UNIVERSITY OF BRISTOL

DEPARTMENT OF ECONOMICS
(Agricultural Economics)

Selected Papers in Agricultural Economics

Vol. VII. *No. 1.*

Uncertainty and Risk in the Vegetable Sector of the Horticultural Industry

by

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Price 5s. 0d.

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December 1958

Introduction

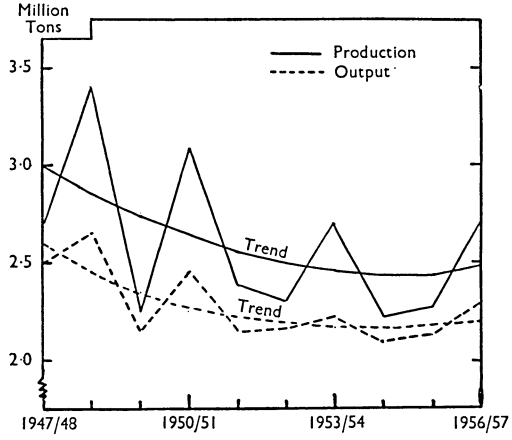
HORTICULTURAL products have, for reasons that are already well known, been excluded from the system of guaranteed prices which has been applied, with various modifications, to the main agricultural products since the Agriculture Act of 1947. To compensate for this disability a substantial measure of protection has been conferred on the horticultural industry by means of tariffs levied seasonally on competing imported products. Although this form of assistance is very welcome it obviously lacks the real solidity and comprehensive cover of a minimum price guarantee. For while agriculturalists enjoy nothing like the same measure of tariff protection from foreign competition, their ultimate receipts are very efficiently insulated from its effects. Of perhaps even greater importance today is the high degree of short-run immunity from the competition of their fellow producers which they, the agriculturalists, also enjoy as a result of forward price guarantees. In striking contrast, horticultural prices are completely and immediately vulnerable to every adverse change in the supply and demand conditions for their products. When, as a result of a seasonal surplus, prices fall or, as is sometimes the case, collapse entirely, it is but a poor consolation for producers to know that the offending surplus is 99 per cent home produced.

This absence of an ultimate guarantee, a cushion able to absorb the main shocks of excessive fluctuations in demand and supply, is felt most acutely in horticulture on account of the special conditions which characterise the production and marketing of its products. Among the more important of these are the wide variations in yield and quality, the highly seasonal nature of demand, the fleeting interval in which a crop passes from a state of ripeness to one of over-maturity and, in most instances, its highly perishable nature when once harvested. These and other factors inevitably create conditions of acute uncertainty and involve a high degree of commercial risk. Yet, ironically enough, these same disabilities, which would plead so eloquently the case for equality of treatment with agriculture over the matter of price guarantees, are among the strongest reasons why such a policy has been ruled out as a practical proposition.

Part I

The production of vegetable crops* was increased substantially during the war, both on nutritional grounds and also because many such crops were capable of yielding comparatively high quantities of dry matter per acre. Since the end of the war both acreage and production have declined.

CHART 1. Production and Output of Vegetables in the U.K. 1947/48–1956/57



Trends during the ten-year period 1947/48 to 1956/57 in production and output† are shown in Chart 1. There are two points of special interest in this graph. First, the annual fluctuations about the trend in production are much greater than they are about the trend in output. Secondly, the annual gap between production and output is seen to be much wider in years of high production than in years of low production. This can be taken as an indication of the extent to which, on

* Throughout this report "vegetable crops", "the vegetable-producing industry" and other similar expressions will include, in addition to vegetables grown in the open, vegetables produced under glass.

† Production is defined as the total quantity of crops fit for the market including crops over-matured because they could not be marketed early enough, but crops rendered unsaleable as a result of damage or disease are not included. Output is that part of production which reaches the market plus an estimated quantity used on farms.

the one hand, the market is either unprepared or unwilling to absorb sudden and substantial increases in production when they arise, while, on the other hand, it is presumably quite willing and able to absorb practically everything that becomes available in years of comparatively low production. Percentage variations from the trend values are shown in Table 1 below.

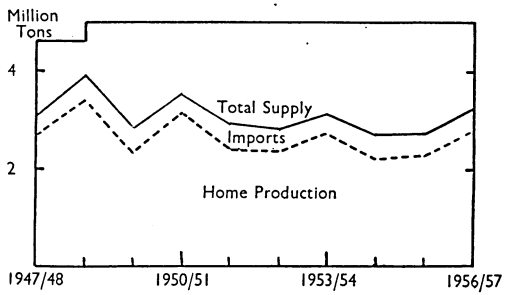
TABLE 1

Observed Values as a Percentage of the Trend

Year	*Production* %	*Output* %
1947/48	90	97
1948/49	120	108
1949/50	83	90
1950/51	117	108
1951/52	94	97
1952/53	93	99
1953/54	111	103
1954/55	91	98
1955/56	93	98
1956/57	108	102

Imports of fresh vegetables, which, as already mentioned, are subject to seasonal tariffs, have been remarkably steady during this ten-year period. What is, perhaps, even more surprising is the absence of any clear evidence of quantitative integration between imports and home production. As the graph in Chart 2 illustrates quite clearly, year to year variations in total supply are almost entirely the result of variations in the volume of home production.

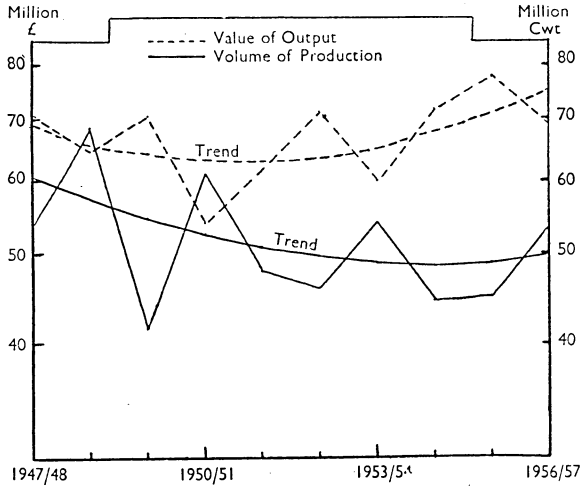
CHART 2. Home Production, Imports and Total Supplies of Vegetables 1947/48–1956/57



Of prime importance to an industry is the value of its output, both in its absolute magnitude and in relation to that industry's volume of production. In Chart 3 the value of the annual output and the volume of the annual production of vegetables

have been plotted for each year of the period 1947/48 to 1956/57 using a vertical logarithmic scale thus enabling movements in the two series to be more easily compared. Included on the same graph are the two lines of trend fitted to the natural numbers.

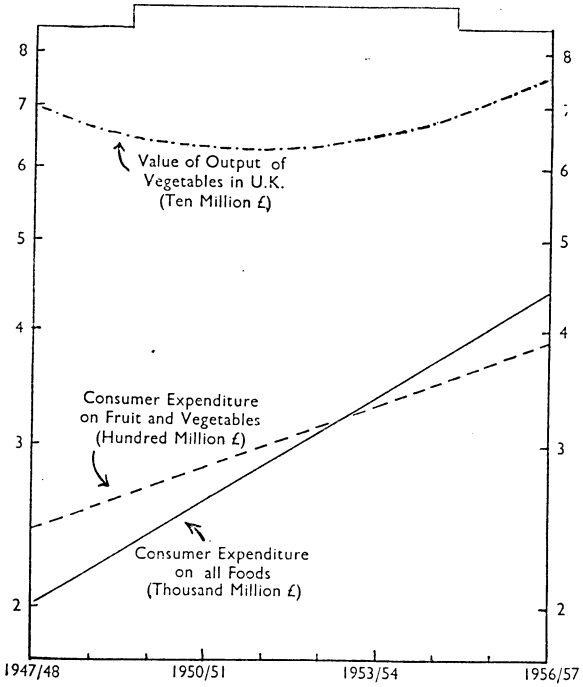
CHART 3. Value of Output and Volume of Production 1947/48–1956/57 (*Logarithmic Scale*)



Both series show considerable variation about their lines of trend. They vary inversely with one another, but in very similar proportions, the value of the correlation coefficient being $-0{\cdot}82$. A negative correlation ($r = -0{\cdot}71$) was also established between the percentage deviations of the value and the volume of output from their respective trends. The logical inference to be drawn from this situation is that, in the short run, demand, for one reason or another, is highly inelastic.

In Chart 4 the trend in the annual value of vegetable output is compared with trends in consumer expenditures on (*a*) total food and on (*b*) fruit and vegetables, again using a vertical logarithmic scale. The contrast is worth noting. While consumer expenditures on both total food and on fruit and vegetables have been rising steadily and substantially over the period, producers' gross receipts from the sale of vegetables tended to fall during the first five years and had only slightly improved on the initial position by the end of the ten-year period. Unfortunately there are no figures available for consumer expenditure on vegetables alone which makes a precise

CHART 4. Trends in Consumer Expenditure and in the Value of Vegetable Output from Holdings in the U.K. 1947/48–1956/57
(*Logarithmic Scale*)

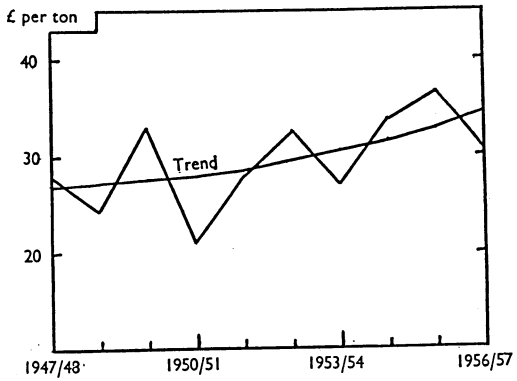


interpretation of the picture somewhat difficult. The trend in the total supply of vegetables showed a moderate fall during the early part of the period and a slight recovery during the latter part, whereas the total supply of fresh and processed fruit has tended to rise throughout the period, but nothing like enough to account for what might be regarded as a substantial part of the additions to joint consumer expenditure on these items. The only reasonable inference to be drawn from this picture is that the gap between producers' receipts for vegetables and their retail price has been widening quite appreciably, particularly during the first half of the period under review*

With regard to the trend in vegetable prices, the Ministry of

* The cost of additional processing such as canning and deep freezing may be one important factor accounting for this apparent rise in distributors' gross margins.

CHART 5. Growers' Average Price per ton for All Vegetables 1947/48–1956/57



Agriculture's statistics unfortunately combine fruit and vegetables into one single index. It is, however, possible to calculate a form of overall price indicator for vegetables only by dividing the estimated value of the total output of vegetables in each year by the corresponding volume of estimated total output. The price indicators so obtained and expressed in terms of pounds sterling per ton are plotted, together with the trend, on the graph shown in Chart 5. In so far as the method of calculation ignores changes in the composition of the output, as between high and low value crops, the results are not necessarily a true reflection of changes in the general price level. From an inspection of the details, however, there do not appear to be any changes in the composition of the total output over the period as a whole large enough to affect these results significantly. It seems, therefore, reasonable enough to accept them as an adequate estimate of the general price level for vegetables. The trend suggests a slowly accelerating rate of increase in prices. This we can regard as being a logical expectation in the light of what has already been established concerning the trends in output and consumer purchasing power over the same period. The observed price estimates expressed as a percentage of the trend are shown in Table 2 and provide further evidence of the considerable element of uncertainty which is characteristic of the vegetable sector of the horticultural industry. They also lend further support to the view already expressed that, in the short run, demand is inelastic. A high negative correlation was found to exist between variations from the trend in production and variations

from the trend in prices, the coefficient of correlation being −0·91.

TABLE 2

Observed Prices as a Percentage of Trend Value

Year	*Per Cent*
1947/48	105
1948/49	91
1949/50	120
1950/51	76
1951/52	99
1952/53	111
1953/54	88
1954/55	108
1955/56	112
1956/57	90

In the chapter on horticultural products in the Agricultural Register for 1956/57* there is a brief discussion on the efficacy of horticultural tariffs as a means of maintaining and improving producers' prices. The writer comes to the conclusion that "growers of fruit and vegetables in the open or under glass are, as a group, not unduly penalised by the absence of guaranteed prices". The evidence on which this conclusion is based is a table of comparative price indices which is reproduced below.

TABLE 3

Group Price Indices of Agricutulral Products in England and Wales

Base—1927/28 to 1929/30 = 100

Group	1938/39	1939/40	1949/50	1950/51	1954/55	1955/56
Cereals and Farm Crops	88·0	113·5	246·0	260·0	291·0	337·5
Livestock and Livestock Products	88·5	110·0	235·0	248·0	284·0	286·5
Fruit, Vegetables and Glasshouse Products	96·0	123·5	288·0	223·5	286·5	318·5
All Products	89·5	112·5	246·0	247·5	286·0	300·0

While it is true that, in the four post-war years quoted above, the index for the horticultural group is frequently relatively higher than the other indices, this is not altogether surprising in view of the particular years selected for illustration. By reference to Table 1 of this report, it will be seen that in the

* *The Agricultural Register*, 1956/57, Chapter IV. Published by the Agricultural Economics Research Institute, Oxford.

years 1949/50, 1954/55 and 1955/56, when horticultural prices were at their comparative best, the production of vegetables was conspicuously below the ten-year trend; whereas in 1950/51, when the horticultural price index was in fact below the other three indices, the production of vegetables was well above the ten-year trend. Moreover, the existence of a high negative correlation between variations in production and prices has already been noted.

But apart altogether from this, it would appear that the real point at issue has been overlooked. The system of price guarantees is not intended to produce high prices as such. Its prime purpose is to ensure a reasonable degree of price stability and this is precisely what the horticultural industry lacks, in spite of the heights to which, on occasions, its group price index has risen. This situation is made very clear by the figures in Table 2. Moreover, it is also worth pointing out that producers of farm crops, livestock and livestock products have enjoyed a fairly stable and rising price level concurrently with a growing volume of output, whereas the recent upward trend in horticultural prices has almost certainly been achieved, as the graph in Chart 3 implies, partly at the expense of a reduction in the industry's volume of output.

It would, no doubt, be true to say that ten years is but a brief period to take for a study of trends. The reasons for doing so are as follows. In the first place both agriculture and horticulture can be said to have started on a new life after the end of the last war. As it was not the purpose of this investigation to study changes in the industry over half a century or more there seemed to be little point in adding on to the present period a few additional years belonging to quite a different economic period. The second reason is that not only did the industry enter on a new life after the war but it has since passed through ten very formative years. Finally, it seemed highly probable that the last ten years might have produced some well-defined trends and these would have to be investigated as a preliminary to considering the question of variability and risk which constitute the main theme of this study.

For the vegetable-producing section of the horticultural industry ample evidence has been found to support the view that the industry's returns are highly variable and unpredictable from year to year. The origin of this instability appears to arise from the highly variable volume of production which becomes available from season and season and year to year on a market in which short-run prices are highly inelastic.

Part II

The discussion so far has centred around the problem of variation and risk in the vegetable producing industry as a whole. But within the industry there are likely to exist differing degrees of variation and risk. It is with this more detailed aspect of the subject, still measured in terms of aggregates, that the following section is concerned.

The most common and widely recognised example of variance associated with production from the soil is found in yield. In Table 4, the more important individual crops are listed in order of increasing yield variability as indicated by coefficients of variation calculated from their respective ten-year average yields.*

TABLE 4

Crop	Average Yield 1947/48–1956/57	Coefficient of Variation	Estimated Range in Yield for 7 out of 10 years
	Tons per acre	%	Tons per acre
Tomatoes (under glass)	33·5	2	32·8 –34·2
Carrots	10·2	9	9·1 –10·9
Celery	13·0	10	11·7 –14·3
Beetroot	9·5	14	8·2 –10·8
Cabbage	7·8	15	6·6 – 9·0
Cauliflower and Broccoli	5·7	15	4·8 – 6·6
Broad Beans	10·4	16	8·7 –12·1
Onions (dry)	8·7	18	7·1 –10·3
French and Runner Beans	3·8	20	2·9 – 4·7
Parsnips	10·0	20	8·0 –12·0
Peas (green market)	2·7	21	2·0 – 3·3
Lettuce (outdoor)	5·2	21	4·1 – 6·3
Leeks	8·2	22	6·4 –10·0
Onions (green)	5·9	23	4·5 – 7·3
Sprouts	3·0	23	2·3 – 3·7
Peas (dry)	0·7	24	0·53– 0·87
Tomatoes (outdoor)	8·5	31	5·9 –11·1

* The main reason for limiting the series to ten years was the fact that from 1947/48 onwards there is scarcely any discernable trend in yields. Moreover, having regard to all the technical changes which have occurred in recent years it was felt that a calculation of variation over the past ten years would probably provide a better estimate of near future variance than one extending over the last twenty years or so.

The coefficients range from 2 per cent for tomatoes under glass to 31 per cent for tomatoes grown in the open. Of the seventeen crops included in the table, nine have coefficients of 20 per cent or above. In the final column of the table is shown the estimated range within which individual crop yields could be expected to lie in approximately seven out of ten years. Yields in the remaining three years would, of course, be expected to lie outside the quoted range. On the whole, the levels of variation are not, perhaps, as wide as might have been expected. But when considering their economic significance it should be borne in mind that the marginal costs incurred or avoided, as yields realised rise above or fall below the expected average, can often be very small indeed. And as profit or loss is the difference between two comparatively much larger quantities, namely costs and returns, one of which tends to be largely predetermined while the other is likely to vary with changes in total production, in the determination of which yield is an important variable, it is quite plain that yield variations of even a modest order are capable of producing substantial modifications in this difference figure which measures the profit or loss on the enterprise.

Although in the context of an extractive industry such as horticulture we tend to think of variation first and foremost in terms of yield, price variables are certainly of no less importance. In fact, as a comparison of the figures in Tables 4 and 5† shows, price variations are, in general, decidedly larger than variations in yield. In the case of carrots, for example, the coefficient of yield variation is only 9 per cent, which means that in seven years out of ten, yields are likely to fall within the modest range of 9·1 to 10·9 tons per acre. The coefficient of price variation, on the other hand, is 32 per cent, which means that the seven out of ten year price range is 12/5 to 24/– per cwt. When it is also borne in mind that in the remaining three years prices are likely to fall outside even this wide range, then the high degree of uncertainty and commercial risk involved becomes apparent at once. Indeed, all the crops listed in the table, with the exception of tomatoes under glass, could be considered as "high risk" from the price aspect.

But neither variations in yield per acre nor in price per cwt. represent the ultimate in uncertainty and risk. In the final reckoning the really significant figure is the value of output

† Annual prices are unfortunately not available for the full range of crops enumerated in Table 4.

TABLE 5

Crop	Average Price per cwt. 1947/48–1956/57	Coefficient of Variation	Estimated Range in Price per cwt. for 7 out of 10 years
	£	%	£
Tomatoes (under glass)	7·45	10	6·70–8·20
Cauliflower and Broccoli (*a*)	1·43	20	1·14–1·72
Beans (*b*)	3·17	21	2·50–3·84
Sprouts	2·60	25	1·95–3·25
Onions (dry)	1·14	28	0·82–1·46
Celery (*a*)	1·54	32	1·05–2·03
Carrots	0·91	32	0·62–1·20
Cabbage (*a*)	0·90	36	0·58–1·22
Peas (green market)	2·72	39	1·66–3·78

(*a*) Prices per cwt. have been obtained by applying a weight conversion factor to the original prices which were quoted "per dozen".

(*b*) Includes Broad, French and Runner Beans.

per acre, because in this one figure is contained the composite effects and interactions of all the intermediate-stage variables such as yield, acreage planted and price. It is also, together with cost, the sole and direct determinant of profit or loss. It follows, therefore, that variations in the value of output per acre must represent the real criterion of ultimate uncertainty and risk.

TABLE 6

Crop	Average Value of Output per acre 1947/48–1956/57	Coefficient of Variation	Estimated Range in Output per acre for 7 out of 10 years
	£	%	£
Tomatoes (under glass)	5032	11	4482–5582
Celery (*a*)	385	17	320– 450
Sprouts	141	23	109– 173
Carrots	164	29	116– 212
Cauliflower and Broccoli (*a*)	157	31	108– 206
Beans (*b*)	198	33	132– 262
Peas (green market)	122	35	79– 165
Onions (dry)	176	37	111– 241
Cabbage (*a*)	116	38	72– 162

(*a*) Output values derived from yields and prices in Tables 4 and 5 (see there note (*a*)).

(*b*) Includes Broad, French and Runner Beans.

There can be little doubt, if the figures in Table 6 are accepted as a fair measure of the variance, that the wide areas of economic uncertainty associated with the production and sale of these crops constitute a very high degree of business risk. But assuming that the average values of output would generally coincide with normal profit situations, then the risk of making sub-normal profits or of incurring substantial losses cannot of course be dissociated from the compensating and equal chances of making exceptionally high profits. This kind of situation, however, must render planning and business administration exceedingly difficult. Moreover, it must inevitably place a severe strain on the capital structure of the less firmly established businesses.

It is fairly certain that the origin of these unstable conditions, at least during the period under review, is to be found in supply variations. As far as demand is concerned, referring back to the graph in Chart 4, Part I, it is unlikely that there has been anything but a steady increase in demand, although, as already pointed out, a considerable proportion of the additional expenditure by consumers appears to have been absorbed in higher distribution and service charges.

There are two variables concerned in the determination of supply (production), namely yield per acre and acreage planted. While the trend in yield may tend to rise in periods when new techniques are being introduced, or when producers' standards of management are improving, on a broad front as distinct from within small select groups, year to year variations can be assumed to be the result of natural circumstances beyond the control of producers.* The acreage planted, however, is the collective result of a large number of deliberate decisions made by individual producers. But, as so often happens over the whole range of farming products, however sound these may appear to be at the time from the individual producers' standpoint, collectively they are often irrational and not infrequently disastrous.

As a means of investigating the extent to which producers' decisions on cropping are influenced by their experiences of past prices, the total planted acreages in each of the ten years 1947/48–1956/57 for six of the more important vegetable crops

* Allen has shown that for a number of the more important vegetable crops there is a close positive correlation between changes in planted acreages and yields. "Short-term Production Variations for Horticultural Products and the Marketing Systems", G. R. Allen, *The Farm Economist*, Vol. VIII, No. 6.

were plotted on the same graphs as their respective average crop-year prices, the latter being dated twelve months in arrear of the acreage series. The general impression gained from these graphs is that, although producer decisions are influenced by past prices, the pattern of their responses is somewhat ill-defined and variable. On numerous occasions it even appears to run contrary to logical expectations as suggested by prevailing price conditions. The situation, in fact, varies from crop to crop, some showing evidence of a closer and more consistent relationship between the two series than others.

CHARTS 6 to 11.

Acreages 1947/48–1956/57 and Prices 1946/47–1955/56
for Six Major Vegetable Crops
(*Logarithmic Scale*)

CHART 6.

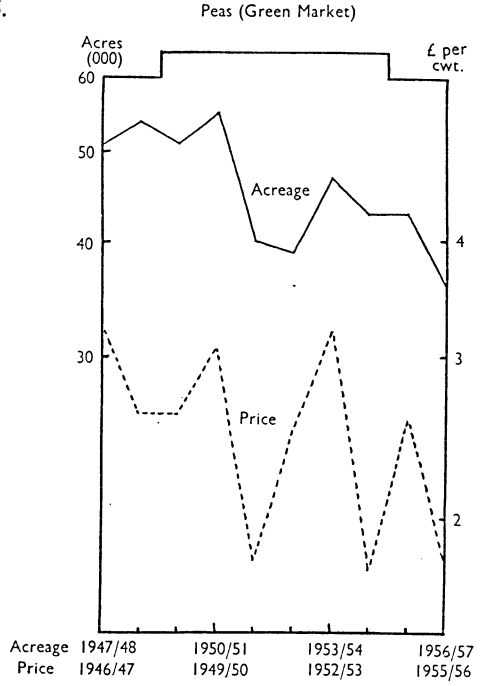


CHART 7.

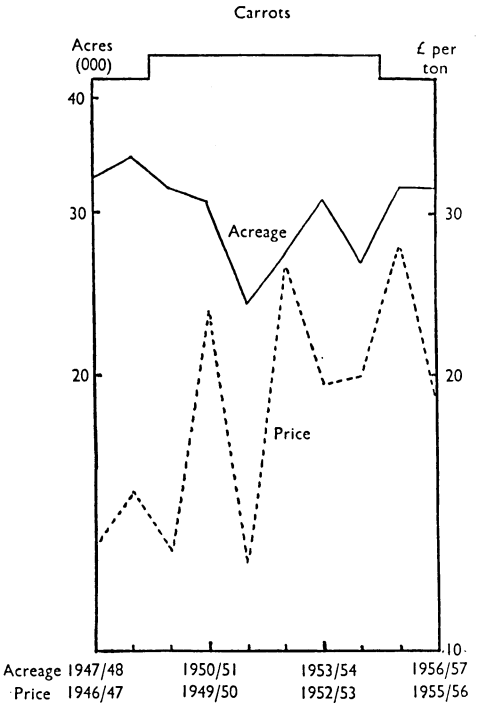


CHART 8.

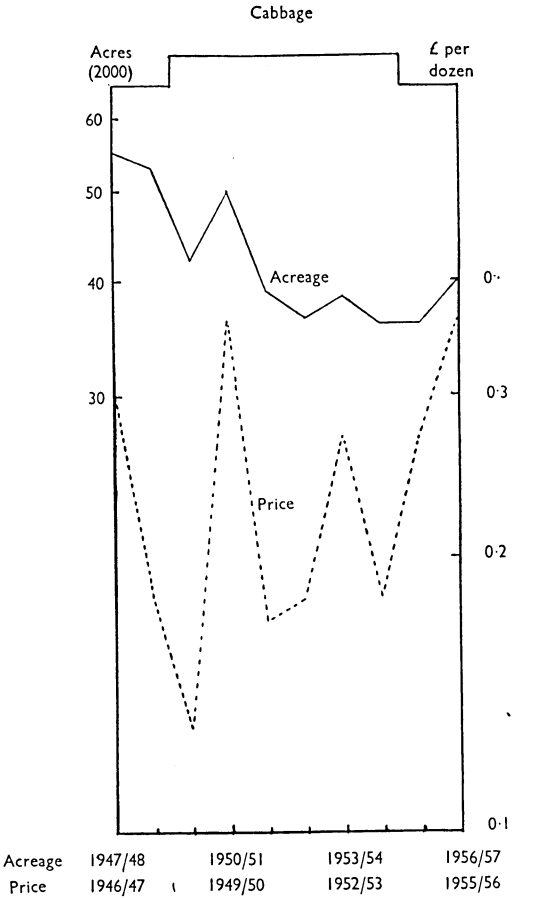


CHART 9.

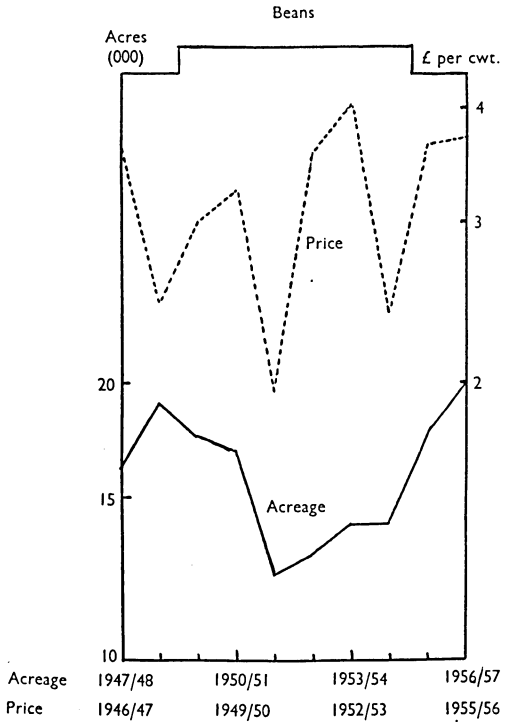


CHART 10.

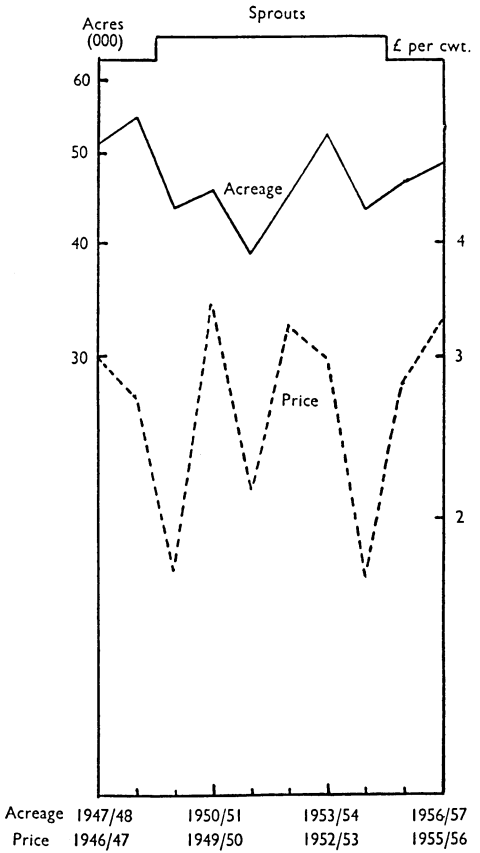
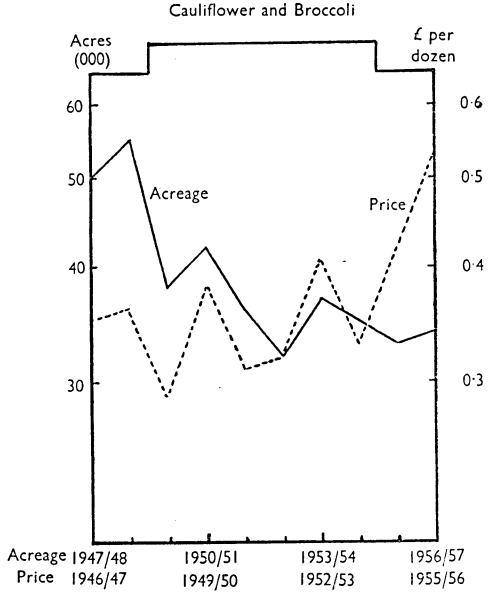


CHART 11.



The graphs, being constructed with a vertical logarithmic scale, also show the proportionate changes occurring in the two series. It will be seen that price changes are, as a rule, proportionately much greater than the corresponding changes in planted acreages. One reason for this seems fairly obvious. A substantial proportion of the total vegetable acreage is occupied by horiticultural specialists, and in their case, land withdrawn from the production of one vegetable crop would almost inevitably be used for the production of some other vegetable crop. But as the dates on which the major price peaks and troughs occur tend to be the same for each of these six crops, the alternatives presented, when a grower is considering his future cropping programme from the angle of last season's prices, may not appear to offer any marked advantage over a repeat, with perhaps minor adjustments, of last year's programme.

The important point to note is, that such attempts as are made by producers to catch up with the price situation are singularly unsuccessful in achieving their objectives. This is obvious from the graphs themselves and from the variation coefficients of price and output values given in Tables 5 and 6.

In the previous section dealing with conditions in the industry as a whole, it was shown that annual variations in the

volume of total production and in the value of total output are negatively correlated. In order to discover whether a similar relationship exists in respect of individual crops the percentage variations from the trend in the value of total output were plotted against percentage variations from the trend in the volume of total production for each of seven crops. The results are illustrated in the following charts.

CHARTS 12 to 18.

Relationships between Annual Percentage Variations from trend in the Volume of Total Production and the Value of Total Output for Certain Vegetables during the Period 1947/48–1956/57

CHART 12.

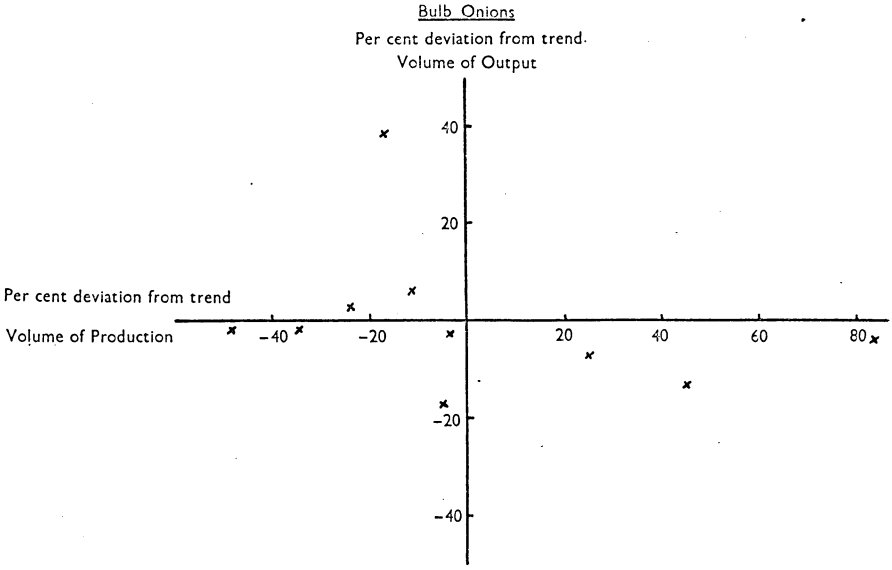


CHART 13.

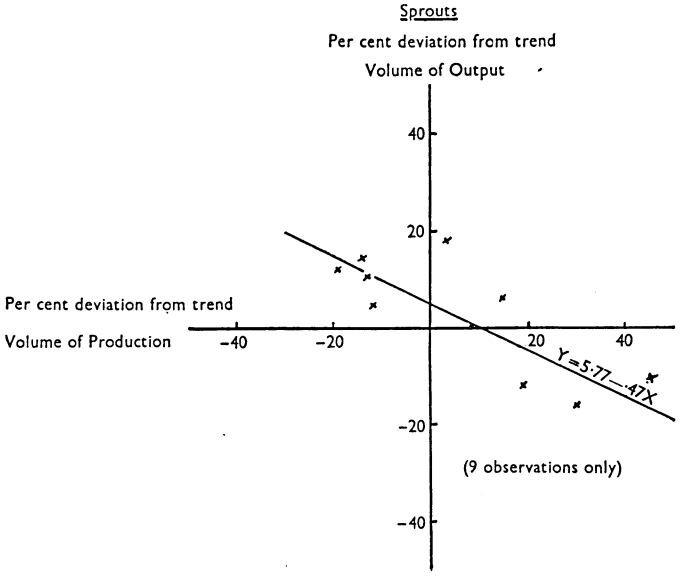


CHART 14.

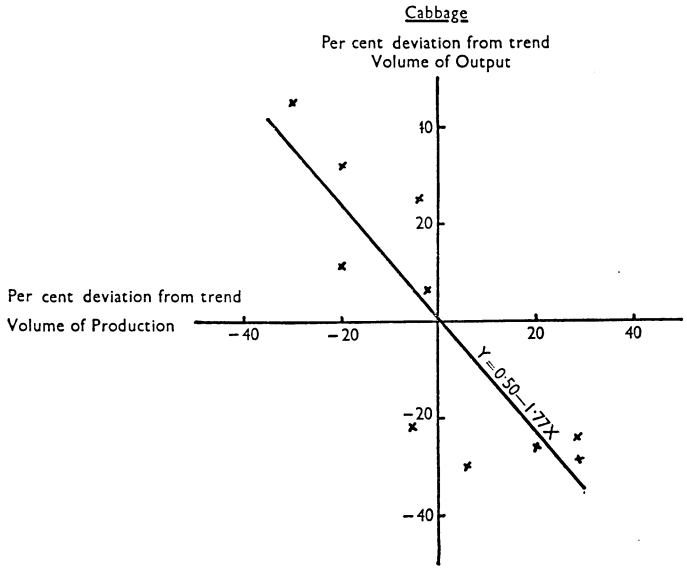


CHART 15.

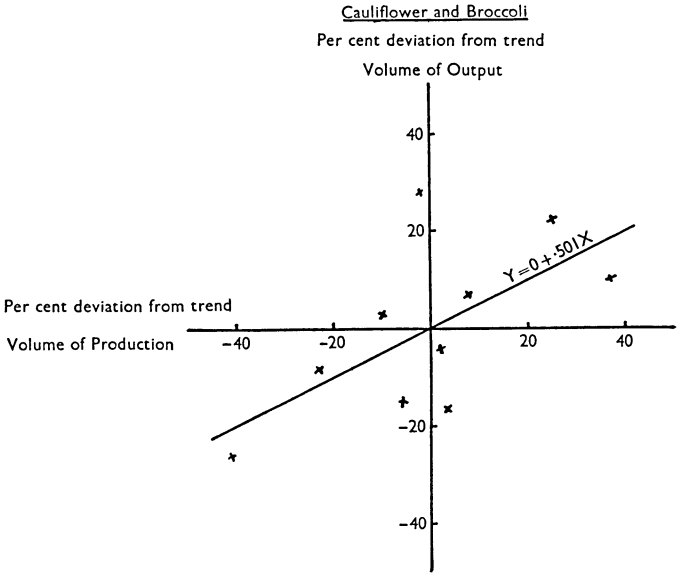


CHART 16.

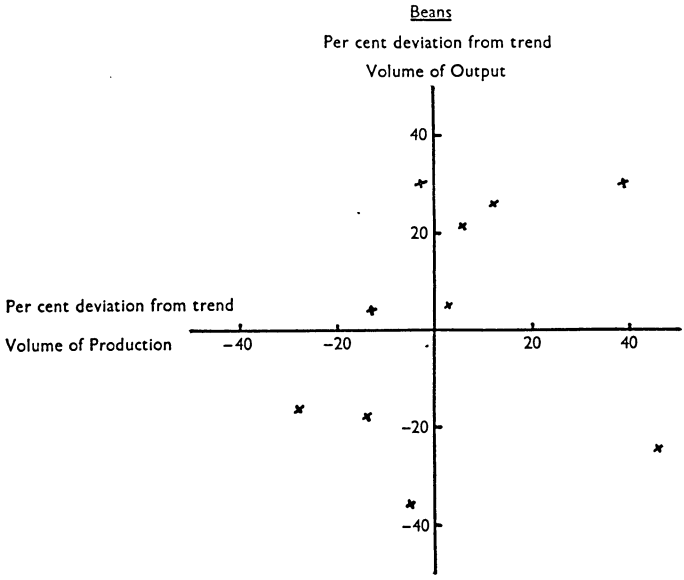


CHART 17.

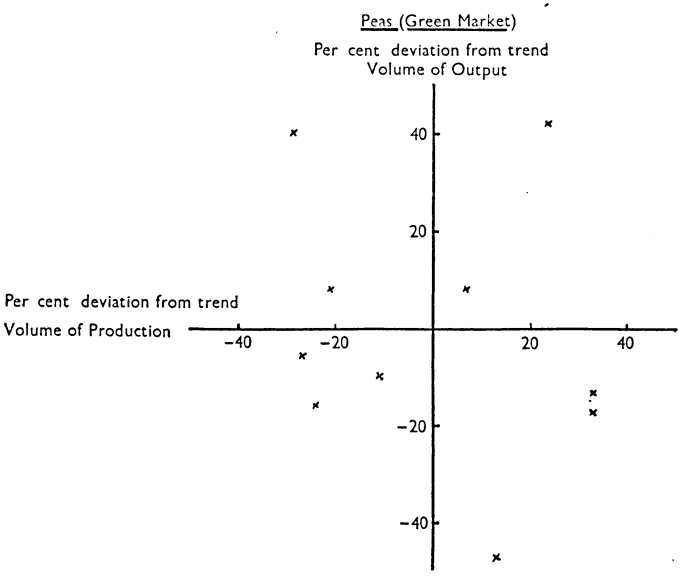
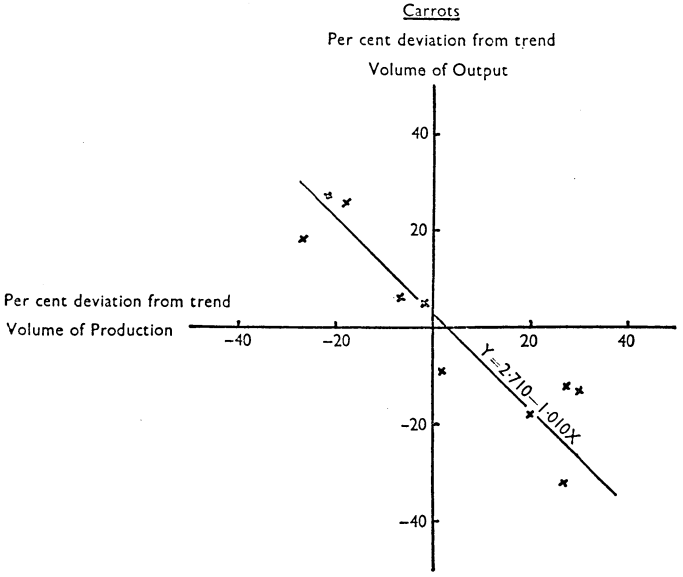


CHART 18.



The data for carrots show the closest relationship, yielding a negative coefficient of −0·92. For cabbage and sprouts the coefficients are −0·84 and −0·68 respectively. In the data relating to sprouts there was one quite exceptional pair of observations which could probably be explained by the fact that, not only was the volume of production very low in that year (1949/50), but the quality was also of an exceptionally low order, thus inhibiting the natural tendency of scarcity to raise the selling price per ton. If this exceptional year is omitted then the correlation coefficient for sprouts becomes −0·81. The negative correlation coefficients for these three crops imply that as the total volume of production increases the total value of that part of the crop which is actually sold declines, which, in turn, implies that the demand for these products is very inelastic.

Cauliflower and broccoli yielded a positive correlation coefficient of 0·62 but this just failed the significance* test at the 5 per cent level. In the scatter diagram for beans there is some slight suggestion of a positive correlation but in the case of the remaining crops, green market peas and bulb onions there is no trace whatsoever of correlation. The latter results are, perhaps, not altogether surprising. The situation with respect to onions may be influenced by the fact that imports account for a substantial part of the total supply while the situation with respect to peas may be influenced by the existence of a variety of very close substitutes such as dried, tinned and frozen peas and also, of course, fresh beans.†

* The "r's" for carrots and cabbage are significant at the 1 per cent level. The original "r" for sprouts is significant at the 5 per cent level and the revised "r" is significant at the 1 per cent level.

† These results are in general agreement with the price elasticities for various vegetables calculated by J. A. C. Brown. Carrots −0·57, Cabbage −0·12, Sprouts −0·41, Cauliflower +1·78, Fresh Legumes +2·02, Onions, Shallots, etc. −0·12. "Seasonality and Elasticity of Demand for Food in Great Britain since De-Rationing", J. A. C. Brown. A paper read to the Agricultural Economics Society, December 1958.

Part III

So far in this study, uncertainty and risk have been considered in respect of aggregates, first in terms of the industry as a whole and secondly in terms of some of the individual crops which are sub-aggregates of the industry. In this final section uncertainty and risk will be considered in the context of the individual producer.

In industries which are composed of a large number of comparatively small independent producers, the problems facing the individual producer differ in certain important respects from those facing the industry considered as a single unit. Both agriculture and horticulture are classic examples of this situation. The basic differences arise from the fact that the contribution of any individual producer to the total volume of production, and his share of total resources used, are so infinitesimally small that changes in their magnitude, however large, can have no measurable effect on either total supply in the case of output or on total demand in the case of resources used. It follows, therefore, that the actions of the individual producer, when considered in isolation, can have no measurable effect on either product prices or unit costs. He sells and buys in markets where price and cost conditions are determined by the collective action of all concerned.

But market prices and costs are not the only factors upon which the financial success of the individual depends. Of no less importance is the extent to which his own personal achievements, in respect of yield and quality compare with the aggregate situation. When the price level of a particular crop falls, as a result of a higher than average national yield, combined, maybe, with an abnormally high total planted acreage; the individual producer who, contrary to general experience, obtains a yield below his normal expectations,* suffers a double penalty. For the result of a low price and a low yield per acre is inevitably an exceptionally low value of output per

* This situation should not be confused with the usual kind of comparison made between individual and average results and stated in some absolute terms such as tons or pounds sterling per acre. The situation envisaged here is one in which, in a given year, for example, the national yield is 15 per cent above the ten-year average, whereas the yield obtained by the individual in question, in the same season, happens to be 15 per cent below his own ten-year average.

acre. In the reverse situation, when limited or short supplies cause the price of a crop to rise, individual producers who happen to obtain yields above their normal expectations enjoy thereby the best of both worlds; for a combination of high price and high yield obviously results in an exceptionally high value of output per acre. Individuals, therefore, face not only the uncertainties and risks inherent in the instability of the industry as a whole, but superimposed on these are the added uncertainty and risk that their own achievements in respect of yield, and quality, may fail to conform to the general experience in these matters.

This latter concept of uncertainty and risk is synonymous with Rasmussen's idea of "luck", the title which he bestows on the residual variance in farm profits after measuring and deducting from the total variance that part which he estimates to have arisen as a result of differences in management and seasonal factors.* The same kind of statistical technique, namely analysis of variance, has been employed in the present study to investigate the nature and incidence of uncertainty and risk as they affect individual producers of vegetable crops. The data used in the following analysis were obtained from the annual surveys of financial accounts relating to horticultural holdings situated in the Vale of Evesham.† Analysis of variance were carried out on yields, prices and values of output per acre for each of six crops. It was not possible to use an identical sample of holdings throughout but it was, of course, essential to keep the sample identical for each crop studied. Even the latter requirement meant that a compromise had to be reached between the size of the sample and the number of years in the series. It was eventually decided to limit the number of years to five and to exclude from the analysis any crop for which a sample of less than ten holdings was available. It was further decided not to proceed with an anlysis of average total values of output per acre because of the possibility that year to year changes in the pattern of cropping might contribute substantially to the residual variance and would be difficult and tedious to isolate. Variance analysis was, however, carried out on profit per acre. The main purpose being to enable a comparison to be made between horticulture and

* "The Importance of Variance in Farm Profits", K. Rasmussen, *Journal of Proceedings of the Agricultural Economics Society*, Vol. X, No. 3.

† University of Bristol—Broadsheets of Financial Results of Market Garden Holdings, 1950–54, E. B. Fekete, LL.D.

agriculture with respect to the degree of uncertainty and risk attaching to profitability.

This form of two-sided variance analysis, performed on data from an identical sample of holdings over a period of years, makes it possible to measure and subsequently eliminate that part of the total variance (between rows) which can be attributed to differences between both the holdings themselves and the managerial capacities of their respective occupiers. Of the remaining variance, part can be identified as being the result of differences in annual conditions (between columns) while there is a residual element of variance (interaction within rows and columns) which is not explained by any of the above-mentioned causes, but is considered to be quite random and fortuitous.*

Variance due to changes in annual conditions and the residual variance due to random effects constitute the two elements of uncertainty and risk for the individual producer. In order to measure total uncertainty and risk, in each analysis the sums of squares for between years and for interaction were pooled and the variance obtained by dividing this total by the appropriate degrees of freedom. Following the method of presentation used in the two earlier sections, standard deviations (the square root of the variance) were calculated for (*a*) seasonal effects and for (*b*) combined seasonal and random effects, and as percentages of the means they are shown in columns 3 and 4 of the following tables.†

In the final column of each table the standard deviations for the combined annual and random effects, i.e. for total uncertainty and risk, have been used to compute the coefficients of variations from which can be deduced the ranges in yields,

* In the discussion on Rasmussen's paper, op. cit., the suggestion was put forward that a substantial portion of the "so called" unexplained variance could, in fact, be attributed to the effects of the anomalies and arbitrary practices involved in the accounting procedures used in calculating the original data. Tansey in "The Significance of Variations in Annual Farm Profits", *Journal of Agricultural Economics*, Vol. XII, No. 2, provides evidence which appears to lend some support to this contention. It is, however, hardly likely that these explanations would be significantly relevant in this present study. For the data being analysed on this occasion, viz. yields, prices and sale values, are much more simple concepts calculated by much more direct means than are annual farm profits. Moreover, it could also be argued that in the case of horticultural holdings, even the annual profit calculations are comparatively free from most of the hazards which beset the computer of agricultural profits. The claim is, therefore, made, errors in recording excepted, that the whole of the residual variance in each of the following analyses is the result of chance or random events.

† Full details of these analyses are given in the appendix.

prices and values within which seven out of ten (or 68 per cent to be precise) of the observed measurements could be expected to fall. Again, it should be borne in mind that the remaining three, or 32 per cent, of observed measurements could be expected to lie outside these stated limits.

TABLE 7

Variations in Yield per Acre for Certain Crops as Recorded on Groups of Holdings over a Five-Year Period

Crop	Average Yield (*a*) per acre	Coefficient of Variation		Estimated Range in Yield (*a*) for 7 out of 10 observations
		Annual	Total	
	000 lb.	%	%	000 lb.
Cabbage	14·6	(*b*)	44	8·2–21·0
Beans	9·3	(*b*)	44	5·2–13·4
Sprouts	7·0	15	47	3·7–10·3
Lettuce	1·6 (*c*)	(*b*)	55	0·7– 2·5 (*c*)
Peas (green, market)	5·3	32	64	1·9– 8·7
Onions (salad)	12·7	31	69	3·9–21·5

(*a*) Yield here refers to the quantity sold and is therefore equivalent to "output" as defined in Part I.
(*b*) Not statistically significant at the 5 per cent probability level.
(*c*) Thousand dozen.

It will be noted in Table 7 above that the annual yield variations in respect of three crops were described as not statistically significant. This does not mean that the variations are non-existent or even that their magnitudes are very small. It simply means that the results obtained from the available evidence provide insufficient proof one way or the other. The coefficients for total uncertainty and risk are substantial. The estimated ranges in yield shown in the table can be interpreted as meaning that, having eliminated the possible effect of variations in the quality of holdings and management, there is an approximate 7 in 10 chance that in any year the yield of green salad onions, for example, on any holding, might be as low as 3,900 lb. per acre or as high as 21,500 lb. per acre or indeed anywhere in between these two extremes. There is also an approximate 3 in 10 chance that the yield would be below 3,900 lb. or above 21,500 lb. per acre. Cabbage and beans appear to be the least susceptible to yield uncertainties while peas and salad onions are the most susceptible.

TABLE 8

Variations in Price per lb. for Certain Crops as Recorded on Groups of Holdings over a Five-Year Period

Crop	Average Price per lb.	Coefficient of Variation		Estimated Range in Price per lb. for 7 out of 10 observations
		Annual	Total	
	Pence	%	%	Pence
Lettuce . . .	41·0 (*a*)	(*b*)	30	29·0–53·0 (*a*)
Peas (green, market)	5·1	30	37	3·2– 7·0
Sprouts . .	4·1	23	39	2·5– 5·7
Cabbage . .	2·7	26	45	1·5– 3·9
Beans . . .	4·5	37	46	2·3– 6·6
Onions (Salad) .	7·3	48	59	3·0–11·6

(*a*) Pence per dozen.
(*b*) Not statistically signfiicant at the 5 per cent probability level.

On the whole, selling prices appear to be somewhat less susceptible to uncertainty and risk than yields. But the coefficients of annual price variations are statistically more significant and also tend to be greater in magnitude than coefficients of annual yield variation. This is probably because price variations are, for the most part, the result of external circumstances while yield variations arise out of events on the holdings themselves. This characteristic difference is further illustrated by the fact that for prices, random effects, which are internal, make a proportionately smaller contribution to total uncertainty variance than they do in the case of yields.

TABLE 9

Variations in the Value of Output per Acre for Certain Crops on Groups of Holdings over a Five-Year Period

Crop	Average Value per acre	Coefficient of Variation		Estimated Range in Value per acre for 7 out of 10 observations
		Annual	Total	
	£	%	%	£
Sprouts . .	116	7	40	69–163
Lettuce . . .	143	(*a*)	54	66–220
Peas (green, market)	105	33	59	43–167
Cabbage . .	163	28	64	58–268
Beans . . .	174	52	65	61–287
Onions (Salad) .	308	10	65	108–508

(*a*) Not statistically significant at the 5 per cent level of probability.

Salad onions, being the least reliable of these six crops as regards yield, are also shown to be the least reliable as regards selling price. Lettuces, surprisingly enough, appear to be the most reliable as regards price.

As was suggested in Part I, it is the value of output per acre which represents the ultimate in uncertainty and risk. With one exception, the coefficients of total uncertainty variation in respect of the values of output per acre are all over 50 per cent, which quite obviously represents an extremely high level of risk and uncertainty. It follows, therefore, that this situation must have a very special bearing on the problems of planning, business management and finance on the individual holding.

During recent years the development and application of systems of management accounting and business analysis have made notable strides in the field of agriculture. As part of his equipment the investigator is armed with a variety of standards of input, output and input/output relationships which are, for the most part, derived from economic studies similar to the ones from which the basic data for this part of the present investigation were obtained. In spite of the many pitfalls inherent in this type of work* and the seemingly dubious ancestry of some of the standards being used, the results have, on the whole, been surprisingly successful. Not unnaturally there are now attempts being made to extend this management advisory work to include businesses which are primarily or wholly horticultural in character.

By and large it seems to have been assumed that the tools and methods used in agricultural business management could be borrowed and, with seemingly quite minor modifications, applied with equal confidence in horticultural business management.† But if uncertainty and risk are present in horticulture to the extent to which the foregoing analysis would suggest, it seems hardly conceivable that standards of output or input/output relationships, at least in their present form, could be applied with any degree of confidence in horticultural business analysis. As regards their use in forward budgeting,

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* Both Rasmussen and Tansey, op. cit., seem to imply that it is the common practice, when investigating individual management cases, to consider the results of one year's operations only. This, as far as the writer is aware, is quite definitely not so. Even the statistically uninformed appreciate that farmers have their ups and downs for which often there is no very obvious explanation.

† *Horticulture as a Business.* A handbook for use in horticultural management, H.M.S.O.

the position must be even less satisfactory. If, in preparing a budget for any lowland farm in this Province, we predict that the average output from the dairy herd will, over the next year or two, be £110 per head, the chances of making more than a 15 per cent error either way are not, in the writer's experience, very great. This should not, by any means, be regarded as a tribute to skilful forecasting. It is very largely the result of the comparatively high degree of price stability for agricultural products which reduces very substantially an obvious source of major error in making such forecasts. In this estimate of variance is also included the variation which may arise as a result of errors in the assessment of the quality of the farm and the managerial capacity of the occupier. If, however, we were to prepare a budget for a horticultural holding using £308 as the predicted value of output from an acre of salad onions, the figures in Table 9 indicate that there is a 7 in 10 chance that the actual result might lie anywhere between £108 and £508 per acre and a 3 in 10 chance that it would be either below £108 or above £508 per acre. This range is exclusive of the additional affects of possible errors in the assessment of the holding and the occupier.

Information concerning profits on horticultural holdings provided the data for a final analysis and also for a comparison of uncertainty and risk as between horticulture and agriculture. The results of this analysis serve not only to illustrate still further the very high degree of uncertainty and risk which are involved in the production of vegetables but they also provide additional support for the contention that the horticultural business is not a suitable subject for treatment by management analysis in its present form.

A two-sided variance analysis was made of profits per acre on an identical sample of horticultural holdings over a period of five years.* The extent and distribution of the variance were then compared with a similar analysis made by Tansey† of profits on two types of agricultural holdings.

The first attempt to analyse the horticultural data produced some remarkably odd results, until it was discovered that in the original data, holdings having glasshouses were included with, and not distinguished from, holdings without glass. As the average gross output from glasshouses is about £5,000 per acre whereas few vegetable crops grown in the open can do

* Broadsheets of Financial Results of Market Garden Holdings in the Vale of Evesham, 1950–1954.

† Op. cit.

better than £200 per acre it was obvious that a disturbing influence of this magnitude would have to be removed by omitting any holding which included an area of glass. Although an absolutely essential step, it unfortunately destroyed the prospect of obtaining one or more samples of holdings of a comparable size. The effects, if any, of variations in size, however, are thrown up in the between-row variance along with the quality and managerial effects.

TABLE 10

Comparisons of Variance in Profits between Horticultural and Agricultural Holdings

	Horticultural Holdings	Fat-Stock Farms (*a*)	Dairy Farms (*a*)
Number of Holdings in Sample	19	15	11
Number of Years in Series	5	5	5
Average Profit per Acre (£)	12·7	5·21	8·94
Total Standard Deviation (£)	±25·7	±3·07	±5·50
Coefficient of Total Variation	202%	59%	61%
Standard Deviation for Residual Effects (£)	±16·5	±1·93	±3·50
Coefficient of Residual Variance	138%	37%	39%
Standard Deviation for Total Uncertainty (*b*) (£)	±19·8	±2·44	±3·63
Coefficient of Total Uncertainty Variance (*b*)	155%	46%	41%
Standard Error of the Mean Profit per Acre (£)	±2·70	±0·80	±1·66
Standard Error of the Coefficient of Total Variance	±14%	±5%	±6%

(*a*) Derived from data quoted by Tansey, op. cit.

(*b*) Between year and residual effects.

It is quite evident, from the results shown in this table, that the very substantial degree of uncertainty, which has been shown to be characteristic of the value of the output per acre from certain vegetable crops, is reflected in variations in the figures of profit per acre; but in the process of calculating profits the effects of the former are magnified. As previously pointed out, profit or loss is the difference figure between two very much larger quantities; and if one of these shows a standard deviation equal to, say, 50 per cent or more of the mean, as indeed the figures of the previous table would suggest, then

it is not surprising that the figures of profit should show a standard deviation as high as 200 per cent of their mean.

The results in this table also prove fairly conclusively that uncertainty and risk are present to a far greater extent in this sample of horticultural holdings than is the case in the two samples of agricultural holdings. Moreover, there is no reason to suppose that these samples are not reasonably representative of the situation in the two industries as a whole.

Finally, the results for the horticultural sample offer additional proof for the contention that, as tools for management analysis and for the appraisal, by budgetary technique, of new or partially revised production programmes, much of the existing data is quite useless, although some of the present standards and forms of analysis may still be valid; particularly those in which output, price and profit measurements are not involved. Probably the whole field of business management in respect of glasshouse production is adequately provided for by the existing analytical methods and standards, because in this particular sector of the industry, variations, both technical and economic, appear to be comparatively very small. In the remainder of the vegetable-growing industry, however, there appears to be a most urgent need for a wholesale reconsideration of the management problems presented by the horticultural holding when considered as a business enterprise.

APPENDIX

Analyses of Variance

BEANS

Yield per acre (100 *lb.*)

Variation	Degrees of Freedom	Sum of Squares	Variance
Between Rows . . .	22	930	42·3
Between Columns . .	4	107	26·8
Within Rows and Columns .	88	1499	17·0
Total	114	2536	22·2

Price per lb. (*pence*)

Variation	Degrees of Freedom	Sum of Squares	Variance
Between Rows . . .	22	34	1·6
Between Columns . .	4	262	65·5
Within Rows and Columns .	88	197	2·2
Total	114	493	4·3

Value of Output per Acre (£)

Variation	Degrees of Freedom	Sum of Squares	Variance
Between Rows . . .	22	661,473	30,067
Between Columns . .	4	768,618	192,154
Within Rows and Columns .	88	390,737	4,440
Total	114	1,820,828	15,972

CABBAGE

Yield per acre (1000 *lb.*)

Variation	Degrees of Freedom	Sum of Squares	Variance
Between Rows . . .	13	107	8·2
Between Columns . .	4	8	2·0
Within Rows and Columns .	52	142	2·7
Total	69	257	3·7

Price per lb. (pence)

Variation	Degrees of Freedom	Sum of Squares	Variance
Between Rows	13	22	1·7
Between Columns	4	32	8·1
Within Rows and Columns	52	52	1·0
Total	69	106	1·5

Value of Output per Acre (£)

Variation	Degrees of Freedom	Sum of Squares	Variance
Between Rows	13	290,530	22,348
Between Columns	4	157,192	39,298
Within Rows and Columns	52	461,455	8,874
Total	69	909,177	13,176

LETTUCE

Yield per Acre (100 *doz.*)

Variation	Degrees of Freedom	Sum of Squares	Variance
Between Rows	9	4800	533
Between Columns	4	39	10
Within Rows and Columns	36	3196	89
Total	49	8035	164

Price per Dozen (pence)

Variation	Degrees of Freedom	Sum of Squares	Variance
Between Rows	9	2195	244
Between Columns	4	215	54
Within Rows and Columns	36	4669	130
Total	49	7079	145

Value of Output per Acre (£)

Variation	Degrees of Freedom	Sum of Squares	Variance
Between Rows	9	759,192	84,355
Between Columns	4	48,778	12,194
Within Rows and Columns	36	764,825	21,245
Total	49	152,795	32,097

ONIONS (SALAD)

Yield per Acre (100 *lb.*)

Variation	Degrees of Freedom	Sum of Squares	Variance
Between Rows	19	2400	126
Between Columns	4	1488	372
Within Rows and Columns	76	4561	60
Total	99	8549	86

Price per lb. (*pence*)

Variation	Degrees of Freedom	Sum of Squares	Variance
Between Rows	19	620	33
Between Columns	4	1033	258
Within Rows and Columns	76	483	6
Total	99	2136	22

Value of Output per Acre (£)

Variation	Degrees of Freedom	Sum of Squares	Variance
Between Rows	19	2,391,248	125,855
Between Columns	4	231,197	57,799
Within Rows and Columns	76	3,035,184	39,936
Total	99	5,657,629	57,148

PEAS (GREEN, MARKET)

Yield per Acre (100 *lb.*)

Variation	Degrees of Freedom	Sum of Squares	Variance
Between Rows . . .	12	245	20·4
Between Columns . .	4	187	46·8
Within Rows and Columns .	48	408	8·5
Total	64	840	13·1

Price per lb. (*pence*)

Variation	Degrees of Freedom	Sum of Squares	Variance
Between Rows . . .	12	80	6·7
Between Columns . .	4	121	30·3
Within Rows and Columns .	48	71	1·5
Total	64	272	4·3

Value of Output per Acre (£)

Variation	Degrees of Freedom	Sum of Squares	Variance
Between Rows . . .	12	110,243	9187
Between Columns . .	4	76,471	19,118
Within Rows and Columns .	48	123,566	2574
Total	64	319,280	4989

SPROUTS

Yield per Acre (100 *lb.*)

Variation	Degrees of Freedom	Sum of Squares	Variance
Between Rows . . .	21	575	27
Between Columns . .	4	138	35
Within Rows and Columns .	84	831	10
Total	109	1544	14

Price per lb. (pence)

Variation	Degrees of Freedom	Sum of Squares	Variance
Between Rows . . .	21	25	1·2
Between Columns . .	4	80	20·0
Within Rows and Columns .	84	69	0·8
Total	109	174	1·6

Value of Output per Acre (£)

Variation	Degrees of Freedom	Sum of Squares	Variance
Between Rows . . .	21	176,602	8410
Between Columns . .	4	14,739	3685
Within Rows and Columns .	84	174,352	2076
Total	109	365,693	3355