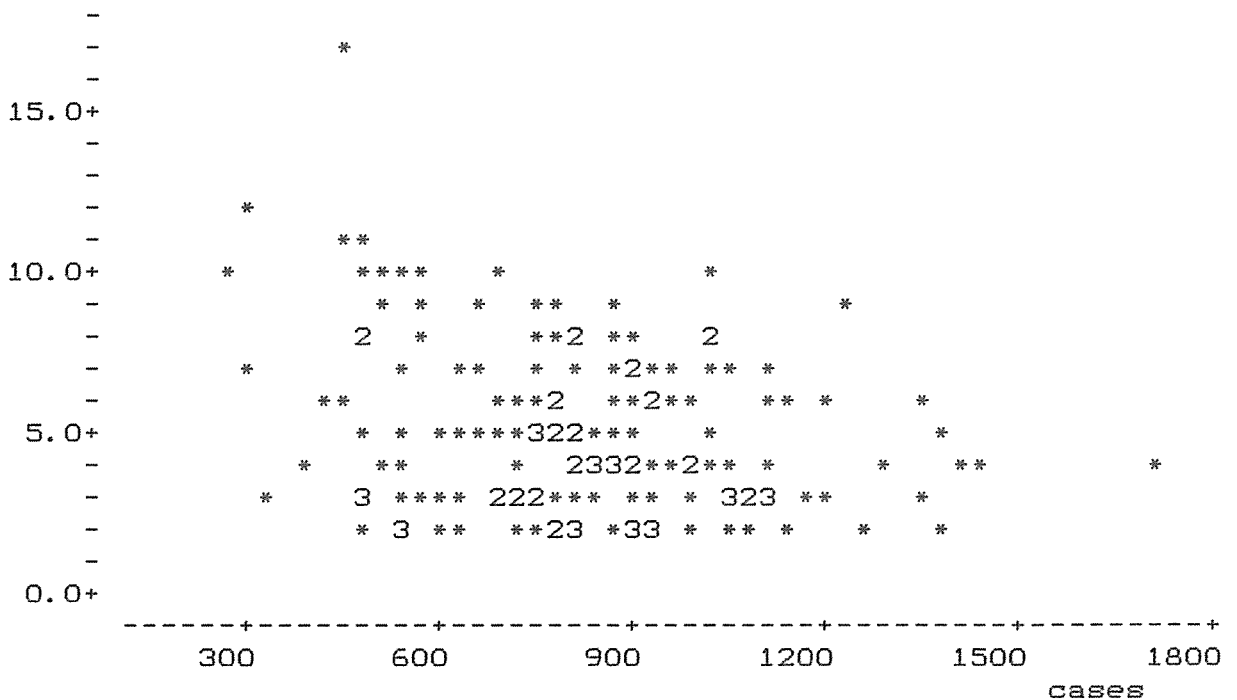
$$\text{price} = 7.6735 - 0.0055\text{cases}$$

Broccoli
price



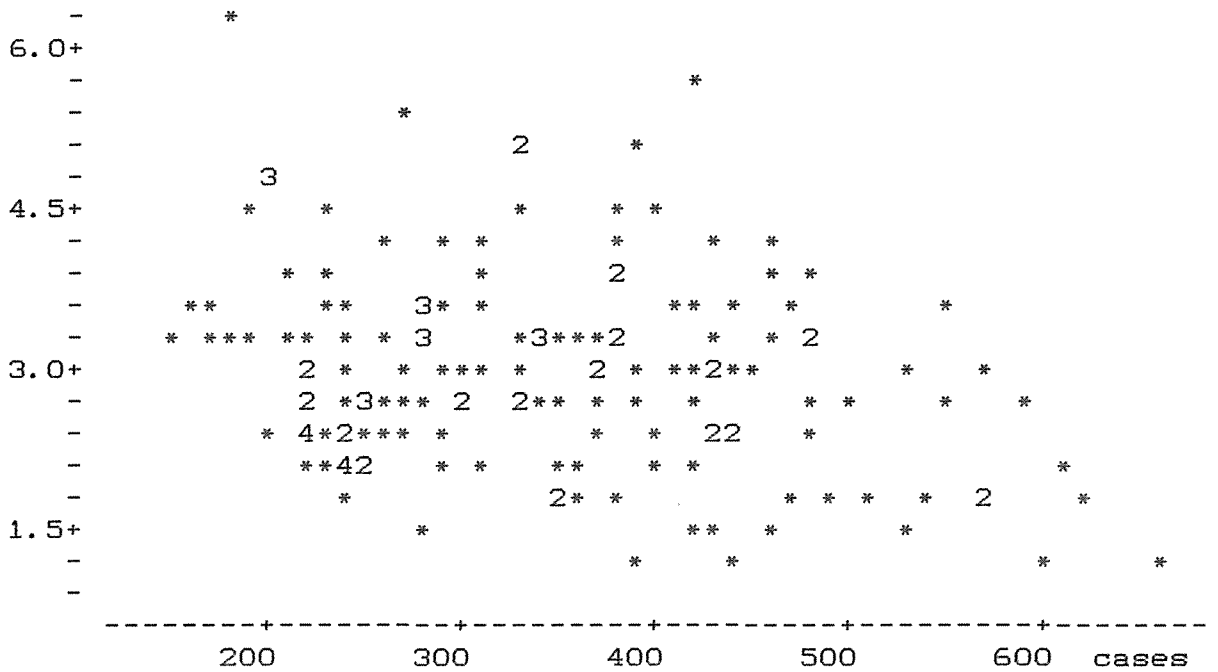
Slope = -0.0055 Level = 7.6735 Half-slope ratio = -2.159

Cabbage
price



Slope = -0.0021 Level = 6.1678 Half-slope ratio = -5.595

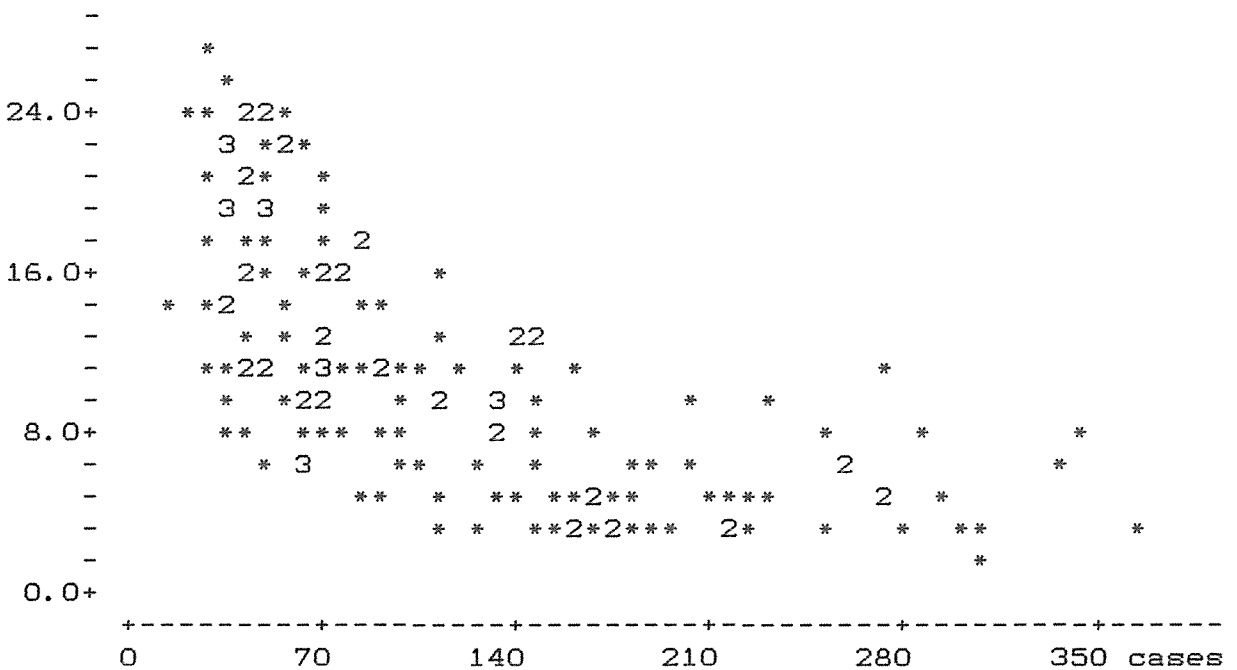
Spring onions
price



Slope = 0.0002 Level = 2.7650 Half-slope ratio = -0.764

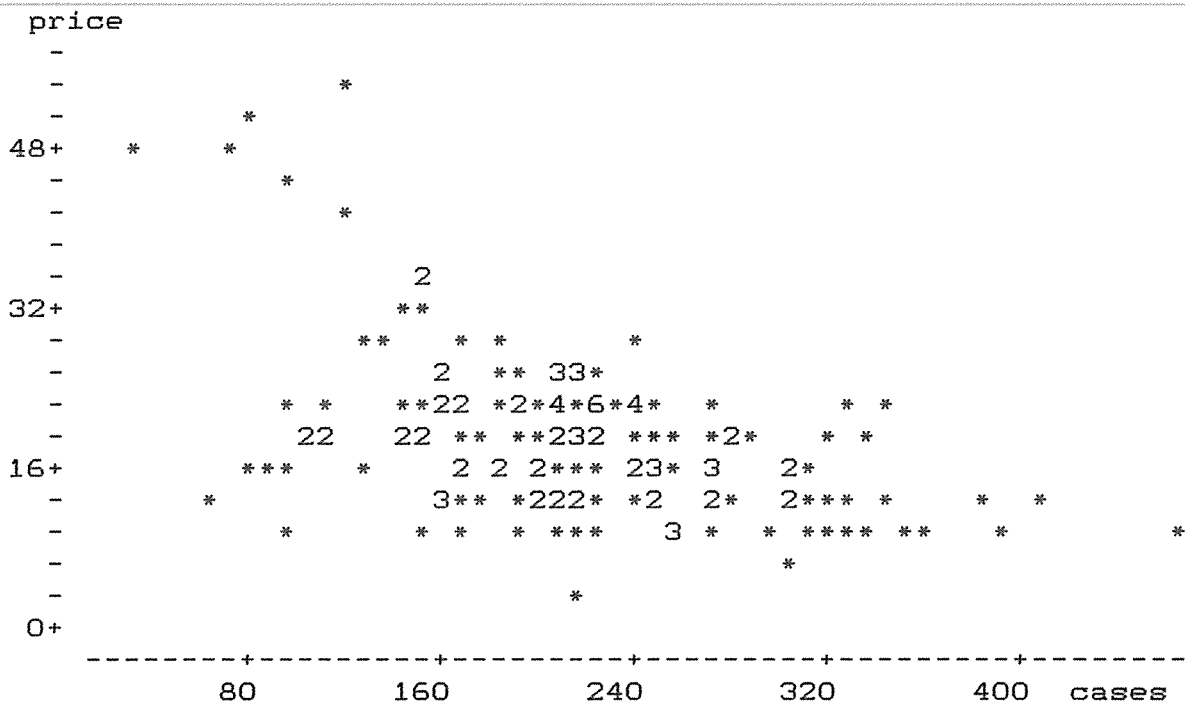
The slope in the left half of the scatterplot is negative and in the right half is positive for broccoli, cabbage, garlic, pumpkins, and spring onions. Linearity cannot be improved by re-expression.

Capsicums
price



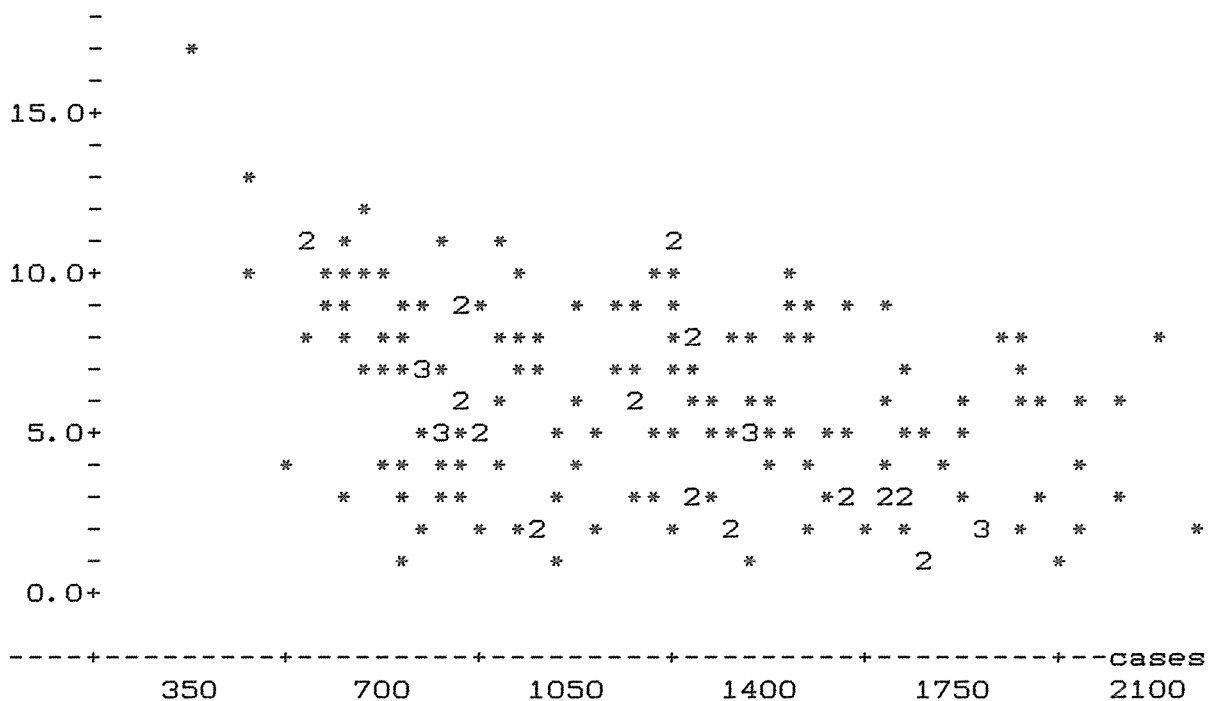
Slope = -0.0789 Level = 19.9347 Half-slope ratio = 0.298

Kumaras



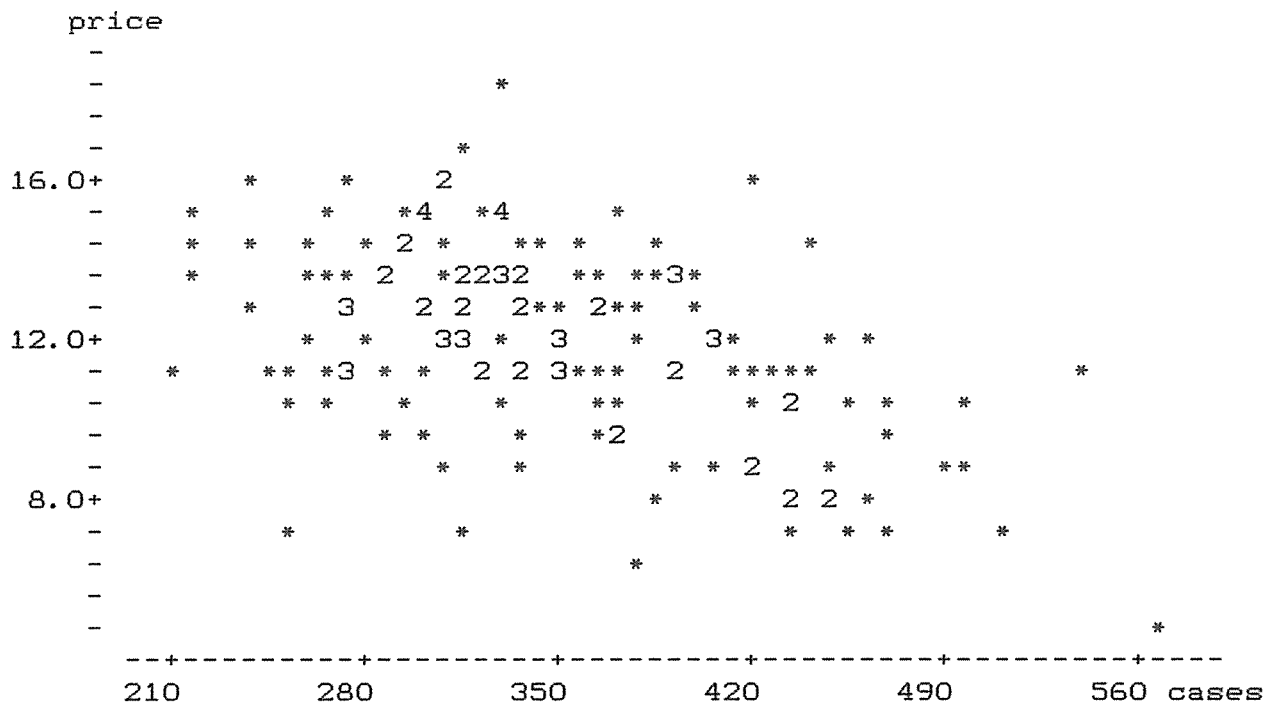
Slope = -0.0350 Level = 25.9688 Half-slope ratio = 2.265

Lettuce price



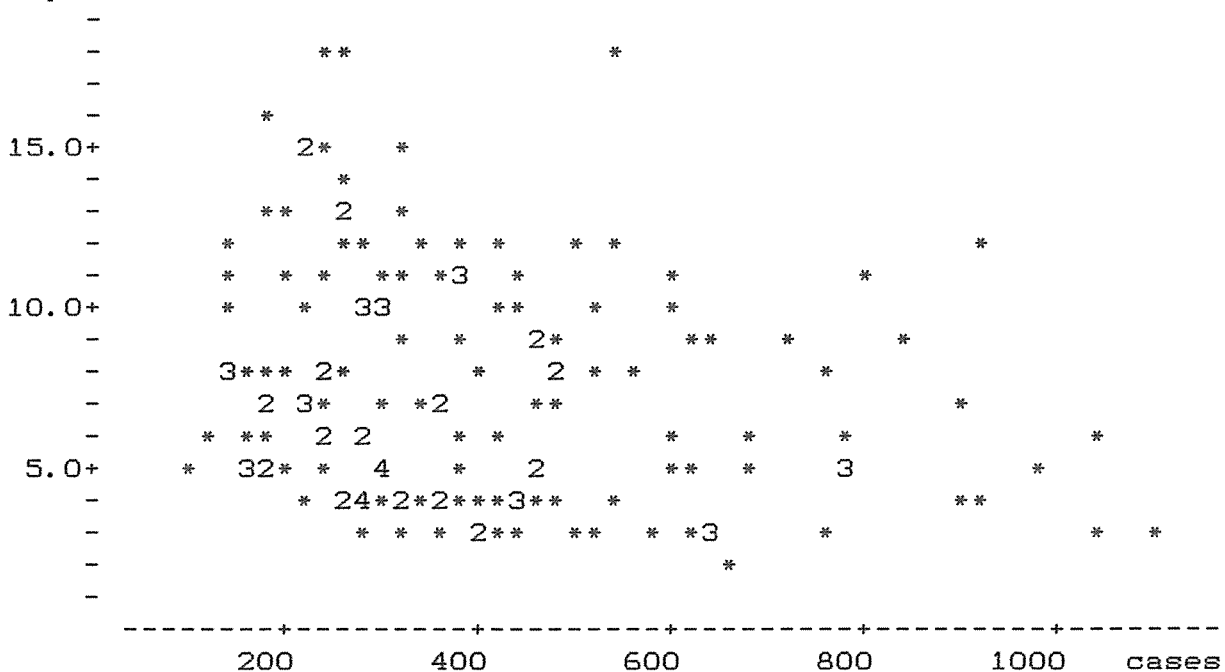
Slope = -0.0031 Level = 9.3966 Half-slope ratio = 0.896

Mushrooms



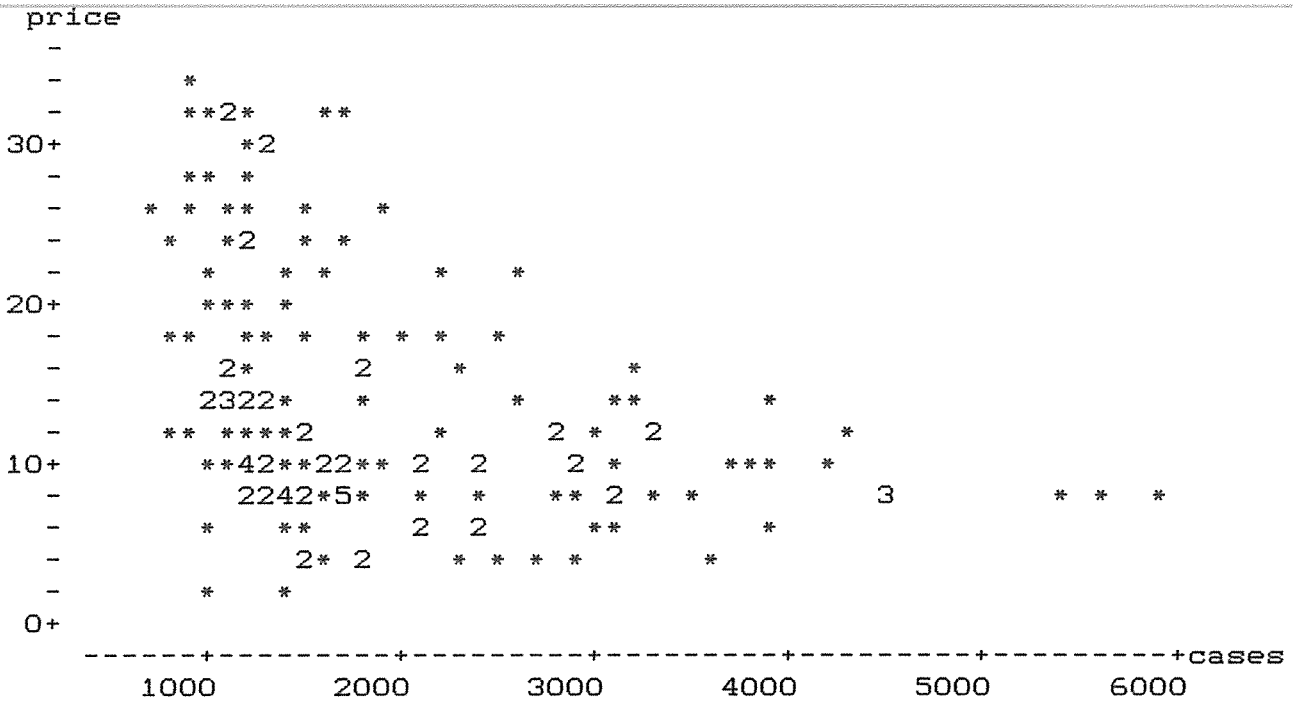
Slope = -0.0135 Level = 16.9187 Half-slope ratio = 5.213

Onions
price



Slope = -0.0030 Level = 7.9186 Half-slope ratio = 0.010

Tomatoes



Slope = -0.0033 Level = 18.6181 Half-slope ratio = 0.047

Capsicums

The half-slope ratio and scatterplot suggested going down in the ladder of powers in price or quantity or both. The best re-expression of those used was logarithms of both price and quantity.

 Table 20 Transformations: capsicums

expression	HSR	adj.rsq
p v q	0.298	44.4
p ^{.5} v q ^{.5}	0.600	53.9
logp v logq	1.211	56.0
p v q ^{.5}	0.430	50.5
p v q ^{.25}	0.517	52.6

Cauliflower

The half-slope ratio was very close to 1 which suggested that re-expression would not improve the linearity of the relationship between price and quantity. Logarithms were taken and these improved adjusted r-squared by 1%.

Table 21 Transformations: cauliflower

expression	HSR	adj.rsq
p v q	1.028	42.0
logp v logq	1.872	43.3

Lettuce

The half-slope ratio and scatterplot suggested going down in the ladder of powers in price or quantity or both. The best re-expression of those used was $q \cdot^{33}$. This is the cube root of q.

Table 22 Transformations: lettuce

expression	HSR	adj.rsq
p v q	0.896	15.0
logp v logq	1.688	13.0
p v $q \cdot^5$	1.091	16.6
p v $q \cdot^{33}$	1.136	16.9

Celery

The half-slope ratio and scatterplot suggested going down in the ladder of powers in price or quantity or both. The best re-expression of those used was $q \cdot^{125}$. This is the eighth root of q.

Table 23 Transformations: celery

expression	HSR	adj.rsq
p v q	0.039	25.9
$p \cdot^5$ v $q \cdot^5$	0.064	32.9
logp v logq	0.103	36.1
p v $q \cdot^5$	0.051	35.6
p v $q \cdot^{25}$	0.058	40.6
p v $q \cdot^{125}$	0.062	43.1

Kumaras

The half-slope ratio and scatterplot suggested going up in the ladder of powers in price or quantity or both. None of the re-expressions used were any better than the original variables.

Table 24 Transformations: kumaras

expression	HSR	adj.rsq
$p \ v \ q$	2.265	23.6
$p \ v \ q^2$	1.675	19.3
$p^2 \ v \ q$	1.996	21.0
$p^3 \ v \ q^3$	0.968	6.6

Mushrooms

The half-slope ratio and scatterplot suggested going up in the ladder of powers in price or quantity or both. The best re-expression used was q^3 .

Table 25 Transformations: mushrooms

expression	HSR	adj.rsq
$p \ v \ q$	5.213	21.9
$p \ v \ q^2$	4.241	24.0
$p^2 \ v \ q$	4.806	19.6
$p^2 \ v \ q^2$	3.909	21.2
$p \ v \ q^3$	0.000	25.3

Onions

The half-slope ratio and scatterplot suggested going down in the ladder of powers in price or quantity or both. None of the re-expressions used made much difference to the half-slope ratio or to adjusted r-squared.

Table 26 Transformations: onions

expression	HSR	adj.rsq
$p \ v \ q$	0.01	4.1
$p \cdot 5 \ v \ q \cdot 5$	0.013	4.5
$p \ v \ q \cdot 5$	0.012	4.0
$p \cdot 5 \ v \ q$	0.01	4.5
$p \ v \ q \cdot 25$	0.014	3.8

Parsnips

The half-slope ratio and scatterplot suggested going up in the ladder of powers in price or quantity or both. None of the re-expressions improved adjusted r-squared, however, $p^2 v q^2$ resulted in a more linear relationship.

Table 27 Transformations: parsnips

expression	HSR	adj.rsq
$p v q$	1.865	16.7
$p v q^2$	1.22	14.8
$p^2 v q$	1.648	16.3
$p^2 v q^2$	1.078	13.7
$\log p v \log q$	3.275	12.2

Silverbeet

The half-slope ratio and scatterplot suggested going down in the ladder of powers in price or quantity or both. The best re-expression used was $q \cdot^5$.

Table 28 Transformations: silverbeet

expression	HSR	adj.rsq
$p v q$	1.03	18.6
$p \cdot^5 v q \cdot^5$	1.348	19.2
$p v q \cdot^5$	1.153	20.2
$p \cdot^5 v q$	1.206	18.2
$\log p v \log q$	1.768	17.3

Tomatoes

The half-slope ratio and scatterplot suggested going down in the ladder of powers in price or quantity or both. The best re-expression used was $q \cdot^{125}$.

Table 29 Transformations: tomatoes

expression	HSR	adj.rsq
$p v q$	0.047	12.9
$p \cdot^5 v q \cdot^5$	0.070	13.8
$p v q \cdot^5$	0.060	15.2
$p \cdot^5 v q$	0.054	11.7
$\log p v \log q$	0.103	12.3
$p v q \cdot^{33}$	0.068	16.2
$p v q \cdot^{125}$	0.072	16.7

Re-expression resulted in large absolute improvements in adjusted r-squared for capsicums and celery only. For the other vegetables, a straightening in the relationship between price and volume did not lead to much of an improvement in adjusted r-squared.

The scatterplots of weekly prices and volumes are mostly broadly scattered. When separate plots for each year were produced, the scattering of points was still broad. These scatterplots have not been included. There is large inherent variability in weekly prices and volumes.

2. Quantity as a function of price lagged by one week.

It has been shown that the relationship between current prices and current marketed volumes for vegetables in this study is not very strong.

There are many examples in the literature of recursive systems in which current quantity is expressed as a function of lagged price, and this has already been discussed in the introductory sections. Usually the price variable which is being lagged is the annual average price or the average price received over the last season. This means that the period of the lag is sufficient for production to respond to lagged price.

When we are dealing with weekly data we need to recognise the fact that production cannot respond to price from week to week. However, harvested quantity and imports can respond to weekly price changes and it is therefore sensible to explore the relationship between marketed quantities and lagged price.

1. The first hypothesis tested was that the quantity at auction in a given week is a linear function of the price in the previous week.

This was tested by regressing current quantity against price lagged by one week. The results are presented below.

Table 30 Quantity as a function of price
lagged one week $qt = f(pt-1)$

quantity of:	rsq	arsq	F	sig	D
broccoli	.00	-.01			
cabbage	.00	.00			
capsicum	.29	.28	63.52	0.000	1.07
cauli	.08	.08	14.46	0.0002	1.28
celery	.24	.24	58.45	0.000	0.77
garlic	.00	-.01			
kumara	.08	.07	13.20	0.0004	1.24
lettuce	.05	.04	8.47	0.0041	0.75
mushrooms	.03	.02	4.43	0.037	1.13
onions	.00	.00	6.45	0.012	0.72
parsnips	.04	.03	4.20	0.042	1.31
pumpkins	.03	.02			
silverbeet	.00	.00			
springons	.00	-.01			
tomatoes	.06	.05	9.21	0.0028	0.44

Coefficients and constants were not printed because of the lack of significance of most of the relationships.

Capsicums and celery have a small amount of variation in weekly volume explained by price lagged by one week, the other vegetables show virtually no relationship. On the whole price lagged one week was not very useful at explaining variation in current volume marketed.

2. The second hypothesis tested was that the logarithm of quantity in a given week was a function of the logarithm of price in the previous week.

This was tested by regressing the logarithm of current quantity against the logarithm of price lagged by one week. The results are presented in table 31.

 Table 31 Log volume regressed on log price
 lagged one week $\log q_t = f(\log p_{t-1})$

log quantity	rsq	arsq	F	sig	Durbin
broccoli	.00				
cabbage	.00				
capsicum	.32	.32	74.78	.000	1.18
cauli	.08	.07	13.71	.000	1.46
celery	.31	.31	71.24	.000	.84
garlic	.01	.00			
kumara	.04	.04	6.94	.009	1.17
lettuce	.04	.04	7.33	.008	.67
mushroom	.02	.02	4.05	.046	1.07
onions	.01	.00			
parsnips	.02	.01	2.98	.086	.78
pumpkins	.03	.03	5.37	.021	1.40
silverbeet	.00				
springons	.00				
tomatoes	.04	.03	5.95	.016	.40

The relationship was improved slightly for capsicums and celery when logarithms were used. However the levels of significance, and the small values of adjusted r-squared indicate that the relationship between current marketed volume and price lagged one week is extremely weak.

3. The third hypothesis was that the current volume is a function of the price one year ago, that is 52 weeks ago. This analysis was concerned with detecting the effect of a longer lag on the volume marketed. It was believed that in 52 weeks a production response to a price change would be able to take place.

This hypothesis was tested by regressing current quantity on volume lagged by 52 weeks. The results are presented below.

```

-----
Table 32  Volume as a function of price
          lagged 52 weeks      qt = f(pt-52)
-----
quantity of:  rsq  arsq  F      sig  Durbin

broccoli      no variables entered
cabbage       no variables entered
capsicum      .35  .34  57.72 .000    .99
cauli         no variables entered
celery        .26  .25  37.73 .000    .76
garlic        no variables entered
kumara        no variables entered
lettuce       .10  .09  11.76 .001    .75
mushroom      .04  .03   4.60 .034    1.42
onions        .11  .10  13.56 .000    1.34
parsnips      .09  .09  11.18 .001    .70
pumpkins      no variables entered
silverbeet    .06  .05   7.39 .008    1.30
springons     .06  .05   7.13 .009    .45
tomatoes      .07  .06   8.30 .005    .45
-----

```

Except for capsicums and celery, the relationship between current volume and price lagged by 52 weeks is very poor.

4. The final hypothesis was that marketed quantity was a function of lagged prices within the previous 52 weeks, but we do not know which ones.

Current quantity was regressed against prices lagged by up to 52 weeks. The procedure stepwise, was used to eliminate independent variables with coefficients which were not significant.

- a) Only 36% of the variation in the marketed quantity of broccoli could be explained by lagged prices of broccoli. The lagged prices which were retained by the stepwise procedure were price 8, 14, 22, 34, and 50 weeks ago.

R squared = .388 Adjusted R squared = .358
 F = 13.04 sig .0000 Durbin-Watson 1.34

- b) Only 41% of the variation in the marketed quantity of cabbage could be explained by lagged prices of cabbage. The lagged prices retained by the stepwise procedure were price 6, 10, 15, 26, and 44 weeks ago.

R squared = .440 Adjusted r squared = .413
 F = 16.17 Sig = .0000 Durbin-watson = 1.27

c) Nearly 60% of the variation in the marketed quantity of capsicums could be explained by lagged prices of capsicums. The lagged prices retained were for weeks 2, 13, 19, 32, 45, and 52.

R squared = .620 Adjusted r squared = .597
F = 27.71 Sig = .0000 Durbin-watson = 1.22

d) Only 13% of the variation in the marketed quantity of cauliflower could be explained by lagged prices. The lagged prices retained by the procedure stepwise were for 16, 45, and 50 weeks ago.

R squared = .154 Adjusted r squared = .130
F = 6.40 Sig = .0005 Durbin-watson = 1.45

e) Just over 60% of the variation in the marketed volume of celery could be explained by the variation in lagged prices. The lagged prices retained were for 3, 4, 13, 18, 29, 41, 45, and 51 weeks ago.

R squared = .633 Adjusted r squared = .603
F = 21.55 Sig = .0000 Durbin-watson 1.22

f) Only 27% of the variation in the marketed quantity of garlic could be explained by variation in lagged prices. The prices retained were for 2, 6, and 29 weeks ago.

R squared = .295 Adjusted r squared = .274
F = 14.65 Sig = .0000 Durbin-watson = 1.30

g) Only 19% of the variation in the marketed volume of kumaras could be accounted for by the variation in selected lagged prices. The lagged prices retained by stepwise were for 9, 16, 18, and 52 weeks ago.

R squared = .224 Adjusted r squared = .194
F = 7.49 Sig = .0000

h) Just over 46% of the variation in the volume of lettuce marketed could be accounted for by variation in lagged price. The lagged prices retained were for 2, 16, 23, 26, 32, and 51 weeks ago.

R squared = .495 Adjusted r squared = .465
F = 16.64 Sig = .0000 Durbin-watson = 1.24

i) Only 29% of the variation in the marketed volume of mushrooms could be explained by the variation in lagged prices. Prices were retained for 5, 22, 35, 40, and 52 weeks ago.

R squared = .327 Adjusted r squared = .294
F = 10.01 Sig = .0000 Durbin-watson = 1.58

j) The variation in lagged prices of onions accounted for only 32% of the variation in marketed quantity. Prices were retained for 1, 9, 17, and 52 weeks.

R squared = .350 Adjusted r squared = .324
F = 13.95 Sig = .0000 Durbin_watson = 1.96

k) About 30% of the variation in the marketed quantity of parsnips could be accounted for by the variation in lagged prices. Prices were retained for 3, 29, 30, 47, and 52 weeks ago.

R squared = .334 Adjusted r squared = .302
F = 10.33 Sig = .0000 Durbin-watson = .79

l) Only about 19% of the variation in the marketed quantity of pumpkins could be accounted for by the variation in lagged price. Prices retained were for 2, 21, and 49 weeks ago.

R squared = .211 Adjusted r squared = .189
F = 9.38 Sig = .0000 Durbin-watson = 1.43

m) A little more than 37% of the variation in the marketed quantity of silverbeet could be explained by the variation in lagged prices. The prices retained were for 11, 21, 40, and 52 weeks ago.

R squared = .398 Adjusted r squared = .374
F = 17.16 Sig = .0000 Durbin-watson = 1.98

n) Only 17% of the variation in the marketed volume of spring onions could be explained by the lagged prices. Prices retained were for 14, 17, 35, and 51 weeks ago.

R squared = .204 Adjusted r squared = .173
F = 6.65 Sig = .0001 Durbin-watson = .58

o) Nearly 80% of the variation in marketed volume of tomatoes could be explained by the variation in lagged prices. Prices retained by the stepwise procedure were for 2, 11, 15, 16, 17, and 42 weeks ago.

R squared = .809 Adjusted r squared = .798
F = 72.19 Sig = .0000 Durbin-watson = 1.30

3. Conclusions

For all vegetables, current volume was not very useful at predicting current price.

The amount of variation in current price explained might be improved by including other causal variables such as the weather and by further experimentation with transformations of the price and volume data. The various transformations which were used were not very successful at improving adjusted r-squared.

Sometimes transformations produced a better half-slope ratio but a deterioration in adjusted r-squared. This is due to the effect that transformed outliers would have on the total sum of squares.

Current volume was not predicted at all well by price lagged one week for any of the vegetables, and logarithms produced little improvement.

Price lagged by 52 weeks resulted in no variables being entered in the model for six out of the 15 vegetables. This week's price a year ago was of almost no use in predicting current volume marketed.

Stepwise regression of own price lagged to 52 weeks did produce some moderately strong relationships. Tomatoes were the only vegetable with a large amount of variation in volume explained by variation in lagged prices. 60% of the variation in volumes of capsicums and celery could be explained and the remaining vegetables were not explained well at all.

This suggests that for some vegetables an index of prices over the most recent season, or 52 weeks, may prove useful at predicting current volume. This approach could be extended to predict future volumes.

Price flexibility coefficients were calculated and indicate that for all vegetables in this study, a 1% change in volume resulted in a less than 1% change in price. This implies that in the immediate run price was not very responsive to volume changes. The fact that the values for adjusted r-squared were so low casts serious doubt on the usefulness of these coefficients.

Of the equations estimated, silverbeet had the most responsive price and onions the least responsive price. Capsicums, celery, and cauliflower had the second, third, and fourth most responsive prices respectively.

1. Introduction

It was hypothesised that the prices of certain vegetables were interrelated.

Lee (1973 p 50) did not attempt to include the prices of substitute and complementary vegetables in his model of demand for vegetables at auction. He stated "there is no satisfactory theoretical basis for choosing any particular vegetable and there are considerable problems in obtaining adequate data to include a full range of vegetables sold at auction."

2. Method

Two methods were used to explore the assumed interdependence of prices of the vegetables, regression and principal components analysis.

Principal components analysis was favoured over other methods of analysis for interdependence because, according to Green and Tull (1981), it produces results which are unique and which can be reproduced.

3. Regression of the price of each vegetable against the price of other vegetables

1. The current price of each vegetable was regressed against the current and one week lagged prices of all other vegetables in the data set. The method used was STEPWISE.

The logic behind this analysis was as follows: if the price of a vegetable was high last week then we might expect more of it to be brought to the market this week. The auctioneers import vegetables from other regions if possible in times of shortage.

We would then expect its price to fall. If this effects other vegetables by making less of them available then we would expect their prices to rise.

Furthermore, if the price of a vegetable which belongs to a class of vegetables is for example high, then perhaps the prices of the other vegetables belonging to this class will also be high.

If demand is fixed in the immediate run as we believe it will be, a fall in the price of a vegetable with substitutes may cause the price of substitutes to fall also, in order to clear the market.

It has already been noted that the quantities brought to market from week to week cannot change much. Therefore we would not expect much of the variation in price of a given vegetable to be explained by one week lagged prices of other vegetables.

~~Where the current price of one vegetable accounted for a large amount of the variation in the price of another vegetable it may be that this is due to some underlying cause such as similar growing behaviour, the effect of the weather, or some substitute or complimentary relationship.~~

The sign of the regression coefficient will not prove causality but will indicate the direction of the effect of the price of some vegetables on the price of a vegetable.

The most important explanatory variable may be detected by examining the partial regression coefficients, the Beta coefficients, or the significance of the t-values. Where appropriate these variables have been listed.

a) Broccoli

50% of the variation in price could be accounted for by variation in the independent variables. These were the current prices of cauliflower, tomatoes, and mushrooms, and the lagged prices of cabbage, and parsnips.

F = 33.17 sig = 0.000 D = 1.17

Cauliflower was the most important of the explanatory variables. Since it is of the same family, and grows under very similar conditions, it is not surprising to find that variation in its price contributes information to explain the variation in the price of broccoli. The relationship between broccoli and tomatoes and mushrooms is not clear.

b) Cabbage

35% of the variation in price could be explained by the independent variables. The variables retained by stepwise were the current prices of silverbeet, broccoli, and lettuce, and the lagged prices of spring onions, silverbeet, and parsnips.

F = 15.47 sig = 0.000 Durbin-Watson = 0.93

Most of the vegetables mentioned might be considered as substitutes for cabbage, and all but the lagged price of parsnips had positive coefficients.

c) Capsicums

39% of the variation in price could be explained by the independent variables. These were the current prices of tomatoes and silverbeet, and the lagged prices of garlic, celery, and cauliflower.

F = 21.64 sig = 0.000 Durbin-Watson = 0.98

The price of tomatoes was the most important predictor variable. This is not surprising since tomatoes and capsicums are very similar in the manner in which they are grown.

d) Cauliflower

48% of the variation in price could be explained by the independent variables. These were the current prices of broccoli, lettuce, garlic, and pumpkins, and the lagged prices of tomatoes, onions, and kumaras.

F = 21.76 sig = 0.000 Durbin-Watson = 1.39

Both broccoli and lettuce might be considered consumption substitutes for cauliflower, and it is not surprising that they were selected for the model. The relationship of the other variables is not so clear.

e) Celery

68% of the variation in price could be accounted for by variation in the independent variables. These were the current prices of silverbeet, onions, pumpkins, spring onions, and broccoli, and the lagged prices of pumpkins, tomatoes, and parsnips.

F = 43.03 sig = 0.000 Durbin-Watson = 1.05

Onions and celery are both grown for their vegetative storage organs rather than for leaf, Mengel (1979). Indeed many of the vegetables which were retained are grown for their storage organs. This suggests that they have some price behaviour in common as well.

f) Garlic

22% of the variation in price could be accounted for by variation in the independent variables. These were current prices of cauliflower and cabbage, and lagged prices of tomatoes, spring onions, and capsicums.

The price of cauliflower, and the lagged prices of tomatoes and spring onions had negative coefficients.

F = 10.03 sig = 0.000 Durbin-Watson = 1.09

This relationship is not very strong and may be entirely spurious. Examination of the correlation matrix revealed that the price of garlic was not highly correlated with the price of any other vegetables.

g) Kumaras

61% of the variation in price could be accounted for by variation in the independent variables. These were current prices of cabbage and pumpkins, and the lagged prices of cauliflower, celery, pumpkins, and spring onions. The lagged price of spring onions had a negative coefficient.

F = 41.96 sig = 0.000 Durbin-Watson = 0.94

The most important predictor variable was the lagged price of pumpkins. Both of these vegetables are harvested at about

the same time and are stored. Median monthly prices rise in the same smooth fashion and so similar price behaviour is not unexpected.

h) Lettuce

22% of the variation in price could be accounted for by variation in the independent variables. These were the current price of cabbage, and the lagged prices of garlic, pumpkins, and silverbeet. The lagged price of garlic and the lagged price of pumpkins had negative coefficients.

F = 12.58 sig = 0.000 Durbin-Watson = 0.84

Cabbage was the most important explanatory variable but the coefficient of multiple determination is not very large. Some relationship between the prices of cabbages and lettuces might be expected given that they tend to be consumption substitutes.

i) Mushrooms

25% of the variation in price could be accounted for by variation in the independent variables. These were the current prices of broccoli and onions, and the lagged prices of cauliflower, kumara, and parsnips. All but the current price of broccoli had negative coefficients.

F = 11.74 sig = 0.000 Durbin-Watson = 1.22

Mushroom prices were not highly correlated with any other prices. The most important explanatory variable was onion prices which possibly has something to do with both vegetables having less variable prices and volumes than some of the other vegetables.

j) Onions

66% of the variation in price could be accounted for by variation in the independent variables. These were the current prices of celery and pumpkins, and the lagged prices of celery, pumpkins, mushrooms, and tomatoes. Of these the current and lagged prices of pumpkins and the lagged price of mushrooms had negative coefficients.

F = 53.05 sig = 0.000 Durbin-Watson = 0.83

The most important explanatory variable was the lagged price of celery. The price by month boxplot depict the price pattern of these two vegetables as having been quite similar.

k) Parsnips

27% of the variation in price could be accounted for by variation in the independent variables. These were the current prices of onions, cabbage, celery, and tomatoes, and the lagged prices of tomatoes, capsicums, broccoli, and mushrooms.

The lagged prices of capsicums, and mushrooms and the current prices of onions and cabbage had negative coefficients.

F = 8.20 sig = 0.000 Durbin-Watson = 1.20

The most important predictor was the lagged price of capsicums. Inspection of the price by month boxplots reveals that the two vegetables did not have similar price patterns over the year. There is probably more spuriousness than causation at play.

l) Pumpkins

65% of the variation in price could be accounted for by variation in the independent variables. These were the current prices of kumaras, celery, and mushrooms, and lagged prices of cauliflower, onions, and broccoli. The lagged prices of cauliflower and onions and the current price of mushrooms had negative coefficients.

F = 50.04 sig = 0.000 Durbin-Watson = 0.91

The most important explanatory variable was the price of kumaras. The same reasons advanced in respect of kumaras apply in this case.

m) Silverbeet

50% of the variation in price could be accounted for by variation in the independent variables. These were the current prices of cabbage, capsicum, celery, and garlic, and the lagged prices of cauliflower and lettuce. All coefficients were positive.

F = 27.81 sig = 0.000 Durbin-Watson = 1.42

The price of celery was the most important explanatory variable. Perhaps this was because the coefficient of variation was quite similar for the price of these two vegetables.

n) Spring onions

Only 14% of the variation in price could be accounted for by variation in the independent variables. These were the current price of cabbage and the lagged prices of garlic and kumaras. The lagged prices had negative coefficients.

F = 9.77 sig = 0.000 Durbin-Watson = 1.43

The price of cabbage was the most important predictor variable. The coefficient of variation for each of these variables was quite different as was the pattern of prices within a year.

o) Tomatoes

49% of the variation in price could be accounted for by variation in the independent variables. These were the current prices of broccoli, onions, and parsnips, and the lagged prices of capsicums and silverbeet. All variables except the lagged price of silverbeet had positive coefficients.

F = 31.35 sig = 0.000 Durbin-Watson = 1.12

The lagged price of capsicums was the most important explanatory variable. As has already been noted, tomatoes and capsicums have certain common characteristics, and it appears to a certain extent this is also reflected in their prices.

2. It is questionable as to whether the above analysis is of any use. All of the relationships were significant but, without a guiding theory regarding causality, it is not possible to evaluate the logic of some of the apparent dependencies.

Some of the vegetables are quite close consumption substitutes and it would not be surprising to find their prices related in some way.

Other vegetables require similar growing conditions and have a similar supply behaviour. The prices of these vegetables might also be expected to behave similarly.

Regression analysis, in which one variable is dependent and other variables are independent, is not an entirely satisfactory procedure to explore interrelationships. For a start, the dependent-independent structure limits the relationship to being a one way relationship. Secondly, the SPSSx regression procedure has certain criteria which protect against intercorrelation of the independent variables. These can be changed, but the default was retained to try to find those variables which had the strongest relationship with the dependent variable. The analyst, rather than the data, specifies the nature of the interrelationship.

Principal components analysis was used to search for interrelationships and this is discussed in the next section.

4. Principal components analysis

1. Literature

Klein (1974) describes a use of principal components in two-stage least squares estimation of the Klein-Goldberger model of the US economy.

Maddala (1977) discusses the use of principal components in resolving problems of multicollinearity.

However, no report could be found of the use of principal components analysis in the analysis of vegetable prices or indeed agricultural products as a whole.

Doll and Chin (1970) report an application of principal components analysis in investigating fluctuations in shrimp prices.

2. Description of PCA

Principal components analysis is one of several techniques known generically as factor analysis and is described in detail by Green and Tull (1978), Aaker and Day (1983), Aaker (1971), Nie et al (1975), and Hair et al (1979).

Harman (1976) notes that principal components had its beginnings in the early 1900's.

Green and Tull (1978 p 429) write:

the objective (of principal components analysis) is to portray a set of associated variables in terms of a set of orthogonal (mutually uncorrelated) linear combinations of those variables. The linear combinations are chosen so that each set of component scores accounts for a decreasing proportion of the total variance in the original variables, subject to being orthogonal with previously extracted components.

Principal components analysis "systematically explores which variables exhibit high intraset correlations and low intersets correlations, how many such sets there are (each set defining a dimension), and whether the dimensions can be considered as uncorrelated themselves" (Green and Tull 1978).

Harman (1976) points out that the first principal component is the linear weighted sum of the original variables which accounts for the maximum amount of variance in the total variables space. The next principal component is uncorrelated with the first, and is the particular linear combination of the original variables which accounts for the maximum amount of the residual variance, and so on until the maximum possible variance is analysed.

No one variable is deemed to be the dependent variable, and the analysis concentrates on the global variance shared by the variables. The first principal component generated has the maximum explained variance, Aaker and Day (1983).

Norusis (1985) points out that the correlation coefficient must be a logical summary statistic to justify the use of this technique.

Factor loadings are the correlations between components and variables. Interpretation of the principal components solution is based on these loadings, which according to Hair et al (1979 p 217), "are the key to understanding a particular factor".

Thus, analysis is primarily concerned with the correlation of variables with components and in particular, with the component that a given variable is most highly correlated with.

The ultimate aim of the procedure is to have each original variable highly correlated with one component only, and for the number of components to be less than the number of variables.

Each variable has a correlation, or loading, on each component, and each component can be described as a linear combination of the original variables. The (factor) loadings describe how much a given variable contributes to defining a given component or dimension.

3. Objective

The objective of this analysis was to find constructs of vegetable prices which might describe the prices of subsets of vegetables. Any new constructs or dimensions might provide information regarding common price behaviour.

4. Method

The program FACTOR in SPSSx was used to generate the components. The procedure in SPSSx involves four steps. The first is to decide the variables to be included in the analysis, the second is to decide how factors or components are to be extracted, the third is to decide which rotation technique to apply, and the fourth is to request the calculation and saving of factor scores.

The program used for this analysis is in appendix 3.

Current prices of all of the vegetables were considered in the analysis.

All variables involved are considered as independent variables and the basis of the analysis is the correlation matrix between variables. The correlation matrix from this application is in appendix 4.

SPSSx provides nine extraction techniques. The one used was PC, which extracts subsequent components orthogonally to previous components.

SPSSx provides three orthogonal rotation schemes, varimax, quartimax, and equamax. Hair et al (1979) and Aaker and Day (1983) note that varimax is the one most frequently used.

Rotation involves moving the reference axes about the origin to try to improve the interpretation of the solution. The aim is to transform complicated matrices into simpler ones.

Hair et al comment that interpretation is enhanced by simplifying the rows and columns of the factor matrix, which is a listing of the correlation of each original variable with the components. The objective is to make as many values in the matrix as possible close to zero, thus giving a simpler structure to the factor matrix.

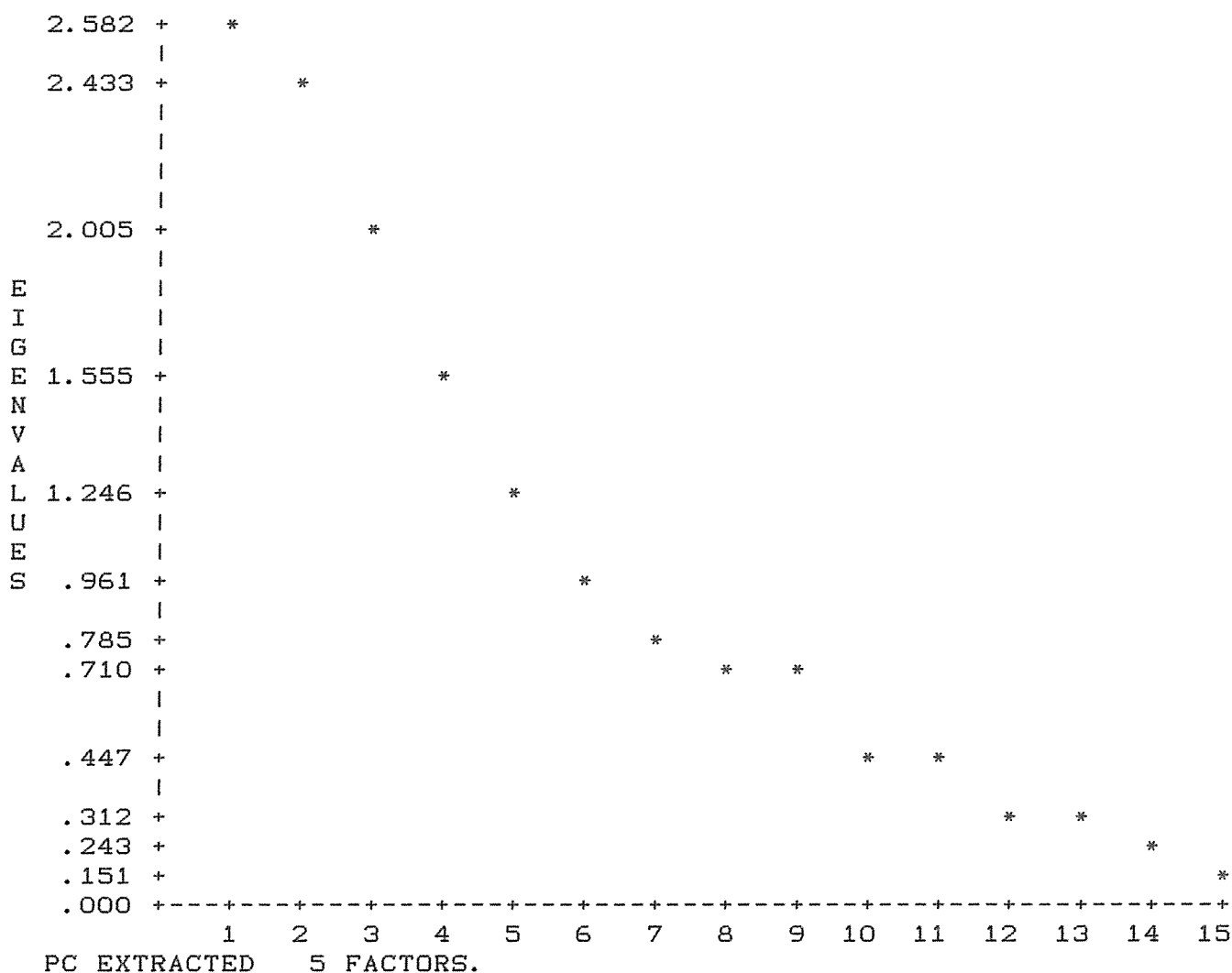
A plot of the loadings on two of the components will indicate whether a simple structure has been achieved by a rotation scheme. A simple structure will be indicated if loadings cluster at the ends and at the intersection of the axes. Plots of component 1 against component 2 were made after each rotation, and these are included below.

There can be as many components as original variables. SPSSx FACTOR extracts components which have eigen-values greater than or equal to 1.00.

Hair et al (1979) list four methods for deciding the optimal number of components. They assert that the eigen-value = 1 criterion extracts too few components when there are less than 20 variables.

A scree plot can be used to establish the optimal number of components. This is a plot of eigen-values against the number of components. When the scree plot begins to level off, that is approaches zero slope, the number of components is given on the horizontal axis. Scree plots are described further in Norusis (1985).

The scree plot obtained in this analysis is given below and suggests that up to 8 components might have been extracted.



Another method is to extract the number of components which account for a predetermined cumulative variance in the original variables.

Eigen-values were calculated for each component and the following components were selected:

COMPONENT	EIGENVALUE	PCT OF VAR	CUM PCT
1	2.58222	17.2	17.2
2	2.43311	16.2	33.4
3	2.00482	13.4	46.8
4	1.55510	10.4	57.2
5	1.24560	8.3	65.5

The selected components accounted for 65.5% of the variance in the original variables. It was decided to have the smallest number of components which seemed sensible to simplify the interpretation of the components. The analysis proceeded with five components having been extracted.

The following components were not selected:

COMPONENT	EIGENVALUE	PCT OF VAR	CUM PCT
6	.96144	6.4	71.9
7	.78499	5.2	77.1
8	.74338	5.0	82.1
9	.70975	4.7	86.8
10	.49639	3.3	90.1
11	.44686	3.0	93.1
12	.32974	2.2	95.3
13	.31238	2.1	97.4
14	.24322	1.6	99.0
15	.15100	1.0	100.0

These accounted for 34.5% of the variance in the original variables.

In the discussion which follows, variables which had correlations with a given component of greater than or equal to 0.50, in absolute value, were considered highly correlated with the given component.

5. Unrotated solution

The unrotated solution had the prices of broccoli and cauliflower highly correlated with component 1. The prices of pumpkins and kumaras had high negative correlations with component 1.

The prices of silverbeet, celery, kumaras, and pumpkins were highly correlated with component 2.

The price of capsicums had a high positive correlation with component 3 while the price of onions had a high negative correlation with this component.

The price of parsnips was highly negatively correlated and the price of garlic was highly positively correlated with component 4.

Finally, the price of capsicums also had a high negative correlation with component 5.

 Table 33 Unrotated factor matrix

	COMPONENT				
	1	2	3	4	5
broccoli	.69970	.29345	.32402	-.12012	.20809
cauli	.65014	.23532	-.13491	-.06702	.46723
pumpkin	-.57560	.50025	.41113	-.12193	.24981
lettuce	.46217	.26137	-.24234	.26430	.02000
spring o	.42669	.21280	-.02201	-.05760	-.13391
silverbeet	-.09991	.74876	-.24069	.25586	-.07115
celery	-.36870	.65575	-.44629	-.12136	.06730
kumara	-.52176	.54189	.29142	.01966	.33495
onions	.10483	.28038	-.73636	-.23853	-.29984
tomatoes	.34299	.39064	.46801	-.30490	-.43123
parsnips	.01762	.12578	.25399	-.64926	.21261
garlic	-.38567	.06463	.15701	.59715	-.17719
cabbage	.39528	.46681	-.05750	.48709	.12655
mushrooms	.26928	-.21061	.37869	.44324	.26509
capsicums	.13557	.36056	.56056	.07643	-.58542

Clearly there is a certain amount of overlap between components on given variables and the factor matrix is not easily interpretable.

6. Varimax solution

Varimax rotation is a procedure which aims to get loadings which are close to zero on all but one component for each variable.

Nie et al (1975) comment that varimax is concerned with simplifying the columns of the factor matrix. This means that the procedure attempts to have only one variable loading highly on each component.

"...this procedure tends to produce some high loadings and some near-zero loadings on each factor", Green and Tull (1981 p 432).

Norusis (1985) asserts that varimax should make components easier to interpret.

Varimax rotation resulted in all variables but the price of silverbeet being highly correlated with only one component.

The prices of cabbage, cauliflower, lettuce, and broccoli were highly correlated with component 1.

The prices of pumpkins and kumaras were highly correlated with component 2.

The prices of onions, celery, and mushrooms were highly correlated with component 3.

The prices of capsicums and tomatoes were highly correlated with component 4.

Finally, the price of garlic had a high negative correlation with component 5, while the price of parsnips had a high positive correlation with component 5.

Silverbeet was fairly evenly correlated between components 1, 2, and 3.

The factor matrix is given below.

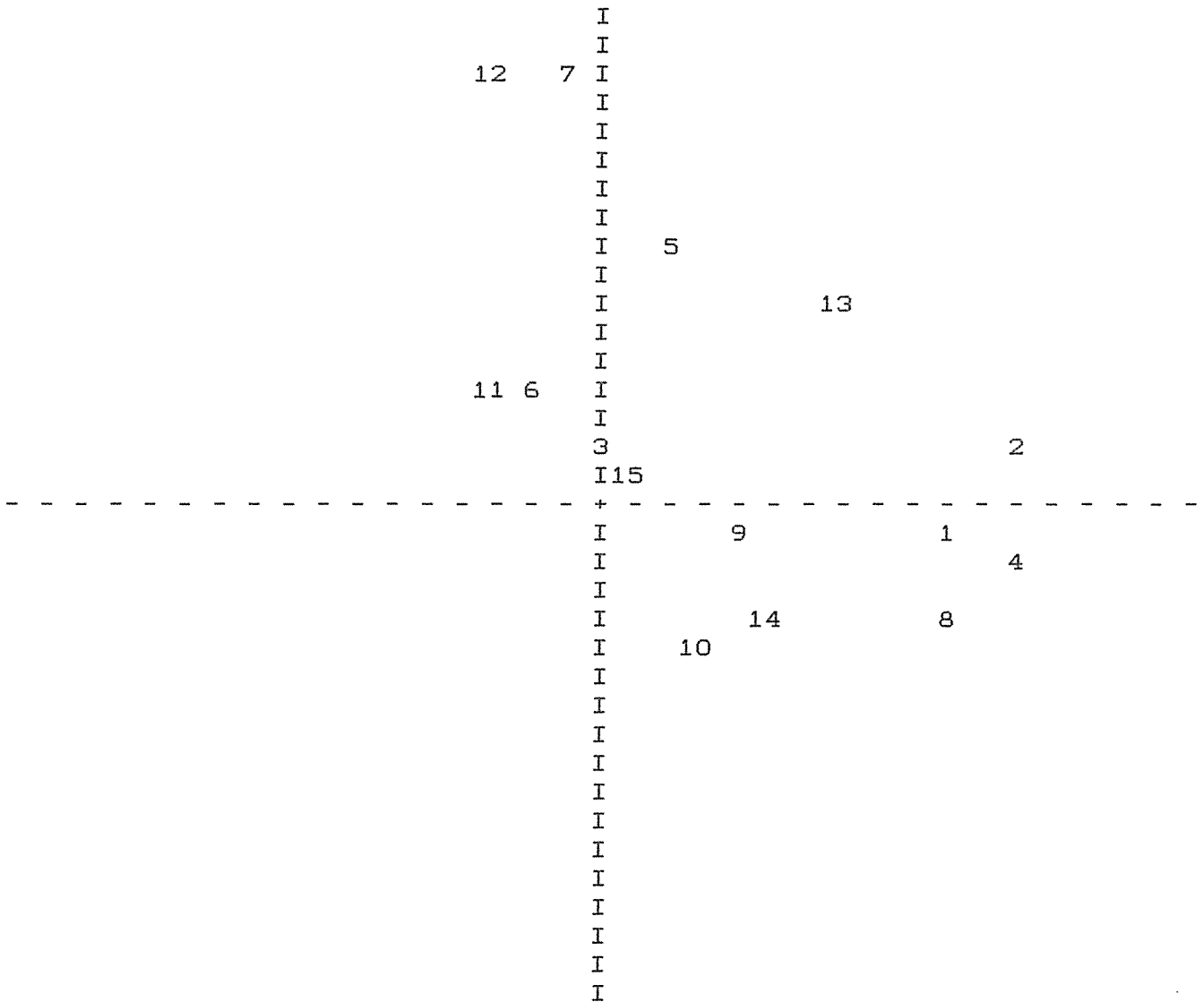
 Table 34 Rotatated factor matrix: varimax

	COMPONENTS				
	1	2	3	4	5
cabbage	.74651	.10486	-.03247	.08467	-.23289
cauli	.69952	-.06974	-.06774	-.12870	.45133
lettuce	.60283	-.16983	.10661	.02783	-.08071
broccoli	.57858	-.00921	-.27340	.34648	.45691
spring o	.34073	-.16790	.09403	.27589	.14084
pumpkin	-.18521	.88260	-.00445	.11365	.04068
kumara	-.02409	.87241	.01296	-.00273	-.03901
onions	.17262	-.26056	.82279	-.04307	.04571
celery	.14363	.49283	.70814	-.13160	-.04583
mushrooms	.25446	-.04306	-.66293	-.04108	-.13874
silverbeet	.44119	.41477	.47198	.12625	-.30610
capsicums	.02747	.10320	-.08720	.86871	-.19365
tomatoes	.09778	.03762	.02449	.83252	.25205
garlic	-.07729	.23783	-.14377	.04516	-.69305
parsnips	-.16236	.24490	.01080	.14350	.66358

A scatterplot of loadings on components 1 and 2 is given below. Some clustering has occurred.

- - - - - F A C T O R A N A L Y S I S - - - - -

HORIZONTAL FACTOR 1 VERTICAL FACTOR 2



KEY

- | | | | |
|----|---------------------|----|------------------------|
| 1 | Price of broccoli | 2 | Price of cabbage |
| 3 | Price of capsicums | 4 | Price of cauliflower |
| 5 | Price of celery | 6 | Price of garlic |
| 7 | Price of kumaras | 8 | Price of lettuce |
| 9 | Price of mushrooms | 10 | Price of onions |
| 11 | Price of parsnips | 12 | Price of pumpkins |
| 13 | Price of silverbeet | 14 | Price of spring onions |
| 15 | Price of tomatoes | | |

Pumpkins and kumaras cluster near the positive end of component 2 which indicates that they had a high positive correlation with this component.

Cabbage, cauliflower, broccoli, and lettuce are shown as having a moderate positive correlation with component 1.

The cluster at the intersection indicates that the prices of these vegetables, for example for tomatoes and capsicums, did not correlate highly with either component 1 or component 2.

7. Quartimax solution

Quartimax rotation involves simplifying the rows of the factor matrix. This means that the procedure attempts to have rows in the factor matrix which contain only one correlation which is near 1.

Nie et al (1975) note that the first component "tends to be a general (component) that is, many variables tend to load high on it, while subsequent (components) tend to be subclusters of variables".

Norusis (1985) asserts that quartimax makes variables easier to interpret and that this leads to one component loading highly on all variables. They point out that this is a weakness of this method of rotation.

Cauliflower, lettuce, and Broccoli correlated most highly with component 1.

Kumara and pumpkin correlated most highly with component 2.

Onions, celery, and mushrooms correlated most highly with component 3. Mushrooms has a negative correlation.

Capsicums and tomatoes correlated most highly with component 4.

Garlic and parsnips correlated most highly with component 5. Garlic has a negative correlation.

Spring onions correlated most highly with component 1 but this correlation is less than 0.50. Silverbeet was again fairly evenly correlated with components 1, 2, and 3.

The rotated factor matrix is given below.

 Table 35 Rotated factor matrix: Quartimax

	COMPONENT				
	1	2	3	4	5
cabbage	.73906	.11907	-.03750	.06386	-.25470
cauli	.70968	-.06185	-.07077	-.15543	.42709
lettuce	.60390	-.15818	.10445	.01020	-.10086
broccoli	.60187	-.00422	-.27660	.32299	.44194
spring o	.35677	-.16204	.09318	.26380	.13142
pumpkin	-.19498	.87912	-.00985	.11800	.05458
kumara	-.03995	.87220	.00682	-.00242	-.03144
onions	.18131	-.25200	.82374	-.04810	.03729
celery	.13343	.50045	.70388	-.13549	-.04823
mushrooms	.24566	-.04261	-.66402	-.04784	-.14711
silverbeet	.43061	.42801	.46631	.11578	-.31563
capsicums	.04646	.10569	-.08893	.86938	-.18469
tomatoes	.13127	.03883	.02307	.82618	.25759
garlic	-.10235	.24055	-.14539	.05496	-.68780
parsnips	-.14084	.23756	.01010	.14081	.67171

 A scatterplot of loadings produced after quartimax rotation, is given below. The plots of the loadings on components 1 and 2 after varimax and quartimax rotations are almost identical.

8. Equamax solution

Equamax rotation is a compromise between varimax and quartimax. It attempts to simplify both rows and columns of the factor matrix, Nie et al (1975).

Norusis (1985) notes that equamax simplifies both variables and components.

Equamax resulted in pumpkins and kumaras being highly correlated with component 1.

Cabbage, cauliflower, lettuce, and broccoli are most highly correlated with component 2.

Onions, celery, and mushrooms were highly correlated with component 3. Mushrooms had a negative correlation with this component.

Capsicums and tomatoes were correlated highly with component 4.

Garlic and parsnips were highly correlated with component 5. Garlic had a negative correlation.

Spring onions were most closely associated with component 2, and silverbeet was fairly evenly correlated with components 2 and 3.

The rotated factor matrix is given below.

 Table 36 Rotated factor matrix: Equamax

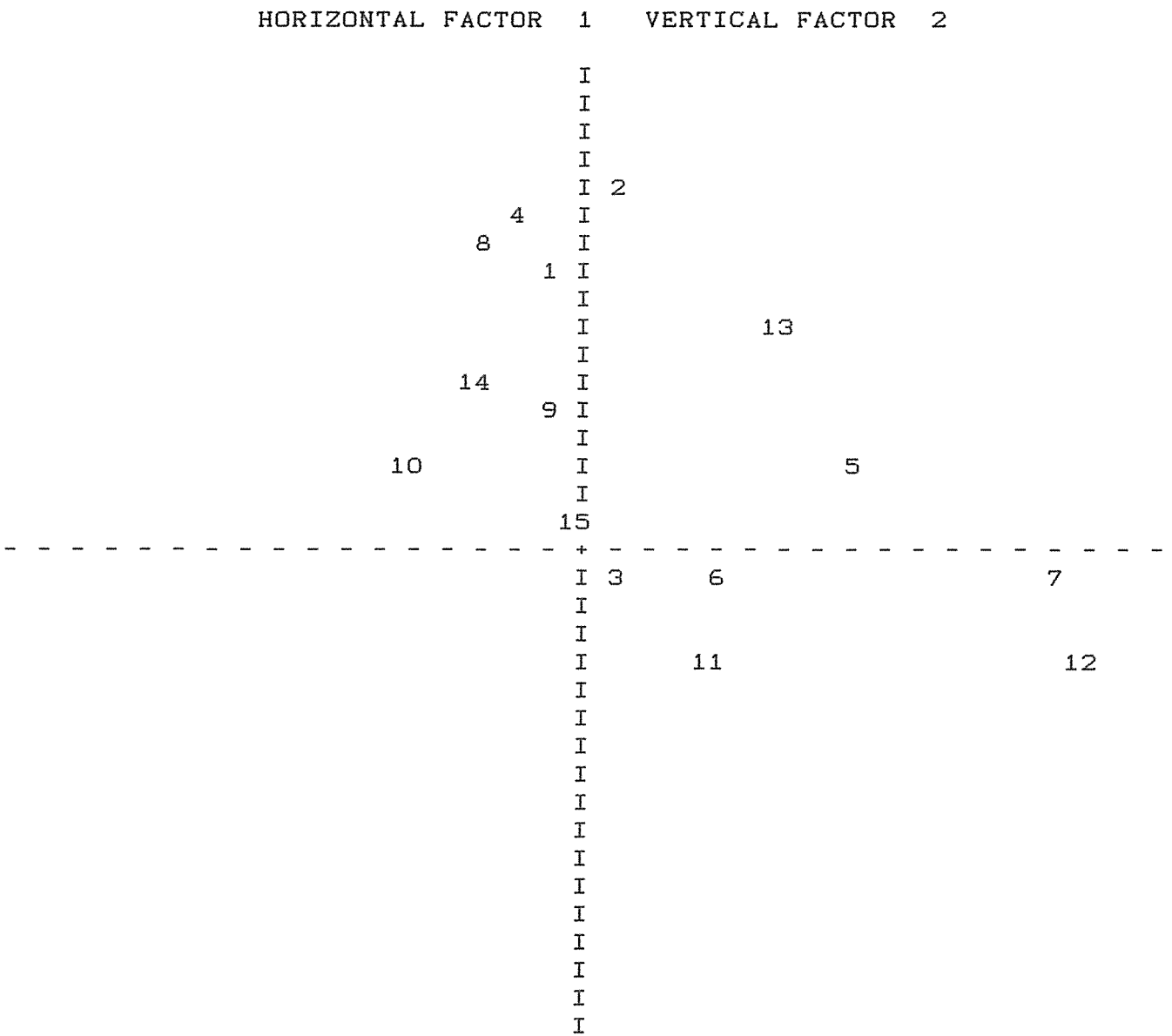
	COMPONENT				
	1	2	3	4	5
pumpkins	.88689	-.17153	.00272	.10694	.02081
kumara	.87204	-.00258	.02110	-.00357	-.04952
cabbage	.08592	.75490	-.02633	.11309	-.19998
cauli	-.07912	.68092	-.06382	-.09400	.48604
lettuce	-.18500	.59958	.10910	.05183	-.05094
broccoli	-.01394	.54321	-.26957	.37592	.47870
spring o	-.17454	.31755	.09478	.29136	.15461
onions	-.27142	.16027	.82140	-.03595	.05720
celery	.48231	.15703	.71372	-.12608	-.04254
mushrooms	-.04409	.26576	-.66155	-.03171	-.12566
silverbeet	.39685	.45545	.47900	.14094	-.29130
capsicums	.10111	.00368	-.08571	.86686	-.20529
tomatoes	.03826	.05209	.02570	.83883	.24436
garlic	.23255	-.04001	-.14183	.03389	-.69901
parsnips	.25619	-.19372	.01190	.14466	.65051

A scatterplot of loadings on components 1 and 2 after equamax rotation is given below.

Equamax correlated the prices of cabbages, cauliflower, lettuce, and broccoli highly on component 2. Under varimax and quartimax rotation these variables were highly correlated on component 1.

The plot also indicates that there is a greater difference between the loadings of these variables on the same component than under the other two rotation schemes.

- - - - - F A C T O R A N A L Y S I S - - - - -



KEY

1	Price of broccoli	2	Price of cabbage
3	Price of capsicums	4	Price of cauliflower
5	Price of celery	6	Price of garlic
7	Price of kumaras	8	Price of lettuce
9	Price of mushrooms	10	Price of onions
11	Price of parsnips	12	Price of pumpkins
13	Price of silverbeet	14	Price of spring onions
15	Price of tomatoes		

9. Discussion and conclusions

The component (factor) score coefficients produced by this analysis are listed in appendix 5.

Varimax rotation seems to have produced the best correlation of variables with components, where best is defined as a variable correlating highly with one component only. The following discussion relates to the factor matrix produced by varimax rotation.

First it should be noted that all variables are price variables. They are all measured in dollars per case, but the case variable is not constant. Applications of principal components are usually described as involving many different variables which essentially are qualitative in nature. See for example Hair et al (1979) and Aaker (1971). This qualitative nature is often an aid in interpreting components.

It is recognised that the interpretation of components is largely a subjective activity, Aaker (1971) and Harman (1976). However, in the following paragraphs descriptions of the components are advanced.

Prices of cabbage, cauliflower, lettuce, and broccoli are grouped together on component 1. Perhaps this component reflects the price of everyday greens. It may be describing substitute "greens", or leaf vegetables. Any one of these vegetables would be eaten with an evening meal but probably not more than one. Silverbeet loads moderately on this component implying that its price behaves similarly.

The prices of kumaras and pumpkins were grouped together on component 2. Perhaps this component is describing the price behaviour of warm-weather grown "root" crops, or warm-weather grown storage vegetables. Certainly there are long periods when the prices of these vegetables are not subject to wild fluctuation and they are both harvested at about the same time and then stored. Parsnips, another stored root crop was not highly correlated with this component which suggests that the time when vegetables are harvested may have something to do with their component loadings.

Prices of onions, celery, and mushrooms were highly correlated with component 3. The range of prices received for mushrooms and onions was about the same over the three year period, but for celery it was considerably larger. No

satisfactory description could be advanced.

Prices of tomatoes and capsicums were grouped together on component 4. These vegetables are very similar in the manner in which they are grown and in the conditions under which they thrive. Their grouping on a common component suggests that their prices behave similarly also.

During about two thirds of the year they are grown under glass. For tomatoes, only about one third of total national production is grown outdoors. The proportion is greater for capsicums. See tables 8 and 9. They are both salad crops, but have a myriad of other uses which make a description somewhat difficult.

Perhaps the component on which they are loaded highly might be described as the price of vegetables grown under glass in winter but outdoors in summer.

Garlic and parsnips are both stored vegetables and were grouped on component 5. No satisfactory description could be advanced for this component.

The technique has grouped common price behaviour and the resulting components seem to describe the price behaviour of classes of vegetables.

Prices of green leafy and curd vegetables; root and stored vegetables; and crops grown under glass, were found to move closely.

Descriptions of the five components according to varimax rotation might be summarised as follows:

component (1) leafy and green vegetable prices;
component (2) stored warm-growth root vegetable prices;
component (4) prices of winter-glasshouse summer-outdoor
vegetables;
component (3) no description advanced;
component (5) no description advanced.

5. Summary

The principal components solutions were more easy to interpret than the regression output and gave some insights into common or interdependent price behaviour.

Five principal components were found which described about two-thirds of the global variation in price of the 15 vegetables retained for this analysis.

Some descriptions of these components were advanced based primarily on the varimax rotation. Quartimax rotation produced a very similar factor matrix.

The remaining components were difficult to interpret and require more information about the specific vegetables in question.

The regression analysis found prices of individual vegetables which explained variation in the price of a given vegetable rather than finding variance in common. The main problem was establishing the "true" direction and nature of causation. Some of the common variation discovered by the principal components analysis was discovered by the regression analysis, but in a less cohesive manner.

CHAPTER 10 WEATHER RELATIONSHIPS

1. Introduction

The effect of various climatological influences on prices and volumes was explored.

Data on air temperature, rainfall, and sunshine hours were supplied by Dr John Brock of the Grasslands division of the DSIR Palmerston North for the period under study.

It should be noted that these data are collected at the DSIR buildings and are not necessarily the same as conditions experienced by growers.

However, it is assumed that the weather patterns occurring at the DSIR were representative of conditions experienced by all growers in the region.

It is also important to note that according to Mr Peter Arlidge approximately 50% of volume traded is from outside the Manawatu region. There are no measures of this included in the price data set and so care needs to be taken in interpreting the effect of weather on volume and price.

An SPSSx system file was produced and then matched onto the existing system file which contained the price and volume data for all of the vegetables.

2. Literature

Tomek and Robinson (1981) comment that the acreage planted of certain crops depends to a great extent on the prevailing weather conditions during planting. Very dry, very windy, or very wet weather may make it impossible to plant in the planned quantity. Growers may have to plant a hardier lower yielding crop or may have to plant a different crop all together. What ever the case it is likely that the relative quantities of different crops planted will depart from plans.

Kohls and Paarlberg (1950) note that weather conditions during planting may alter original planting intentions. Therefore planned production will deviate from actual production.

Johnson (1955) included rainfall as an independent variable in a model to estimate aggregate yearly supply of farm products in New Zealand.

Jones (1961) found that in the U.K. spring rainfall had a marked negative effect on the vegetable acreage sown.

Lovell (1963) suggests that the influences of climate be filtered out of series by explicitly including variables for precipitation and temperature in models.

According to Shaw (1964) the relationship between crop yield and weather has usually been estimated using multiple regression, where yield is the dependent variable, and the predictors include "a trend variable and meteorological variables."

Shaw notes that some researchers believe that precipitation affects yield and temperature affects plant development, while other researchers have found that both precipitation and temperature affect yield.

He suggests soil moisture and a drought index be used as explanatory variables.

Doll (1967) points out that the relationship between the growth of a plant and climatological variables is complex.

He notes that direct measures of climate have not been used by many researchers. Doll estimated yield response for corn as a function of rain, trend, and their interaction.

Shaw (op cit) notes that too much and too little rain will be harmful as far as yields go and this will affect wholesale price. Too much heat and too little heat will similarly affect yields and therefore prices.

He suggests that the functional form of the relationship between yield and weather might be quadratic. He reasons that the marginal increase in output for a weather factor would increase, become zero, and then become negative as the weather factor increased. We would expect prices to behave in the opposite manner; first decreasing with higher yields, then bottoming out at optimal weather conditions where yield is greatest, and then rising as yields fell due to worsening weather conditions.

This ignores the possibility of growers ploughing in excess output or the possibility of the auctioneers importing vegetables from other regions which may have experienced better weather conditions.

While new hybrids have been developed which are more weather resistant, weather still features as an important determinant of farm output, and farm output directly influences prices at auction.

Stallings (1960) wrote "weather is often the most important variable influencing yield and production of a crop." Stallings studied the effect of certain weather variables by holding other influences on crops constant. He developed weather indices for the years 1900 to 1957 for different crops in the US.

Weichmann (1983) reported that weather conditions prior to harvest influenced the storage ability of chinese cabbage and carrots and hence affected the marketable quantity.

Oury (1965) reviews various measures of weather and after analysis concludes that it is better to include an index of

weather variables in models for predicting acreage response than individual weather variables.

He comments that there are distinct times for which different weather variables might be useful. One variable allowing for weather influences at each of planting time, growth, and harvest time is needed for both winter and summer crops, as well as a separate variable allowing for the effect of winter, for winter crops.

Oury also suggests that the weather data relating to each stage in a crop's growth could be weighted by the historical weather variance. This would require some quite detailed information concerning planting dates.

An aridity index has been used to reflect the effect of weather during planting, growth, and harvest with some success.

The effect of winter has been included in a production function by Oury, also. It effectively involved including the largest absolute deviation of a month's average temperature from the month's normal temperature.

The method for accounting for weather proposed by Oury is to combine precipitation and temperature data into what is called an aridity index. There are many measurable variables which might form the construct, "weather".

Lang (1920, cited in Oury) uses a rain factor:

$$I = P / T \text{ where } P \text{ is precipitation and } T \text{ is temperature.}$$

The important point is to be clear regarding the effect of various components of the weather on yields. The important consideration presumably would be abnormal weather. It would be appropriate to be able to include deficient or excessive rainfall, abnormal heat or cold, excessive wind, and so forth as predictors of yield.

The inclusion of weather is limited to the manner in which the components of weather are measured.

A general weather index, calculated with reference to Lang (1920) and de Martonne (1926) cited in Oury (1965) is as follows:

$$I = \frac{\sum_{i=1}^n E(P_i) \times 12}{\sum_{i=1}^n E(T_i) + 10}$$

where P_i = monthly rainfall for month i in mm
 T_i = average temperature for month i in degrees C
 $i = 1, \dots, n$
 n = the number of months in the period referred to.
 10 is included so that negative numbers are avoided.
 E is the summation symbol

If a higher temperature is accompanied by lower rainfall, the aridity index will fall. Oury comments that an index value of less than 20 indicates a drought. The index can be interpreted as describing moisture. A low index denotes low moisture and a high index high moisture. The effect of rainfall is mitigated by the effect of temperature.

Oury recommends a test be made of the aridity index. He advocates using models with and without the index. In a test conducted by Oury to predict yield per acre of corn in the U.S.A. the parameter estimate in the equation with the aridity index was significant at the 1% level. (t test of $B_i = 0$). In the other equation, parameter estimates were significant only at the 10% level for rainfall, and the 30% level for temperature. The R squared for each equation was about the same. (.2932 and .3155)

Doll (1967) noted that many of the indices which have been used to account for the effect of weather have not been any better than the original meteorological variables used to compute them.

Lee (1973) commented that "It is difficult to obtain a single factor to account for weekly weather variation." He used heat units to account for the influence of weather on supply. Lorenz and Maynard (1980) calculate heat units as follows:

Heat Unit = mean day temperature - base temperature. Base temperature depends on the vegetable we are concerned with. Lee calculated heat units as Mean daily temperature - 32 degrees F.

Lee found that weather lagged two weeks was better than weather lagged one week at accounting for variation in supply to the auction floor.

Abnormal weather may need careful consideration as it may cause crops to spoil, or come onto the market at an earlier time than was planned, or to be of higher or lower quality.

3. Objective

The objective of this part of the study was to explore the relationship between various "weather" variables and quantity marketed and price. These weather variables were air temperature, rainfall, and direct sunshine hours.

Concern was mostly with the effect that weather had on the quantity of produce brought to market in a given week.

4. Method

Stepwise regression was used to see how much of the variation in current quantity and price could be accounted for by variation in each climatological variable. Each climatological variable was lagged by up to 52 weeks to account for the influence of weather during growth.

5. Quantity regressed against mean air temperature and weekly rainfall.

The logical direction of causation is that weather has some influence on output, and that the quantity of output influences price. Thus weather influences price in that it affects the quantity and quality of produce marketed.

Another possibility is that weather effects demand and this might be reflected in the prices which are bid.

For each vegetable, current quantity marketed was regressed against mean air temperature and weekly rainfall lagged by up to 52 weeks. The results are listed below. In all cases the measure of variance accounted for by regression is adjusted r-squared.

1. broccoli

Mean air temperature lagged 49 weeks was the only variable retained and accounted for only 31% of the variation in broccoli volume marketed.

$F = 47.99$ sig = 0.000 Durbin-Watson = 1.54

2. cabbage

57% of the variation in the marketed volume of cabbage was accounted for by the variation in the independent variables. The independent variables retained by the stepwise procedure were mean air temperature lagged by 17, 19, 32, and 41 weeks, and weekly rainfall lagged by 7, 34, and 44 weeks.

$F = 20.66$ sig = 0.000 Durbin-Watson = 1.70

3. capsicum

64% of the variation in capsicum volumes was accounted for by the variation in the independent variables. These variables were mean air temperature lagged by 1, 3, 8, and 39 weeks.

F = 46.95 sig = 0.000 Durbin-Watson = 1.38

4. cauliflower

Only 17% of the variation in cauliflower volumes could be accounted for by the independent variables which were mean air temperature lagged by 7 and 28 weeks.

F = 11.40 sig = 0.000 Durbin-Watson = 1.03

5. celery

52% of the variation in celery volumes could be accounted for by the variation in the independent variables. These variables were mean air temperature lagged by 27, 29, 42, 49, and 50 weeks and weekly rain lagged by 15, 28, and 30 weeks.

F = 15.07 sig = 0.000 Durbin-Watson = 1.07

6. garlic

Only 24% of the variation in garlic volumes could be accounted for by the variation in the independent variables. The variables retained were mean air temperature lagged by 2 and 12 weeks.

F = 17.43 sig = 0.000 Durbin-Watson = 1.50

7. kumara

Only 14% of the variation in kumara volume could be explained by the independent variables. This is not surprising since virtually all of the kumara volume comes from northland where the weather conditions are quite different.

F = 18.08 sig = 0.000 Durbin-Watson = 1.54

8. lettuce

73% of the variation in lettuce volumes could be accounted for by the variation in the independent variables. The variables retained by the stepwise procedure were mean air temperature lagged by 1, 32, 47, and 52 weeks, and weekly rain lagged by 17 and 47 weeks.

F = 48.71 sig = 0.000 Durbin-Watson = 2.00

9. mushrooms

Mushrooms were not included in this analysis because they are grown indoors and presumably are unaffected by weather conditions.

10. onions

Only 22% of the variation in onion volumes could be accounted for by variation in the independent variables. The variable retained was mean air temperature lagged by 9 weeks.

F = 30.88 sig = 0.000 Durbin-Watson = 1.61

11. parsnips

60% of the variation in parsnip volumes could be accounted for by variation in the independent variables. These were mean air temperature lagged 51 and 52 weeks.

F = 79.01 sig = 0.000 Durbin-Watson = 1.63

12. pumpkins

Only 37% of the variation in pumpkin volumes could be explained by variation in the independent variables. The variables retained were mean air temperature 31, 46, 49, and 51 weeks ago; and rainfall 15 and 33 weeks ago.

F = 11.19 sig = 0.000 Durbin-Watson = 1.71

13. silverbeet

41% of the variation in silverbeet volume marketed was accounted for by variation in the independent variables. These were mean air temperature 6, 9, 28, 31, 37, 41, and 49 weeks ago.

F = 11.32 sig = 0.000 Durbin-Watson = 1.85

14. spring onions

74% of the variation in the volume of spring onions marketed could be accounted for by variation in the independent variables. These were mean air temperature 5, 7, 40, and 47 weeks ago; and rainfall 2, 17, and 38 weeks ago.

F = 44.33 sig = 0.000 Durbin-Watson = 1.17

15. tomatoes

79% of the variation in tomato volume could be accounted for by variation in the independent variables. The variables retained were mean air temperature 1, 5, 30, 38, 40, 47, 50, and 51 weeks ago; and rainfall 19, 26, 28, and 41 weeks ago.

F = 33.63 sig = 0.000 Durbin-Watson = 1.51

6. Quantity regressed against week's mean daily sunshine hours, air temperature and week's rainfall.

Sunshine hours was added as a predictor to see if it would improve the amount of variance in marketed quantity accounted for. Both current and lagged weather variables were used.

No reference was made to the use of sunshine data in the literature cited above. The results are presented below.

 Table 37 Quantity as a function of weather

quantity of:	rsq	arsq	F	sig	D
broccoli	.53	.50	18.06	0.000	1.27
cabbage	.69	.66	20.94	0.000	1.80
capsicum	.75	.73	32.14	0.000	1.69
cauliflower	.20	.18	12.73	0.000	1.02
celery	.80	.75	15.57	0.000	1.66
garlic	.49	.45	13.29	0.000	1.79
kumara	.23	.21	9.98	0.000	1.54
lettuce	.84	.82	39.77	0.000	2.04
onions	.44	.41	15.74	0.000	1.75
parsnips	.67	.66	40.54	0.000	1.60
pumpkins	.51	.47	11.08	0.000	1.43
silverbeet	.40	.37	13.20	0.000	1.71
springons	.78	.76	41.40	0.000	1.16
tomatoes	.85	.83	36.12	0.000	1.36

All of the relationships were significant. A high proportion of the variance in marketed volume was accounted for for cabbages, capsicums, celery, lettuce, parsnips, spring onions, and tomatoes.

7. Price regressed against week's mean daily sunshine hours and mean air temperature and week's rainfall.

It is expected that in general, from the demand point of view, that weather has little effect on prices. If it is hypothesised that weather conditions can stimulate or depress demand then we would expect some sort of relationship between weather and price. Lee (1973 p 50) included a current weather variable in his demand equation for fresh vegetables. He assumed that diets would be affected by the weather.

Current price was regressed against current and lagged sunshine hours, weekly rainfall, and mean weekly temperature. The results are presented below.

 Table 38 Price as a function of weather

price of:	rsq	arsq	F	sig	D
broccoli	.27	.26	18.95	0.000	1.09
cabbage	.06	.05	6.75	0.01	0.58
capsicum	.68	.67	72.95	0.000	1.10
cauliflower	.41	.36	8.36	0.000	1.79
celery	.78	.75	24.46	0.000	0.89
garlic	.60	.56	15.63	0.000	1.88
kumara	.68	.64	17.65	0.000	1.33
lettuce	.35	.33	18.42	0.000	0.66
mushrooms	.57	.52	12.36	0.000	1.43
onions	.32	.31	24.23	0.000	0.40
parsnips	.57	.53	12.51	0.000	1.48
pumpkins	.59	.55	13.71	0.000	0.81
silverbeet	.46	.43	16.72	0.000	1.34
springons	no variables entered				
tomatoes	.87	.85	49.62	0.000	1.87

All estimated equations were significant.

Capsicums, celery, kumaras, and tomatoes all had quite strong associations with the climatological variables.

Interestingly, variables at t=1 were not frequently included in the models estimated by the stepwise procedure. This would imply that current weather conditions do not have a strong influence on prices bid.

8. Aridity index

An aridity index similar to the one discussed by Oury (op cit) was calculated.

The index A, was calculated by dividing weekly rainfall by mean weekly temperature. No constant was added to avoid negative numbers. This was unnecessary as mean air temperature never fell below zero degrees C in the period under study.

Current price and volume for each vegetable were regressed against this index which was lagged by up to 52 weeks.

The results are presented below.

1. The relationship between volume and the aridity index.

 Table 39 Quantity as a function of aridity index

quantity of:	rsq	arsq	F	sig	D
broccoli	.36	.30	6.66	0.000	1.44
cabbage	.39	.35	10.38	0.000	1.13
capsicum	.41	.35	7.36	0.000	1.13
cauliflower	.09	.08	5.26	0.0067	0.91
celery	.19	.15	5.91	0.0003	0.74
garlic	.40	.35	7.11	0.000	1.51
lettuce	.30	.25	6.90	0.000	0.92
onions	.29	.17	6.14	0.000	1.35
parsnips	.48	.43	11.00	0.000	1.26
pumpkins	.20	.17	6.40	0.0001	1.39
silverbeet	.40	.35	9.17	0.000	1.79
springons	.55	.49	8.69	0.000	0.98
tomatoes	.57	.51	10.16	0.000	0.92

All equations were significant at the 99% level.

This particular form of aridity index was not as good at predicting marketed volume as the original weather variables.

2. The relationship between price and the aridity index.

 Table 40 Price as a function of aridity index

price of:	rsq	arsq	F	sig	D
broccoli	.17	.14	5.27	0.0007	1.07
cabbage	.16	.13	6.41	0.0005	0.63
capsicum	.59	.54	13.38	0.000	0.86
cauliflower	.04	.03	4.40	0.0384	0.96
celery	.25	.21	6.68	0.000	0.51
garlic	.26	.22	6.88	0.000	1.31
kumara	no variables entered				
lettuce	.17	.14	6.77	0.0003	1.12
mushrooms	.21	.17	5.24	0.0003	1.12
onions	.04	.03	4.51	0.0361	0.22
parsnips	.32	.28	9.22	0.000	1.22
pumpkins	no variables entered				
silverbeet	.31	.26	6.25	0.000	0.98
springons	.12	.10	4.73	0.004	1.41
tomatoes	.76	.72	17.70	0.000	1.06

All estimated equations were significant at the 95% level.

For most of the vegetables the aridity index is of little value in accounting for variation in current price. Capsicums and tomatoes are exceptions, but the original weather variables were better than the aridity index. Spring onions was the only vegetable for which the aridity index was better than the original variables.

9. Special treatment of tomatoes and capsicums.

For part of the year both of these vegetables are grown under glass. The volume brought to the floor is therefore not affected by weather during this time. The volume boxplots were used to estimate the weeks during which these vegetables were grown under glass as it was not known when in each year main outdoor crops were harvested.

These months were then selected and the regressions of quantity on lagged weather variables carried out. The months excluded were May through October for tomatoes, and April through November for capsicums.

For capsicums this resulted in an adjusted r-squared of 75% which is only a little better than when the entire series was considered.

Not even a slight improvement was achieved for tomatoes. The adjusted r-squared was 75%. Clearly more information was required to make a better exclusion of months.

10. Regression of onion volumes on hours of sun per day.

Onions are noted for there dependence on daylight hours for growth. Onion volume and price were regressed against all sunshine hours lagged up to 52 weeks. The results were as follows:

Only 20% of the variation in price could be explained by the lagged sunshine hours retained in the model.

R squared = .23 Adjusted r squared = .20 F = 7.563 Sig = .000 Durbin-watson = .29

Only 34% of the variation in volume could be explained by the lagged sunshine hours retained in the model.

R squared = .37 Ajusted r squared = .34 F = 11.84 Sig = .000 Durbin-Watson = 1.70

While the length of day affects onion growth, it seems to have little influence on the variation in the volume of onions brought to market. Since onions are an annual and are stored this is not surprising. If fresh onions were isolated from stored onions a better explanation of variance might be obtained.

11. Summary

The addition of sunshine hours improved the ability of weather variables to explain the variation in marketed quantity for all vegetables with the exception of silverbeet.

The division of the year for capsicums and tomatoes did not result in an increase in explained variance of quantity marketed.

However, it should be noted that only about one third of tomato production is directly subject to weather variation.

Prices were predicted well by the weather variables for capsicums, celery, kumaras, and tomatoes. About half of the variance in prices was accounted for for garlic, mushrooms, parsnips, and pumpkins.

The aridity index calculated was not as good as the original weather variables except for a few exceptions which were noted.

Onion volumes was one of the least explained variables. There are two reasons why this is not surprising.

The first is that most onions are grown in the Pukekohe district and so are subject to different climatological influences than were represented in the data set. The second reason is that marketed volume was regressed rather than yield. The market is supplied out of storage for most of the year, and so the effect of climate is really on total crop yield rather than weekly volume marketed. This would introduce complications if an econometric model was to be developed.

CHAPTER 11 LAGGED PRICE RELATIONSHIPS

1. Introduction

Price was regressed against own price lagged. Lagging was restricted to 52 weeks. If a series was purely random we would expect the correlation between successive observations to be low Nelson (1973). It was expected that recent prices would be highly correlated with current prices reflecting the recent price and volume behaviour at the market.

1. All lags up to and including 52 weeks

Knowing what prices have been should give a strong indication of what prices will be. For each vegetable prices were lagged from 1 week to and including 52 weeks.

Current price was then regressed against all of these lagged prices using the method ENTER in SPSSx REGRESSION.

The variation accounted for by this regression is presented below.

Table 41 Regression of price on lags to 52 weeks

price of:	rsq	arsq
broccoli	.58	.19
cabbage	.78	.57
capsicum	.86	.73
cauli	.51	.05
celery	.87	.74
garlic	.57	.18
kumara	.69	.41
lettuce	.64	.31
mushroom	.48	-.01
onions	.91	.82
parsnips	.68	.38
pumpkins	.93	.86
silverbeet	.70	.42
springons	.47	-.03
tomatoes	.85	.72

For most vegetables, lagged prices are good predictors of current price. Presumably they will remain so until some external cause shocks the system. Lagged prices will not enable the prediction of turning points in the series.

Obviously improvements in adjusted R squared can be gained by reducing the number of explanatory variables.

2. Price lagged by one and two weeks

A strong relationship is expected to exist between current price and the most recent price. Current price was regressed against price lagged by one week, and prices lagged one and two weeks. The results of both of these regressions are presented below.

 Table 42 Price regressed on price lagged 1;
 and 1 and 2 weeks

price of:	1 week arsq	1 and 2 weeks arsq
broccoli	.33	.33
cabbage	.54	.58
capsicum	.64	.64
cauli	.21	.21
celery	.73	.73
garlic	.36	.39
kumara	.70	.70
lettuce	.44	.47
mushroom	.27	.26
onions	.83	.83
parsnips	.37	.36
pumpkins	.78	.78
silverbeet	.37	.40
spring onions	.16	.17
tomatoes	.58	.59

Assuming that nothing shocks the marketing system such as abnormal weather, last week's price would be a reasonable predictor of next weeks price for kumaras, onions, and pumpkins. Generally however, the most recent weekly price is not very good at predicting price in the current week. This reflects the fact that prices change considerably from week to week.

Adjusted r-squared improved for only five vegetables when price was lagged by two weeks as well as one week. In general, there was no improvement in adjusted r-squared when price lagged by two weeks was included with price lagged by one week.

3. Price lagged by 52 weeks

The strength of relationship between current price and the price at the same time 52 weeks ago was also examined. The letter plots in chapter 7 indicated that some vegetables had very similar prices 5 weeks apart whilst others had very dissimilar prices. Current price was regressed against own price lagged by 52 weeks.

Table 43 Price regressed on
price a year ago

price of:	rsq
broccoli	.08
cabbage	.07
capsicum	.51
cauli	.01
celery	.50
garlic	.003
kumara	.21
lettuce	.000
mushroom	.000
onions	.000
parsnips	.005
pumpkins	.12
silverbeet	.11
springons	.02
tomatoes	.44

Capsicums and celery indicated moderately strong relationships between current price and price lagged by 52 weeks.

4. Autocorrelation function

Autocorrelation functions were computed for the fifteen vegetables retained in the study.

An autocorrelation is the degree of correlation between observations lagged by k periods (Nelson 1973).

The objective was to determine whether the current price of most vegetables was highly correlated with the most recent price and whether this correlation declined as time passes. This would indicate which particular lags were the most useful in predicting current price. Autocorrelations might also show up seasonality in prices.

The autocorrelation of prices for each vegetable at selected lags is given below.

 Table 44 Selected autocorrelations

	autocorrelation at lag:									
	1	2	3	4	12	24	36	48	52	
broccoli	.57	.35	.22	.21	.04	-.17	-.10	.09	.19	
cabbage	.72	.65	.46	.39	-.01	-.10	-.18	-.18	-.19	
capsicum	.79	.68	.60	.52	.09	-.42	-.12	.35	.47	
cauli	.46	.31	.19	.16	.14	.09	-.03	.00	.03	
celery	.86	.72	.59	.48	-.15	-.27	-.17	.47	.52	
garlic	.60	.51	.60	.51	.42	.19	.07	-.03	-.07	
kumara	.83	.70	.57	.45	.12	-.11	-.10	.15	.21	
lettuce	.63	.54	.39	.27	-.19	.09	-.26	.11	-.02	
mushroom	.52	.29	.28	.25	.04	-.05	.00	.08	.02	
onions	.91	.84	.80	.76	.44	.22	.12	.00	-.05	
parsnips	.60	.40	.39	.33	-.01	.03	-.07	.05	.06	
pumpkins	.88	.81	.77	.72	.23	-.21	-.06	.15	.14	
silverbeet	.61	.52	.46	.37	-.22	.04	-.31	.18	.25	
springons	.39	.28	.23	.10	-.02	-.02	.12	-.07	-.10	
tomatoes	.76	.65	.66	.60	-.08	-.48	-.13	.40	.43	

None of the vegetables had current price highly correlated with price 52 weeks ago.

Celery autocorrelations dampened out after about 8 weeks and those for garlic, onions, pumpkins, and capsicums took a long time to become small. This implies that there is considerable stability in the price series for these vegetables.

2. Summary

The current price of most vegetables was highly correlated with their most recent prices. However, spring onions, cauliflower, and mushrooms have low autocorrelations for the most recent lags. This means that each observation was not very highly correlated with its preceding observation. This means that prices for these vegetables fluctuate considerably.

However, price one week ago and two weeks ago gave a poor prediction of current price for almost all of the vegetables. Only the stored vegetables had high values for r-squared.

None of the vegetables had a high correlation between current price and price 52 weeks ago.

CHAPTER 12 MONTH RELATIONSHIPS

The objective in this part of the study was to quantify the dependence of the price and volume of a given vegetable on the month of the year. The proportion of variation in price attributable to calendar months was established.

1. Method

Each week was coded as belonging to a certain month. This was done on the basis of the date of the last trading day of the week. Where a large proportion of the trade in a given week belonged to the earlier month the week end date still specified the month to which it was assigned. Months were coded from 1 for January to 12 for December.

2. Price

Price was regressed against month of the year. The results are presented below.

Table 45 Price as a function of month

price of:	rsq	arsq	F	sig	
broccoli	.27	.22	5.05	0.000	
brussels	.10	.03	1.46	0.181	#
cabbage	.13	.07	2.03	0.029	
capsicum	.69	.66	29.80	0.000	
cauli	.08	.01	1.18	0.306	#
celery	.68	.66	29.40	0.000	
garlic	.03	-.04	0.41	0.950	#
kumara	.45	.41	11.05	0.000	
leeks	.12	.04	1.56	0.129	#
lettuce	.15	.08	2.34	0.011	
mushroom	.21	.15	3.58	0.0002	
onions	.17	.11	2.80	0.002	
parsnips	.22	.16	3.81	0.0001	
pumpkins	.39	.35	8.72	0.000	
silverbeet	.32	.27	6.32	0.000	
spinach	.26	.20	4.46	0.000	
springons	.08	.01	1.20	0.293	#
tomatoes	.65	.63	25.33	0.000	

For most vegetables month was very poor at accounting for variation in price. The exceptions were celery, tomatoes and capsicums, and to a lesser degree, kumaras and pumpkins. Suprisingly knowledge of the month would not help us account for much of the variation in the price of onions.

Five of the models were not significant at the 95%level. Each of these is marked with a #.

3. Volume

The same procedure was carried out with volume being regressed against months. The results are presented below.

Table 46 Quantity as a function of month

quantity of:	rsq	arsq	F	sig
broccoli	.47	.43	12.18	0.000
brussels	.83	.82	63.83	0.000
cabbage	.53	.50	15.40	0.000
capsicum	.54	.50	15.61	0.000
cauli	.24	.18	4.18	0.000
celery	.51	.47	14.05	0.000
garlic	.16	.09	2.51	0.006
kumara	.25	.19	4.44	0.000
leeks	.61	.58	18.32	0.000
lettuce	.64	.61	23.66	0.000
mushroom	.08	.01	1.21	0.288
onions	.31	.26	6.20	0.000
parsnips	.63	.60	23.27	0.000
pumpkins	.23	.17	3.96	0.000
silverbeet	.26	.20	4.64	0.000
spinach	.53	.50	14.27	0.000
springons	.74	.72	39.18	0.000
tomatoes	.77	.75	45.59	0.000

For some of the vegetables a large amount of the variance in marketed quantity can be explained by using month dummy variables. All models were significant except that for mushrooms.

4. Summary

Month of the year was poor at accounting for variation in weekly price but quite good at accounting for variation in weekly volume.

APPENDIX 1

The storage characteristics of the vegetables in this study are given below.

vegetable	recommended conditions		approximate storage life
	degrees C	relative humidity %	
broccoli	0	90-95	10-14 days
brussels sprouts	0	90-95	3-5 weeks
cabbage - early	0	90-95	3-6 weeks
- late	0	90-95	3-4 months
cauliflower	0	90-95	2-4 weeks
capsicum - green	7-10	90-95	2-3 weeks
- ripe	4.5-7	90-95	1 week
celery	0	90-95	3-4 months
garlic	0	65-70	6-7 months
sweet potato (kumara)	13-16	85-90	4-6 months
leeks	0	90-95	1-3 months
lettuce	0	95	2-3 weeks
mushrooms	0	90	3-4 days
onions - dry	0	65-70	1-8 months
- green/spring	0	90-95	-----
parsnips	0	90-95	2-6 months
pumpkins	10-16	70-75	2-3 months
spinach	0	90-95	10-14 days
tomatoes - mature-green	16-21	85-90	1-3 weeks
- firm-ripe	7-10	85-90	4-7 days

source: Lorenz and Maynard (1980)
(silverbeet not listed but probably as for spinach)

Exhibit 2-4 Re-expressions in the Ladder of Powers ($y \rightarrow y^n$)

p	Re-expression	Name	Notes
	.		Higher powers can be used.
	.		
	.		
3	y^3	Cube	
2	y^2	Square	The highest commonly used power.
→ 1	y^1	"Raw"	No re-expression at all.
1/2	\sqrt{y}	Square root	A commonly used power, especially for counts.
(0)	$\log(y)$	Logarithm*	$\log(y)$ holds the place of the zero power in the ladder of powers. A very common re-expression.
-1/2	$-1/\sqrt{y}$	Reciprocal root	The minus sign preserves order.
-1	$-1/y$	Reciprocal	
-2	$-1/y^2$	Reciprocal square	
	.		
	.		
	.		Lower powers can be used.

*We ordinarily use logarithms to the base 10.

source: Velleman and Hoaglin (1981 p 49).

```
file handle sysin/name = sys7
file handle sysout/name = sysx
get file = sysin
factor variables = p1 p3 to p8 p10 to p15 p17 p18/
  format = sort/
  print = default correlation fscores/
  extraction = pc/
  rotation = varimax/plot = rotation (1,2)/
  rotation = equamax/plot = rotation (1,2)/
  rotation = quartimax/plot = rotation (1,2)/
  save reg (all fsuls)/
```

APPENDIX 4

CORRELATION MATRIX:

P	1	3	4	5	6	7	8	10	11	12	13	14	15	17
P														
1	1													
3	.30	1												
4	.24	.09	1											
5	.56	.30	-.10	1										
6	-.15	.04	-.09	-.01	1									
7	-.19	.09	.13	-.27	.05	1								
8	-.07	.07	.11	-.06	.36	.19	1							
10	.18	.34	.06	.27	.03	-.14	-.11	1						
11	.22	.07	.07	.10	-.25	.08	-.10	.08	1					
12	-.04	.04	-.13	.14	.49	-.17	-.15	.15	-.35	1				
13	.19	-.16	-.01	.04	.05	-.19	.07	-.07	-.11	-.10	1			
14	-.07	-.03	.17	-.21	.39	.12	.70	-.22	-.10	-.27	.18	1		
15	.02	.36	.17	.07	.56	.18	.26	.24	-.12	.25	-.03	.22	1	
17	.25	.24	.14	.20	.08	-.10	-.19	.06	.00	.04	.06	-.12	.06	1
18	.42	.10	.54	.09	-.08	-.14	.06	.08	-.01	.06	.20	.11	.07	.14

FACTOR SCORE COEFFICIENT MATRIX:

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
P1	.24329	.05028	-.15077	.09247	.23445
P3	.35220	.07396	-.06547	-.03006	-.18652
P4	-.04934	-.03235	.00443	.54084	-.17376
P5	.32822	.05425	-.07762	-.19890	.25215
P6	.06525	.19820	.31594	-.08982	.01274
P7	-.00785	.07131	-.09317	.06001	-.42357
P8	.02584	.41430	-.06656	-.07544	.03998
P10	.26835	-.06229	.03716	-.02495	-.09713
P11	.15615	.04100	-.36725	-.08985	-.10759
P12	.03187	-.17289	.44633	.03301	.01002
P13	-.09284	.13812	.00881	.03500	.43956
P14	-.05986	.40592	-.05835	.00832	.09249
P15	.19588	.15661	.19655	.04672	-.19297
P17	.12048	-.08338	.06491	.14337	.04205
P18	-.03133	-.03591	.06538	.48863	.10447

COVARIANCE MATRIX FOR ESTIMATED REGRESSION FACTOR SCORES:

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
FACTOR 1	1.00000				
FACTOR 2	.00000	1.00000			
FACTOR 3	.00000	.00000	1.00000		
FACTOR 4	.00000	.00000	.00000	1.00000	
FACTOR 5	.00000	.00000	.00000	.00000	1.00000

- 5 PC EXACT FACTOR SCORES WILL BE SAVED WITH ROOTNAME: FSULS
 -FOLLOWING FACTOR SCORES WILL BE ADDED TO THE ACTIVE FILE:

NAME	LABEL		
FSULS1	REGR FACTOR SCORE	1 FOR ANALYSIS	1
FSULS2	REGR FACTOR SCORE	2 FOR ANALYSIS	1
FSULS3	REGR FACTOR SCORE	3 FOR ANALYSIS	1
FSULS4	REGR FACTOR SCORE	4 FOR ANALYSIS	1
FSULS5	REGR FACTOR SCORE	5 FOR ANALYSIS	1

APPENDIX 6

The law regarding sale by auction is contained in section 59 of the Sale of Goods Act 1908. This is outlined in Farrar et al (1986). Sale by auction is a branch of contract law. The main difference is that the goods are deemed to have been sold at the fall of the hammer. Further, there is no warranty regarding quality. Section 59 sets out special rules as follows:

1 Where goods are put up for sale by auction in lots, each lot is prima facie deemed to be the subject of a separate contract of sale.

2 A sale by auction is complete when the auctioneer announces its completion by the fall of the hammer, or in the customary manner: until such announcement is made any bidder may retract his bid.

3 Where a sale by auction is not notified to be subject to a right to bid on behalf of the seller, the seller shall not bid himself or employ any person to bid at such sale, nor shall the auctioneer knowingly take any bid from the seller or any such person. Any sale contravening this rule may be treated as fraudulent by the buyer.

4 A sale by auction may be notified to be subject to a reserved or upset price, and a right to bid may also be reserved expressly by or on behalf of the seller.

5 Where a right to bid is expressly reserved, but not otherwise, the seller, or any one person on his behalf, may bid at the auction.

Extract from the Manawatu Evening Standard
 Thursday 2 June 1984.

Vegetables aplenty at market



GOOD quantities of the usual seasonal lines were available on today's fruit and vegetable market, according to Palmerston North auctioneers Arlidge Brothers.

There was some firming in the cabbage market, and these should be selling in the shops for 80c to \$1.20 each. Cauliflower and lettuce met with a steady demand, with cauliflowers retailing for 80c to \$1.20 and lettuce 70c to 85c.

Celery and broccoli supplies increased this week, and there was a slight easing of prices for these as a result. Celery

should be selling in the shops for 80c to \$1.29 a bunch and broccoli \$2.20 to \$2.50 a kilo.

Leeks, silverbeet and spinach continued to sell to steady demand and firm rates. And there were good supplies of kumera available this week, ranging in price from \$1.20 to \$1.30 a kilo.

There was some firming in the mushroom market, and these should be selling at \$6.50 to \$8 a kilo.

Carrots, parsnips and swedes were in fair demand today - retail prices for carrots and swedes should range be-

tween 70c and 90c a kilo, but there was some easing in parsnip prices.

Good quantities of South Island brussels sprouts were available at \$3.50 a kilo retail, while the Ohakune variety continued to sell, with retail prices ranging from \$2.60 to \$2.80.

Hothouse tomatoes remained in good supply with retail prices at \$2.50 to \$3.60 a kilo.

On the fruit side, good supplies of mandarins, including the Satsuma and Clementine varieties, were available. Very good supplies of New Zealand grapefruit also came on to the market.

Quantities of kiwifruit and tamarillos were down slightly and values firmed. New Zealand lemons also sold to firm rates - they should be selling in the shops for

\$1.50 to \$2.50 a kilo.

Exotic lines available this week included a few imported capsicums, eggplant, courgettes and rock melons, all of which sold at very firm rates, and retail prices should be high.

There were also small offerings of babaco, strawberries and hot-

house grapes. Australian oranges should reach the shops within two or three days, while Philippine bananas are in good supply.

Apples available this week included the good eating braeburn, splendour, and red and gold delicious. Winter cole pears were also in good supply.

APPENDIX 8

WEEK	DATE						
1		53	7/1/83	105	6/1/84	157	4/1/85
2		54	14/1/83	106	13/1/84	158	11/1/85
3		55	21/1/83	107	20/1/83	159	18/1/85
4		56	28/1/83	108	27/1/84	160	25/1/85
5		57	4/2/83	109	3/2/84	161	1/2/85
6		58	11/2/83	110	10/2/84	162	8/2/85
7		59	18/2/83	111	17/2/84	163	15/2/85
8		60	25/2/83	112	24/2/84	164	22/2/85
9	5/3/82	61	4/3/83	113	2/3/84	165	1/3/85
10	12/3/82	62	11/3/83	114	9/3/84	166	8/3/85
11	19/3/82	63	18/3/83	115	16/3/84	167	15/3/85
12	26/3/82	64	25/3/83	116	23/3/84	168	22/3/85
13	2/4/82	65	1/4/83	117	30/3/84	169	29/3/85
14	9/4/82	66	8/4/83	118	6/4/84		
15	16/4/82	67	15/4/83	119	13/4/84		
16	23/4/82	68	22/4/83	120	20/4/84		
17	30/4/82	69	29/4/83	121	27/4/84		
18	7/5/82	70	6/5/83	122	4/5/84		
19	14/5/82	71	13/5/83	123	11/5/84		
20	21/5/82	72	20/5/83	124	18/5/84		
21	28/5/82	73	27/5/83	125	25/5/84		
22	4/6/82	74	3/6/83	126	1/6/84		
23	11/6/82	75	10/6/83	127	8/6/84		
24	18/6/82	76	17/6/83	128	15/6/84		
25	25/6/82	77	24/6/83	129	22/6/84		
26	2/7/82	78	1/7/83	130	29/6/84		
27	9/7/82	79	8/7/83	131	6/7/84		
28	16/7/82	80	15/7/83	132	13/7/84		
29	23/7/82	81	22/7/83	133	20/7/84		
30	30/7/82	82	29/7/83	134	27/7/84		
31	6/8/82	83	5/8/83	135	3/8/84		
32	13/8/82	84	12/8/83	136	10/8/84		
33	20/8/82	85	19/8/83	137	17/8/84		
34	27/8/82	86	26/8/83	138	24/8/84		
35	3/9/82	87	2/9/83	139	31/8/84		
36	10/9/82	88	9/9/83	140	7/9/84		
37	17/9/82	89	16/9/83	141	14/9/84		
38	24/9/82	90	23/9/83	142	21/9/84		
39	1/10/82	91	30/9/83	143	28/9/84		
40	8/10/82	92	7/10/83	144	5/10/84		
41	15/10/82	93	14/10/83	145	12/10/84		
42	22/10/82	94	21/10/83	146	19/10/84		
43	29/10/82	95	28/10/83	147	26/10/84		
44	5/11/82	96	4/11/83	148	2/11/84		
45	12/11/82	97	11/11/83	149	9/11/84		
46	19/11/82	98	18/11/83	150	16/11/84		
47	26/11/82	99	25/11/83	151	23/11/84		
48	3/12/82	100	2/12/83	152	30/11/84		
49	10/12/82	101	9/12/83	153	7/12/84		
50	17/12/82	102	16/12/83	154	15/12/84		
51	24/12/82	103	23/12/83	155	22/12/84		
52	31/12/82	104	30/12/83	156	29/12/84		

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