M. A. Walker

Fertiliser Association of Ireland

The Demand for Fertilisers in Ireland - Past and Future

by

John A. Murphy
Dept. of Applied Agricultural Economics,
University College,
DUBLIN.

November 1977

1. INTRODUCTION

There is virtually unanimous agreement among agriculturalists that increased use of fertilisers must be a key factor in the nation's endeavour to expand agricultural output. This is especially so in the grassland sector. Indeed in the First Programme for Economic Expansion[1/] it was grassland fertilisation which was cited as the main weakness of our agricultural production system. As a result, 1958 saw the introduction of fertiliser subsidies in Ireland in a bid to raise the general level of fertility of Irish land and thereby lift the rate of agricultural growth from its abysmally low level of the 1950's[2/].

The year 1958 therefore represents a suitable base year from which to review the changes that have taken place in fertiliser use in Ireland. This paper deals with changes at the national level and in section 2 the magnitude of these changes for the period 1958-76 are examined. In section 3 an attempt is made to identify the main factors that influenced the variation in use over that period and in section 4 the likely position for 1980 and 1985 is considered.

It will be seen in sections 3 and 4 that definitive answers are virtually impossible. Each demand analysis and projection gives different conclusions depending upon the methodology used. For this reason much of the detail and emphasis of these sections is on the approach used rather than the results obtained.

1/ Programme for Economic Expansion, Stationery Office, Dublin, 1958.

2/ During the 1950's the volume of gross agricultural output increased at a mere 1.6 per cent per annum.

Before commencing the analysis I should point out that throughout the paper I have designated the fertiliser year -1/t as year t. This is the system followed by the Central Statistics Office when compiling the fertiliser input statistics for use in the compilation of the national estimates of Net Agricultural Output.

2. Indicators of Developments in Fertiliser Use.

1958 - 1973.

Over this period the total volume of fertiliser used perannum in Ireland expanded by 208 per cent.[1] The average growth rate for the period amounted to 8.8 per cent per annum compared to a growth rate of 2.8 per cent for the volume of gross agricultural output over the same period. In value terms the total expenditure on fertilisers increased from 5.8 per cent of gross output from land-based enterprises[2] in 1959 to 7.9 per cent in 1972. The increasing role of fertiliser in agricultural development is also shown by the fact that over the fifteen years in question expenditure on it increased from 17.5 per cent of all non-factor input expenditure[3] to 21.1 per cent.

In Table 1 these latter two criteria are used to compare Ireland with the other EEC countries in 1972. It can be seen that in terms of the percentage of all inputs fertiliser expenditure in Ireland ranked second highest of the nine countries. In relation to gross output Ireland was in the lower half of the rankings although the gap between it and the countries above it was not very great. These figures for the proportion of output allocated to fertiliser present a somewhat surprising picture in one respect. Fertilisers in the Netherlands with its highly intensive production system were financed in 1972 by just 4.7 per cent of output (revenue) compared to 7.9 per cent in Ireland. The Dutch figure in fact was not very much higher than that of Italy which has one of the least developed farm sectors in the Community. One would have thought that a highly intensive agricultural system

---

1/ This and subsequent figures for total change are based on the three year averages for 1958/9/60 (1959) and 1971/2/3 (1972). All are derived from the Irish Statistical Bulletin.

2/ Including the value of livestock inventory changes but excluding pigs, poultry and eggs.

3/ This excludes rates and depreciation of machinery.

Table 1. Fertiliser expenditure in 1972 [1] as a percentage of gross output [2] from land-based enterprises and of total non-factor inputs.

	% of gross output	% of inputs
Germany	9.2	13.6
France	7.9	21.7
Italy	3.0	10.2
Nederland	4.7	7.5
Belgium	8.4	11.2
Luxemburg	6.7	14.3
Denmark	8.3	11.3
United Kingdom	9.4	12.9
Ireland	7.9	21.1

1/ Average for 1971/2/3. 2/ Labelled "final production" in Eurostat.

Sources: Eurostat: Agricultural Accounts 1975 and 1976, SOEC Luxemburg and Irish Statistical Bulletin.

would require a proportionately greater input of fertiliser. A more detailed analysis of the figures could perhaps explain some of the anomaly as arising from (a) lower prices for fertilisers relative to products in Dutch agriculture [1] and (b) a greater emphasis on horticulture in their production mix. A significant part of the anomaly however, would be found to derive from a different source.

On the highly intensive dairy farms of the Netherlands (as most of them are) virtually all slurry is recycled. That of itself however, is not the crucial factor. The difference arises from a combination of their high stocking rates

1/ A recent NESC study found this to be the case relative to Ireland. NESC, A Comparative Study of Output and Value-added and Growth in Irish and Dutch Agriculture, Report No. 24, Stationary Office, Dublin, Dec. 1976.

and high meal feeding. On such farms it is common to find that a tonne of meals or more are fed per cow and the stocking rate approaches a cow per acre. This has two effects: (1) the meals raise output substantially, thereby lowering the fertiliser:output ratio and (2) a large part of the P and K requirements of the farm is bought through the medium of concentrates (meals)[1/] rather than artificial fertilisers as such. Indeed the account books of many of these farms show zero or negative (forced sale of slurry) purchases of phosphate and relatively low purchases of K. For the Netherlands as a whole the average amount of P purchased per hectare in 1972 was 21.6 kg compared to 17.0 kg in Ireland while the K rate was about double the Irish rate.[2/] Of course the purchases of N were very substantial indeed amounting to 318 kg per hectare compared to a mere 62 kg per hectare in Ireland.[3/]

These particular aspects of Dutch fertiliser use have significance in Ireland for those who turn their attentions to long-term forecasting under assumptions of improved stocking rates and greater meal feeding. This issue will be referred to again in the final section of the paper which deals with projections up to 1985. The Dutch figures however, raise questions of more immediate concern when one considers that even at the present time there are in Ireland a substantial number of well stocked dairy farms using a high level of concentrates per cow and recycling virtually all slurry. While the message from the media to these farmers seems to follow the Dutch line with regard to nitrogen use this does not appear to be the case with regard to recommended P rates. In view of the high cost of phosphate this can be a costly matter and perhaps more specialised media information is called for.

1/ Of which a very high proportion is imported.
2/ Eurostat: Agricultural Statistics No. 3, 1974, SOEC.
3/ Eurostat, Ibid

Post - 1973: Fertiliser use reached a peak in 1973. The following two seasons however, saw a dramatic increase in fertiliser prices with the result that by 1975 the volume index hadfallen by 24 per cent. A recovery began in 1976 and has continued through 1977 so that the 1977 volume index when published will most likely be at or slightly above the 1973 value. It is worth noting however, that the volume index is being restored mostly by virtue of rapid expansion in the use of N. The P and K levels are still significantly below the 1973 levels especially the former.

It is of interest to examine the severity of the volume decline between 1973 and 1975. This was clearly a price response. Suppose we consider the simple ratio of fertiliser prices relative to agricultural product prices to be the relevant factor influencing farmers demand for fertiliser.[1/] Using the fertiliser and agricultural price indices it can be shown that this ratio increased by 78 per cent between 1973 and 1975[2/] thereby providing substantial grounds for the 24 per cent decline in volume. Can it be argued that Irish farmers over-reacted even though there was a massive adverse shift in the real price of fertiliser? How does their response compare with that of farmers in the other EEC countries?

In Table 2 the post-1973 decline in fertiliser consumption is shown for each of the nine EEC countries along with the shifts in the real price of fertilisers. The largest volume declines took place in Ireland and Denmark but these were also the two countries which experienced the worst adverse price movement. In Figure A the percentage declines in volume have been plotted

---

1/ While this format will be modified somewhat in Section 3 of the paper it is adequate for the purpose at hand here.

2/ Derived from the fertiliser (FPI) and agricultural (API) price indices published in the Irish Statistical Bulletin. The ratio used was FPI_t/API_{t-1}. See Section 3 of the paper for comment on the use of a lagged API.

Table 2. Post 1973 volume and real price changes for fertiliser in the EEC Countries.

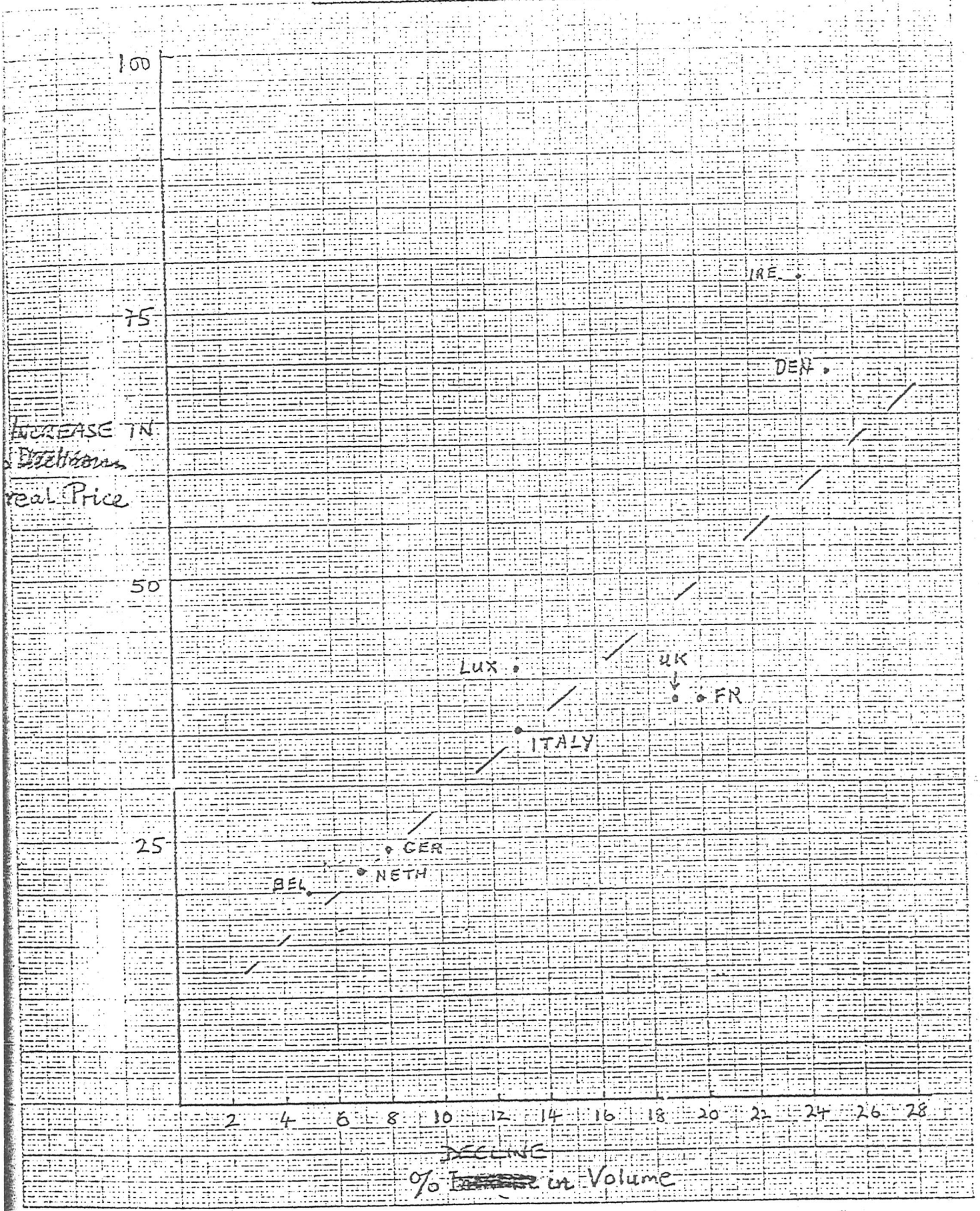
	% change in volume	% change in real price
1. Germany	-8	+24
2. France *	-20	+38
3. Italy *	-13	+35
4. Netherlands	-7	+22
5. Belgium	-5	+20
6. Luxemburg *	-13	+41
7. Denmark	-25	+69
8. United Kingdom	-19	+38
9. Ireland *	-24	+78

Note: For the countries marked * the figures are for 1975 relative to 1973. In the other countries substantial adverse real prices did not emerge until 1975 and in these cases the volume and price changes are for 1975 relative to 1974. See Appendix Table E for more basic data.

against the percentage increases in real price for the nine countries. The exercise although simple and perhaps crude in its approach indicates a surprising degree of conformity across countries in their response to the post-1973 price developments. It would also suggest that by EEC standards the drop in consumption in Ireland was less than "normal" for the price shift that occured.

The decline in consumption in Ireland should also be seen against the background of a massive 25 per cent volume increase in 1973 over 1972. Virtually all of this increase must have gone to grassland since the tillage acreage continued its decline in 1973. In spite of the fact that the grazing livestock population had been building up over the previous years this would not

FIGURE A: POST-1973 CHANGES IN VOLUME AND REAL PRICE OF FERTILISER IN EEC COUNTRIES



appear to have been sufficient justification for an increase of that magnitude in grassland fertilisation. Table 3 shows the estimated increase in fertiliser per acre of grassland on lowland mineral soils and the estimated stocking rate change on these soils from 1970 to 1975.

Table 3. Estimated increases in livestock units, stocking rate and fertilisation on lowland mineral soil grassland.
(Indices : 1970 = 100)

	Livestock Units (1)	Stocking Rate (2)	Fertiliser Rate (3)
1970	100	100	100
1971	103	103	114
1972	108	108	113
1973	116	115	150
1974	118	117	135
1975	113	112	106

Sources: (1) and (2) NESC, Alternative Growth Rates in Irish Agriculture Report No. 34, p178, Stationery Office, Dublin. 1977.
(3) Author's estimate.

Looking at the 1973 figures it can be seen that the fertiliser rate was 50 per cent above the 1970 level whereas the stocking rate was only 15 per cent higher. In the absence of a known national production function relating stocking rates to fertiliser rates it is difficult to draw a firm conclusion but it is quite possible that the increase in fertiliser use on grassland in 1973 was significantly in excess of that which was warranted by the extra stock on farms. This is another reason why the 1974 and 1975 figures for total fertiliser consumption in Ireland are not quite as depressing as they appear at first sight. The problem appears to have been more a question of the balance of nutrients than one of aggregate volume.

3. Some Economic Relationships

Total Volume of Fertilisers

It can be seen from Figure B that from 1958 to 1973 there was a steady upward movement in the volume of fertiliser used in Irish agriculture. This upward trend was temporarily checked in 1965-'66 and 1972. However, as already stated, 1974 and especially 1975 saw a substantial cut-back in consumption. With an estimated increase of 12 per cent in 1977 the renewed growth over the past two seasons has only been sufficient to restore the volume index to approximately its 1973 level.

The purpose of this section is to explore some hypotheses about the factors which have given rise to that sequence of volume changes since 1958. As an economist my first preference is to speculate about the role of prices in these movements and in the following pages a number of hypothesis are checked for supporting evidence by means of regression equations. Thus it is important that the reader correctly understands what is being achieved through these regression equations.

Suppose a "good" relationship is found to have existed between the volume of fertiliser and a certain price variable (P) - that relationship being expressed by:

$$\text{Vol.} = a - b.P \qquad (1)$$

This, of itself, cannot be taken as proof that the shifts in P have caused the changes in volume. A well-fitting equation merely offers strong support for the hypothesis. It does not serve as conclusive evidence that it is true.

This interpretation is in no way different from that applied to the statistical technique of hypothesis testing in non-economic areas of science. It is being stressed here because often the evidence for economic relationships

FIGURE B VOLUME INDEX FOR FERTILISER 1957/8 - 1975/6

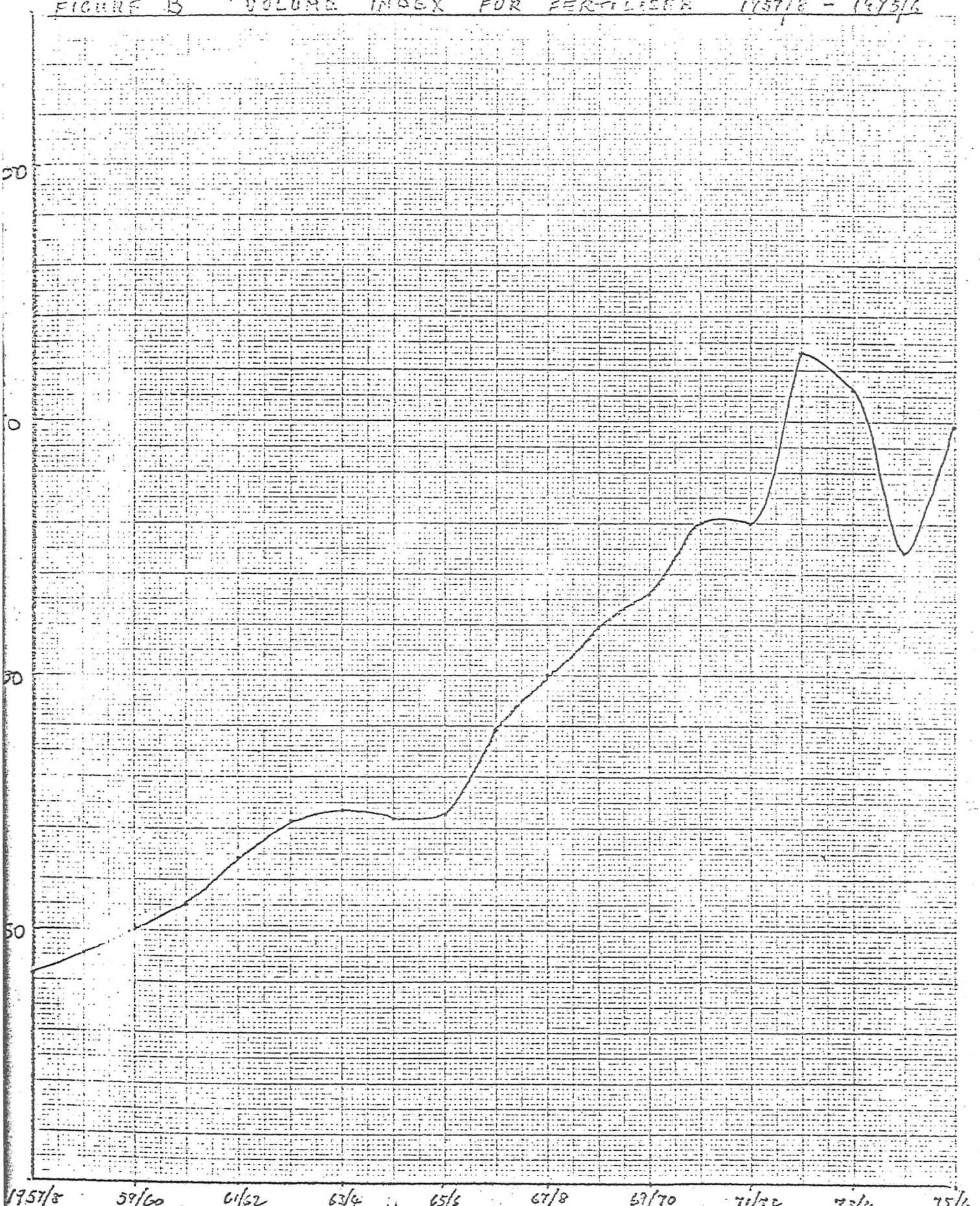


Figure E

has a particular peculiarity as a result of which the researcher must be careful about the manner in which conclusions are stated. This arises when the movement in the variable under examination [vol. in equation (1)] consists almost entirely of a trend. In that case any price variable dominated by a trend - as most absolute prices are - will show a high correlation with the variable in question and least squares regression will provide a good fitting equation. Therefore with economic relationships the researcher must be alert to the possibility that the estimated equations represents merely a spurious relationship rather than a real one.

The series under examination here, viz. volume of fertiliser used, is very much trend dominated for the period 1958 - 1973. The figures for those years therefore, are of very limited value for the task at hand in this section of the paper. While one could find high correlations between the volume of fertiliser and possibly meaningful variables such as crop prices and/or livestock prices equally high correlations could be found with the price of stout, or cigarettes! However the situation is saved by the developments since 1973. The massive price shifts which created such turmoil amongst farmers in recent years have proved a great boon for the econometrician. The ability to explain the downward slide in fertiliser consumption in 1974 and 1975 and its recovery since then provides a very powerful criterion upon which to distinguish relationships that are likely to be real from those that are spurious. In the present study a large number of equations were tested and the above criterion was heavily relied upon when selecting those which are presented below.

Economic theory suggests that the level of fertiliser use is a function of the ratio of fertiliser prices to the product prices of the enterprises in which it is used.[1/] This arises from the theory of optimum use under

---

1/ Where there are substitute or complimentary inputs involved the prices of such inputs may also play a role. This aspect, however has not been analysed in the present study.

conditions of diminishing returns. However a relationship between fertiliser purchases and the fertiliser: product price ratio might be hypothesized on different grounds. Later in the paper it will be suggested that available (cash) income is an important influencing factor. Product prices are perhaps the main determinant of income and this therefore also provides a rationale for using a fertiliser:product price ratio.[1/]

In Figure C the volume indices for fertiliser consumption in each year from 1958 to 1976 are plotted against the ratio of the fertiliser price index (FPI) for the corresponding year and the general agricultural price index (API) of the previous year. The one year lag is introduced for the latter on the grounds that (a) farmers' price expectations for year t are dominated by the experience of year t-1 and/or (b) that it is the prices received in year t-1 which determine the income available for expenditure in the fertiliser year t-1/t.[2/]

One would expect a negative relationship between fertiliser volume and the price variable specified. This however, does not emerge for the long run in Figure C . Two possible explanations might be put forward.

(1) A negative demand curve does exist but that it is shifting to the right over time perhaps in response to fertiliser promotions, advisory work, etc. The two periods of substantial change in the ratio viz. 1958 - 1961 and 1973 - 1976 would suggest this. When the hypothesis was tested statistically the following result was obtained:

1/ Unlike the economic theory of production it does not provide a rationale for using the direct ratio format.

2/ Note again that the fertiliser year t-1/t is designated as year t throughout this paper.

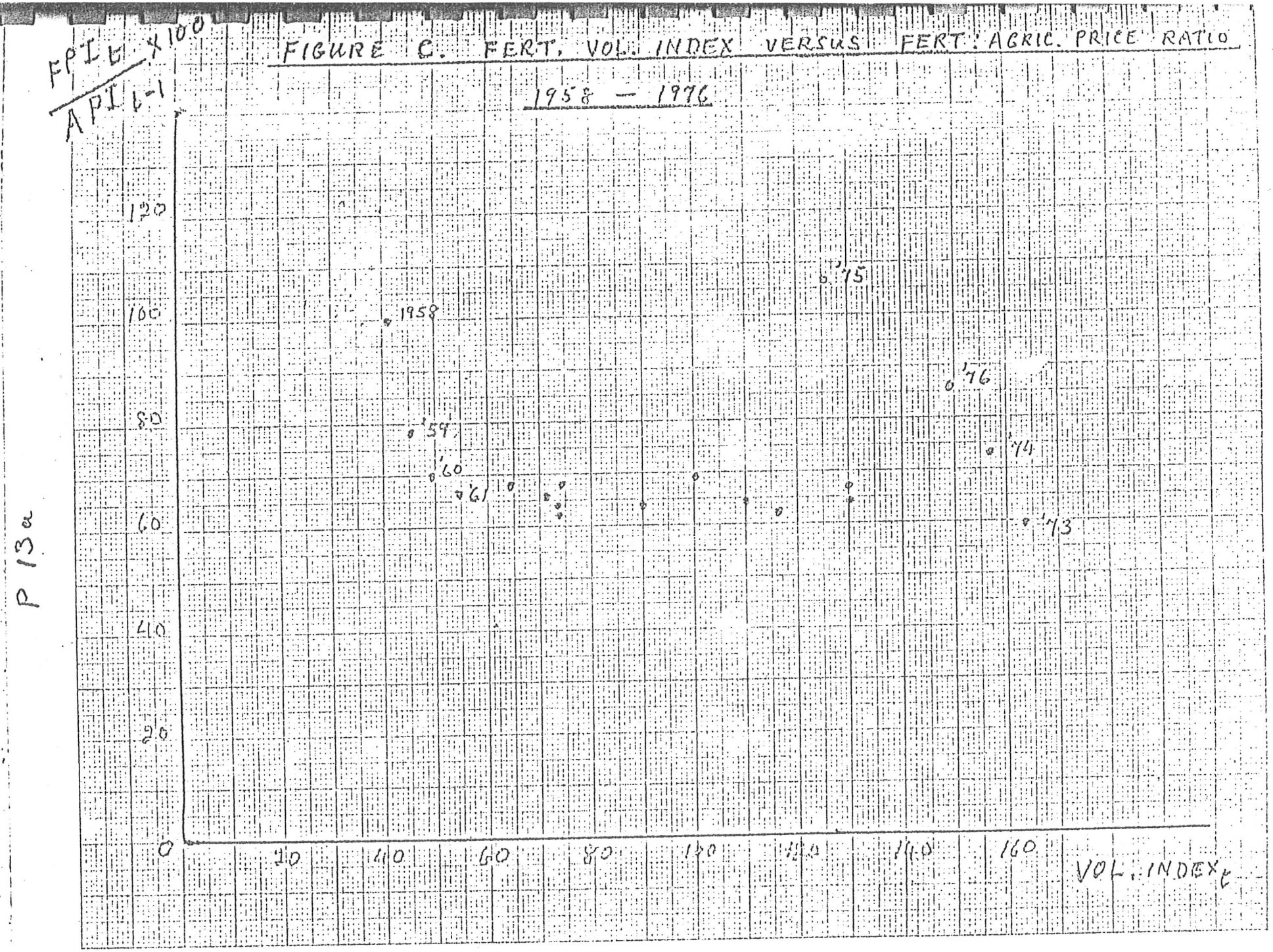


FIGURE C. FERT. VOL. INDEX VERSUS FERT : AGRIC. PRICE RATIO
1958 — 1976
FPI t / API t-1 x 100
120
100
80
60
40
20
0
1958
'59
'60
'61
'75
'76
'74
'73
20
40
60
80
100
120
140
160
VOL. INDEX t

P 13a

$$F.\ Vol_t = \underset{}{30.49} - \underset{(-1.54)}{30.29}\ FPI/API + \underset{(14.88)}{6.68T} \quad \ldots \quad \ldots \quad (1)$$

$$\bar{R}^2 = .92$$

where F. Vol. = volume index of fertiliser use, 1963 = 100

FPI relates to year t and API to year t-1 and 1953 = 100 for both.

T = a time variable, 1955 = 1, 1956 = 2, etc.

t values in brackets.

The t-values attached to the estimated coefficients indicates that the price variable is not significant. The regression therefore, was considered unsatisfactory since the time variable accounted for virtually all the volume change and because of this the equation was not able to predict the drop in consumption in 1974 and 1975.

(2) A second possibility is that the relative importance of fertiliser prices on the one hand and product prices on the other hand are such that they are incorrectly represented by the ratio FPI/API. With this format a 10 per cent decrease in FPI would be represented as being identical, in terms of effect, to an 11 per cent increase in API. If the fertiliser : lagg price ratio is viewed as an index of purchasing power this obviously is not valid since the latter is a far more significant development than the former.

Furthermore the rationale from economic theory for using the input/produc price ratio relates to producers who apply the input at its economically optimum level. Irish farmers can hardly be classified as such, especially in the case of grassland enterprises and the theory scarcely deals at all with non-optimisers.

One way of reflecting a relatively lower level of importance for the fertiliser price index would be to add a large constant(K) to its value in each

year[1] and then relate fertiliser volume to (FPI + K)/API . By means of regression it was estimated that for the 1958 - 1976 period a value of approximately 170 for K gave the best fit. The following is the resulting equation[2] and the scatter diagram is shown in Figure (D) (P 17)

$$F.\ Vol = 309.06 - 103.55\ (FPI + 170.95)/API \quad \ldots \quad \ldots \quad (3)$$

$$\bar{R}^2 = .92$$

The effect of the transformation is to provide a simple prediction equation which has a reasonably good statistical fit ($\bar{R}^2 = .92$). This equation is capable of reflecting both the upward trend in volume in the pre-1973 years as well as the reversal and recovery since then.

At the risk of becoming too complex however, it is possible to make an additional adjustment in the relative price variable so as to improve the equation still further. This can be done by allowing the factor K to change over time. While a number of options are open, the following method was found to give a satisfactory result:[3]

$$F.\ Vol = 239.45 - 61.89\ [\ FPI + (261.40 - 4.92T)\ ]\ /\ API \quad \ldots \quad (3a)$$

$$T = \text{time} = 1 \text{ in } 1955 \qquad \bar{R}^2 = .93$$

The transformation is such that the factor K is diminished over time. Thus the importance of changes in fertiliser prices is increased relative to changes in the agricultural price index. This would appear to be a logical adjustment since over time the use of fertiliser has become more widespread and it now accounts for a greater share of farm expenses and revenue.

1/ Thus for a given percentage change in FPI the percentage change in (FPI + K) will be considerably smaller.

2/ Originally estimated as:

$$F.Vol. = \underset{}{309.06} - \underset{(-4.8)}{103.55}\ FPI/API - \underset{(-14.16}{17701.98}\ (1/API)$$
$$\qquad\quad (14.94)$$

3/ Originally estimated as

$$F.Vol. = \underset{}{239.45} - \underset{(-2.31)}{61.89}\ \frac{FPI}{API} - \underset{(-12.38)}{16178.70}\ \frac{1}{API} + \underset{(2.24)}{304.61}\ \frac{T}{API} \qquad \bar{R}^2 = .93$$
$$\qquad\quad (6.62)$$

Figure (E) shows more clearly the degree to which equation (3.a) is capable of reproducing the changes in the fertiliser volume index that have occured since 1958. A number of comments are suggested by the diagram.

(a) The movement in the new relative price variable accurately predicts the upward trend in the volume index.

(b) The volume increase subsequent upon the introduction of fertiliser subsidies in 1959 and 1960 was less than that which the equation would suggest ought to have occured.

(c) The equation offers no explanation for the static volume in 1965, 1966 and 1972.

(d) The equation accurately reflects the sharp reduction in volume in 1975. It failed however, to fully predict the sharp increase in 1973 and gave the peak volume in 1974 rather than 1973. The latter however, is probably due to the fact that in late 1972 and early 1973 farmers foresaw with confidence very substantial price rises for 1973 and thus were reacting to these expectations rather than the prices of 1972 as assumed in the lagging format of the equation. The fertiliser year 1972/73 however, was unique in that respect.

With a value of 393 for the API in 1976 and an estimated value of 295 for the fertiliser price index (March 1977) the equation predicts a figure of 170 for the 1977 fertiliser volume index (base 1968 = 100). From tonnage data already available it now appears that a 12 per cent volume increase was achieved in 1977.[1/] This will bring the volume index to 167 which is reasonably

---

1/ i.e. in 1976/77 over 1975/76.

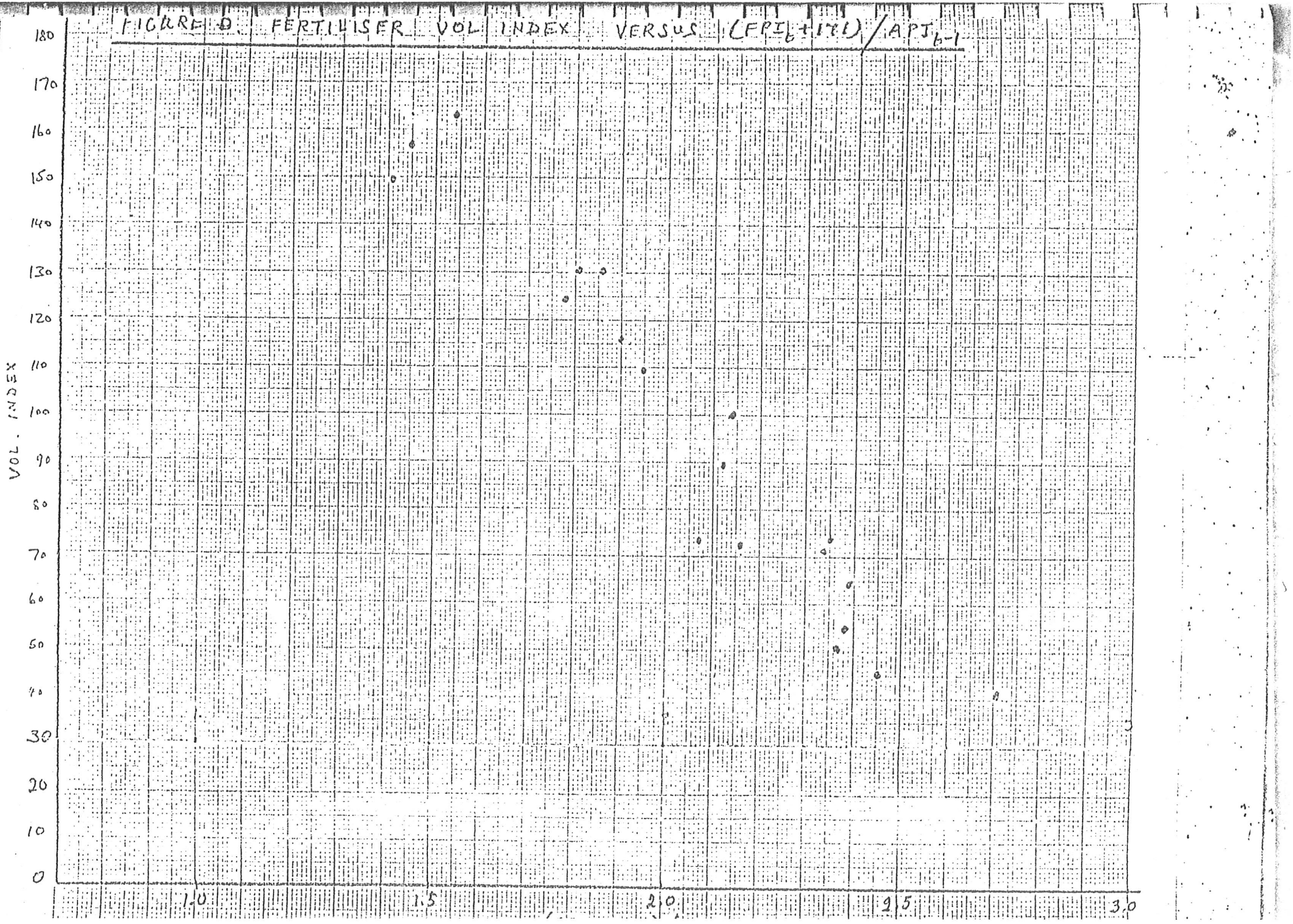
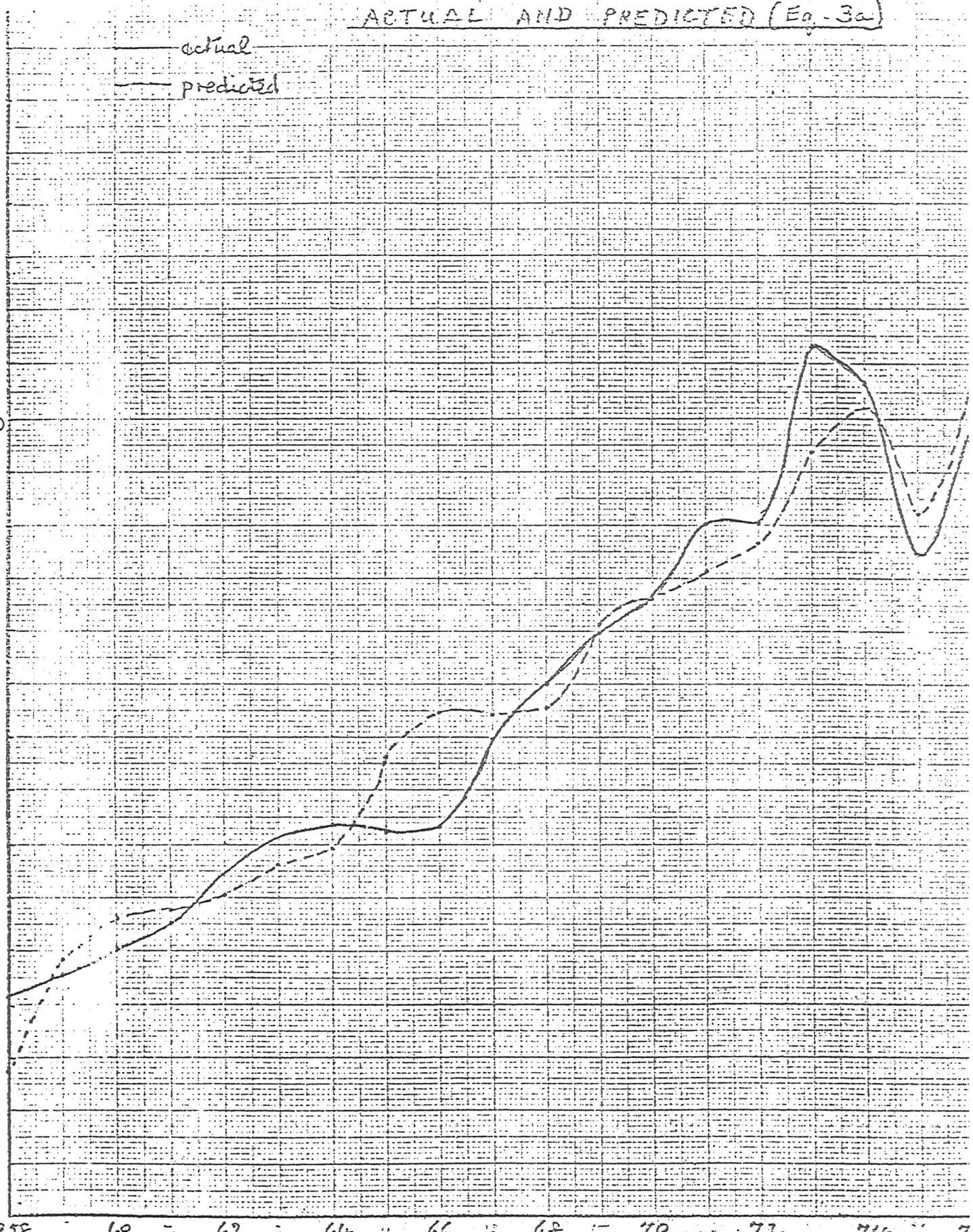


FIGURE 9 FERTILISER VOL INDEX VERSUS $(FRI_{t-1} + 170) / API_{t-1}$
VOL. INDEX
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1.0
1.5
2.0
2.5
3.0

FIGURE F : FERTILISER VOLUME INDEX 1955 - 1976
ACTUAL AND PREDICTED (Eq. 3a)



close to the predicted figure.

A further increase of 8 per cent in fertiliser prices in 1978 (i.e. 1977/78) coupled with an estimated 25 per cent rise in product prices (API) in 1977 would suggest a volume index figure of approximately 181 for 1978. This would amount to an 8 per cent increase on the 1977 level.

Total Expenditure on Fertilisers.

Here it is hypothesized that the interaction of fertiliser demand and price is such that there is a strong relationship between total expenditure on fertiliser and cash income. Two alternative figures from national accounts are available as indicators of total cash income arising in the farm sector each year. These are (1) "Income arising in Agriculture"(INCAR)[1/] (2) "Income from self-employment" in agriculture (INCSE)[2/]. The latter differs from the former by the amount paid out as wages and salaries in agriculture and an adjustment for land annuity charges. In the national accounts both of these figures include the value of livestock inventory changes. Since such income is not yet converted to cash it is excluded from the INCAR and INCSE series used in this study. The resulting series and the fertiliser expenditure series are shown in Appendix Table B.

Logically one would expect that the income level in year t-1 would have the greatest effect on fertiliser expenditure in year t but that the income of earlier years might also play a role. Experimentation with a number of lagging systems showed that a three-year weighted average for t-1, t-2 and t-3 gave good results. Thus $INCAR3 = (3 \times INCAR_{t-1} + 2 \times INCAR_{t-2} + INCAR_{t-3}) \div$

1/ Equivalent to the value of total gross agricultural output including livesto inventory changes less all expenses(but not capital expenses) and plus certain subsidies not related to sales(including a small subsidy paid under the Land Acts).

2/ Defined as "income from self-employment and other trading income" in the national accounts. It includes income spent to finance borrowing.

and similarily for INCSE3. The following relationships emerged between these variables and the fertiliser expenditure variable:

$$\underset{(£m)}{\text{F. Expand.}} = \underset{(-16.03)}{-21.64} + \underset{(38.57)}{0.25}\ \text{INCAR3} \quad \cdots \bar{R}^2 \cdots \cdots = .99 \qquad (4)$$

$$\underset{(£m)}{\text{F. Expend.}} = \underset{(-12.76)}{-18.50} + \underset{(33.96)}{0.27}\ \text{INCSE3} \quad \cdots \bar{R}^2 \cdots \cdots = .98 \qquad (5)$$

The income coefficients estimated in these equations differ very little. Equation (4) indicates that a £100m increase in cash income as measured by INCAR3 translates into approximately £25m increase in fertiliser expenditure.[1/] The ability of this equation to predict the actual expenditure can be gauged from Figure (F). Perhaps the most interesting aspect of these graphs is that in spite of the extraordinary price developments since 1973 the total expenditure on fertiliser has continued to rise in line with cash income in approximately the same manner as over the previous fifteen years although in both 1974 and 1975 the expenditures were somewhat higher[2/] than what might be considered normal according to the equations for the available cash income in those years.

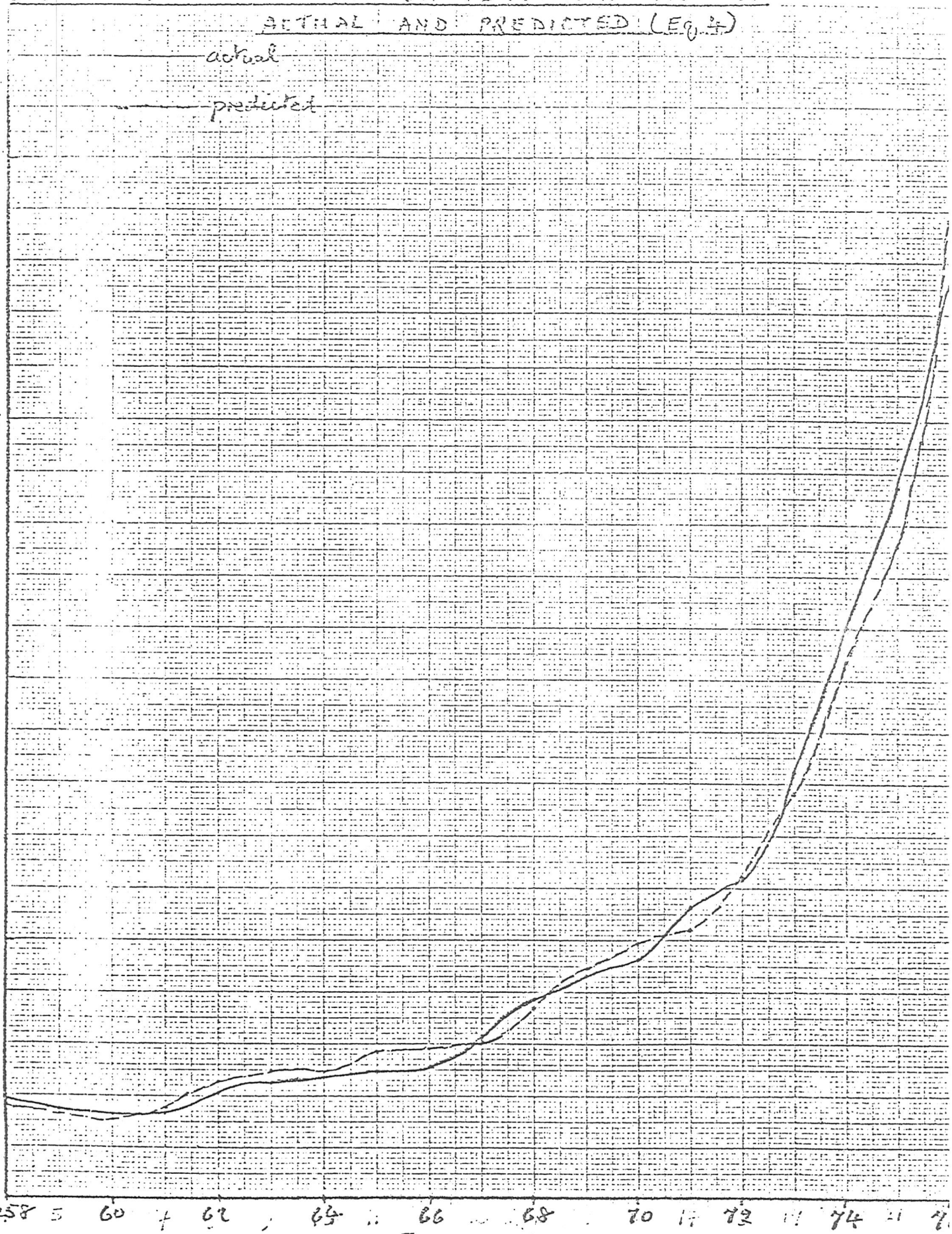
With regard to expenditure on fertiliser in 1977 (1976/77) the weighted average income, INCAR3, for 1974-'76 amounts to £530m. This when substituted in equation (4) gives a predicted expenditure of £111m. Figures available to date indicate that there was a volume increase (N. P and K) of approximately 12 per cent and an 11 per cent price rise.[3/] This would suggest an increase of 24 per cent in the expenditure bringing it to £110m - a figure almost identical to that predicted by the equation.

1/ Virtually the same result emerges from equation (5) since for recent years the changes in INCSE3 have been in the region of 95% of the corresponding changes in INCAR3. Thus the response through INCSE3 would be .27(£100m x .95) = £25m approximately.

2/ By £3m and £6m respectively.

3] Dept of Agriculture and Irish Statistical Bulletin, respectively

FIGURE F. EXPENDITURE ON FERTILISER 1958-76
ACTUAL AND PREDICTED (Eq. 4)



For the coming fertiliser season it is worth noting that a number of sources have predicted increases in the region of 25-30 per cent for income arising in agriculture in 1977. It is likely that some of this increase will have come from inventory changes. Assuming therefore, a 25 per cent increase in the cash income position equation (4) would indicate a total fertiliser expenditure figure of £136m for 1977/8 i.e. a further 24 per cent increase on the level predicted above for 1976/7. Assuming price increases can be kept to an average of about 8 per cent this would entail a 14 per cent increase in volume. The latter figure is considerably higher than that forecasted in the previous section using equation (3a) The divergence however, is not too surprising. The short-fall in precisim in the equations is such that a difference of this magnitude could arise through "normal" forecasting error. The exercise does however, illustrate the fact that while these equations can provide a useful "explanation" of the past movements in fertiliser volume and expenditure some further refinement and testing is needed if they are to function as reasonably accurate forecasting mechanisms.

Volumes of the individual nutrients. N. P and K.

The analysis so far has related to the total aggregate volume of fertiliser or total expenditure. However within the total the individual nutrients have shown somewhat different patterns of expansion as have their prices. This can be seen from the following table.

Table 4. Percentage changes in the volume and price of N, P and K, 1959 to 1967 and 1967 to 1975

	Volume			Price		
	N %	P %	K %	N %	P %	K %
1958 - 1967	+118	+69	+94	+5	-8	-13
1967 - 1975	+212	+18	+36	+122	+329	+217

Sources: Appendix Tables C and D

The percentage growth in the volume of N for the period 1967 to 1975 was substantially greater than that achieved in 1958 - 1967 whereas the opposite is true in the case of both P and K. Comparing these volume increases with the price changes it can be seen that the different growth patterns can be rationalised to a considerable extent by the differences in the individual price changes. Thus although the price of N increased much more rapidly in the second period than the first there was a substantially greater adverse movement in the prices of P and K both of which changed from a small negative rate of inflation to a very high positive rate of inflation.

In an attempt to quantify the price responsiveness of the demand for the individual nutrients the same general approach was adopted as for the aggregate volume of fertiliser. The following results were obtained:

Nitrogen (N) $= 257.9 - 1137.8\ (PN+16.9)/API \quad \bar{R}^2 = .96$ ... ... (6)

Phosphate(P) $= 113.4 - 490.1\ [PP+(14.48-.55T)]/API \quad \bar{R}^2 = .81$ ... (7)

Potassium(K) $= 310.8 - 6771.5\ (PK+2.23)/API \quad \bar{R}^2 = .87$ ... (8)

(N, P and K in ooo tonnes. PN, PP and PK = prices of N, P & K respectively as shown in Appendix Table D).

Apart from the nitrogen equation the goodness of fit ($\bar{R}^2$) obtained is considerably less than that achieved for the total volume of fertiliser.[1/] Apart from this, however, the results are similar to those obtained in the total fertiliser equations and therefore not in need of further discussion except perhaps to summarise the main points which are:

(a) the equations succeed in reflecting the decline and recovery in the use of P and K since 1973 as well as the halt in the N trend.

(b) all three equations "explain" the general upward trend prior to 1973.

(c) the three series (actual) showed a halt in the upward trend in the mid 1960's which was not accurately reflected by the equations.

(d) the actual increases in the three series in the period 1958-60 were less than what the equations predicted in response to the improved price ratios.

1/ This is perhaps to be expected since there may be some degree of substitution among nutrients.

4. Fertiliser Demand in 1980 and 1985

While the equations of the previous section can be used to make short-term projections of fertiliser demand, they are of only very limited assistance in making long-term projections. This is because the information required, viz., future prices and/or income levels, entails a projection exercise which is perhaps more difficult than alternative methods of projecting fertiliser demand.

One such alternative would be to fit a trend equation or line to the consumption data of, say, the past 20 years and extend this trend forward to 1985 or whatever year the projection is required for. There are some inherent difficulties in this approach. It may not be clear as to whether a linear or a curved trend line ought to be fitted. Thus, for example, in relation to the use of N, a linear trend fitted to the data of the past two decades gives an average per annum increase of only 9,000 tonnes and a projected use of 220,000 tonnes in 1985. It is clear from Figure I however that the past series approximates an exponential growth pattern[1/] more than a linear pattern, the average growth rate being of the order of 15 per cent per annum. When projected forward this gives a figure of 500,000 tonnes by 1985 which would be considered extremely unrealistic by informed sources. Brogan estimated N requirements of 380,000 tons for a highly intensive national level of agricultural production involving an average stocking rate of 1.0 LU per acre and without any adjustment for increased recycling of slurry[2/].

1/ i.e. a constant percentage increase per year rather than a constant absolute increase per year.

2/ J.C. Brogan (Fertiliser in the Seventies, Proceedings, Fertiliser Association of Ireland, No. 4, July 1970.

FIGURE I : FERTILISER USE IN IRELAND – N

ACTUAL AND TREND LEVELS

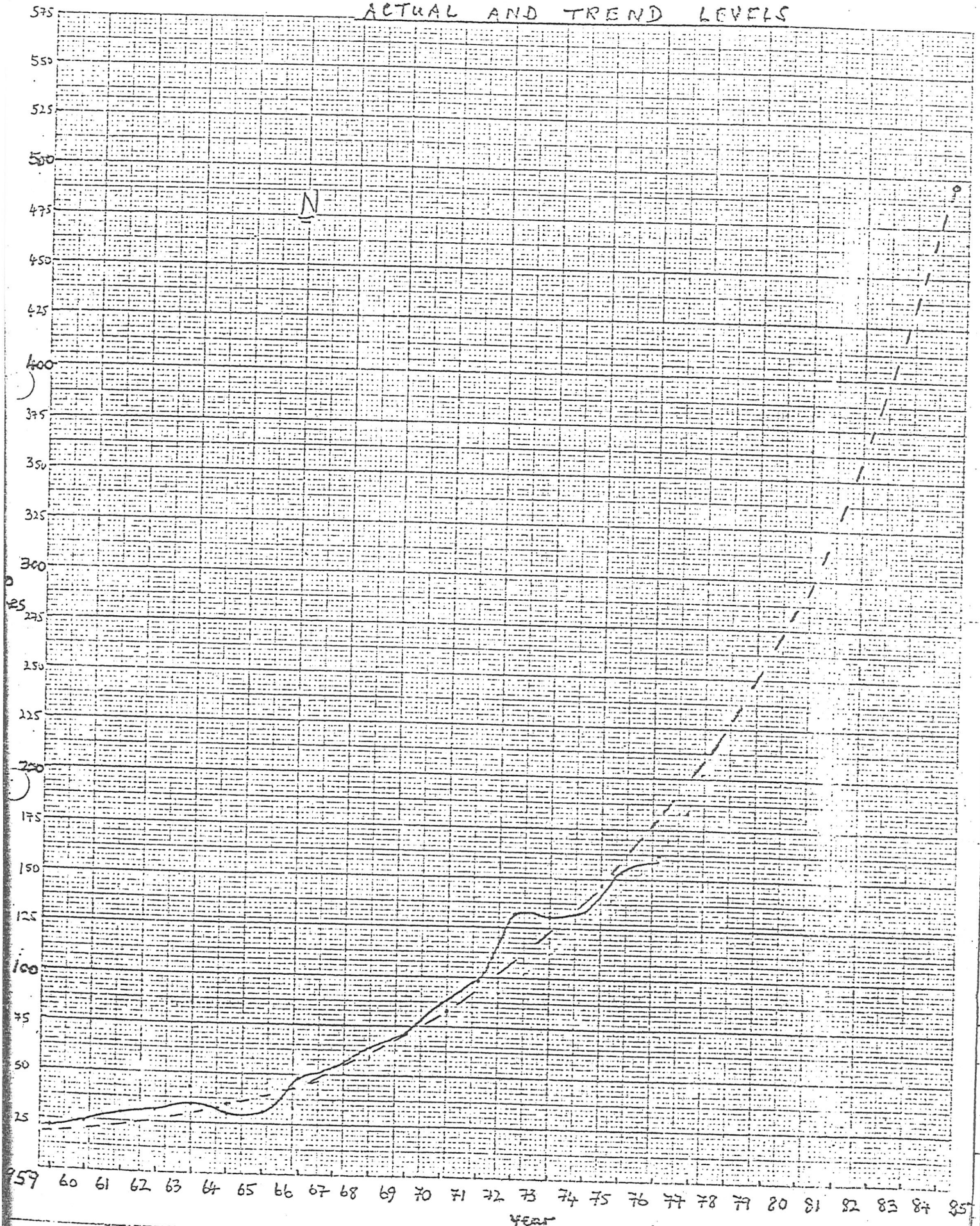
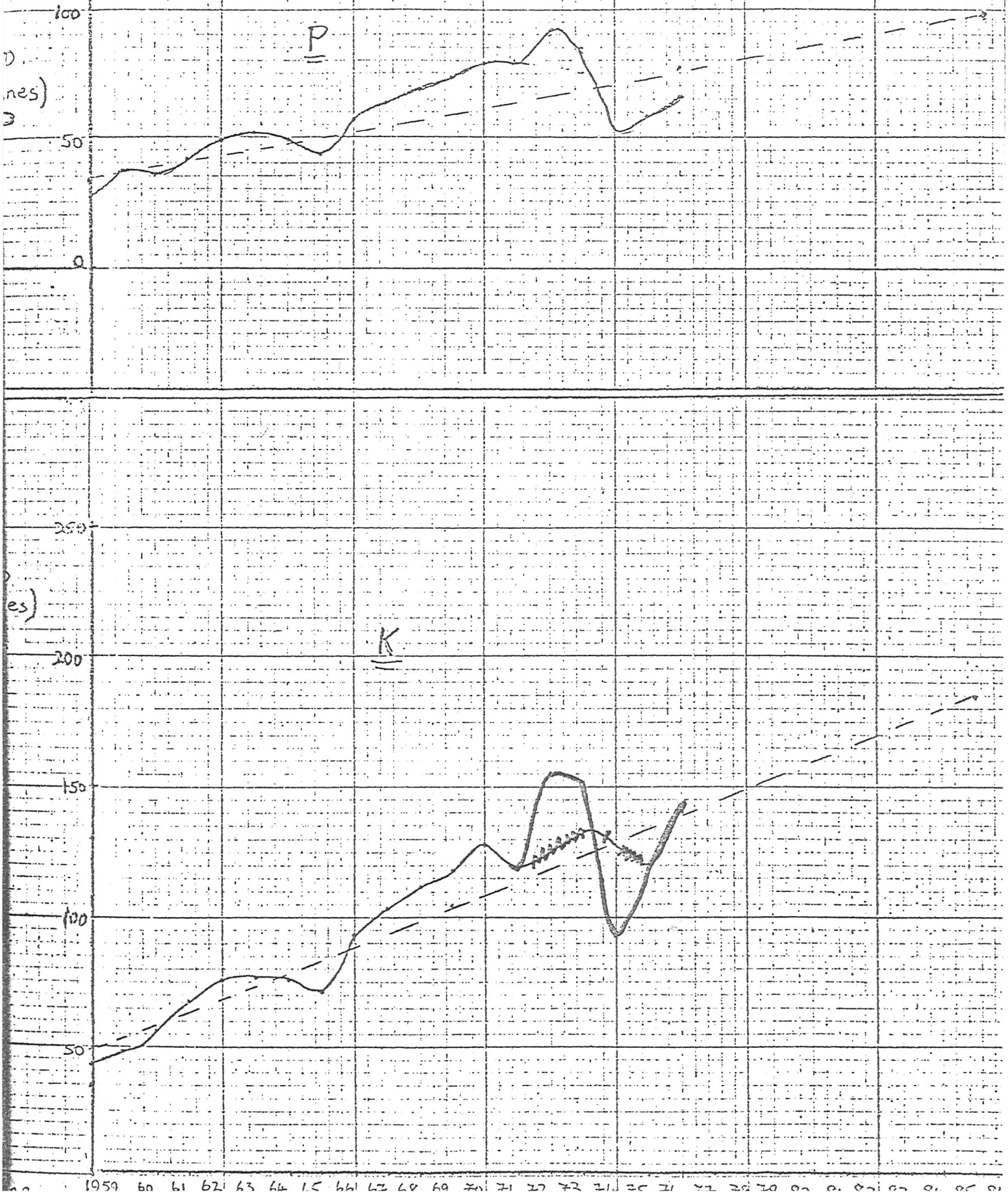


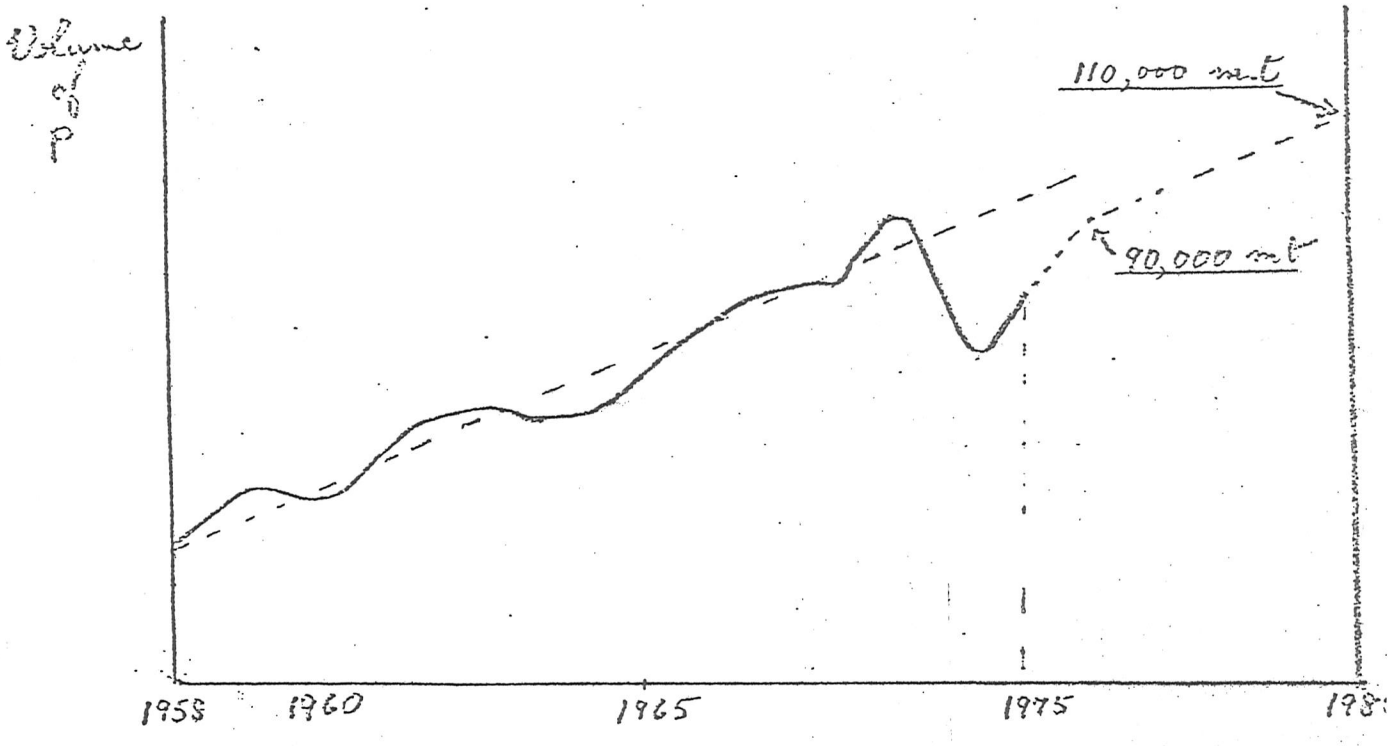
FIGURE J: FERTILISER USE IN IRELAND – P & K

ACTUAL AND TREND LEVELS



Reference to the P and K graphs in Figure J would indicate that for 1985 a linear projection of the 1958-77 levels might be more realistic. This would suggest 100,000 tonnes of P and 185,000 tonnes of K. The linear projection of P however raises significant questions of methodology arising from the sharp decline in 1973-1975. In particular, it must be asked whether the adverse shift in the real price of P will be completely reversed by say, 1979 or 1980. If it were felt that this will occur, then the more correct procedure would be to assume the volume in 1980 to have recovered to its 1973 level and then perhaps to apply the 1958-73 trend 2/ to this 1980 level and project forward. This procedure is illustrated in Figure K and gives a projection of 110,000 tonnes of P for 1985 1/.

Figure K. An alternative trend projection of P to 1985



Note : Not drawn to scale

1/ Because of the nature of the K series since 1972 trends based on 1958 - 72 and 1958 - 77 will not differ greatly.

2/ 3,900 tonnes per annum.

This particular example highlights one of the main weaknesses of trend projections, viz., they abstract completely from the underlying changes in real price or other causal factors which gave rise to the past trend and which may behave quite differently in the future. Perhaps one of the main uses of estimated demand relationships such as those presented in the previous section might be to evaluate simple medium-term projections by asking what relative price movements must arise in the future if these are to evolve.

There is also another reason why a simple trend projection for fertilisers may be unreliable. The levels of fertiliser use shown in the past series are determined by three factors:

(1) the pattern of land use; since all crops do not receive the same rate of fertiliser application,

(2) the percentage of land under each crop which is fertilised, and

(3) the average rate of application on the fertilised area for each crop.

Clearly for each crop, factor (2) has a maximum value which cannot be exceeded while factor (3) also possesses an asymptote beyond which producers are unlikely to proceed. Either or both of these may invalidate a simple linear or exponential projection of trends forward over a period of a decade or so. For projections of this nature it is preferable to take account separately of the three factors listed above. This is the approach adopted by Brogan in 1970[1/] and more recently in an NESC study relating to alternative growth rates in Irish agriculture[2/]. The NESC study entailed projections to 1985 and since this author was involved in the research for that study the remainder of this section will be devoted to

---

1/ J.C. Brogan, Ibid

2/ NESC Alternative Growth Rates in Irish Agriculture Report No. 34, No. 34, Stationery Office, Dublin, 1977.

comments on the findings with regard to fertiliser and the critical issues involved. The primary objective of the study was to project agricultural output and inputs forward to 1985 and assess their implications for employment and the balance of payments. For this purpose, crop acreages and livestock numbers were projected forward by extending the 1960 - 76 trends. This provided a trend and perhaps most likely a pattern of land use for 1985 which was as shown in Table 5

Table 5. Pattern of land-use in 1976 and trend projections to 1985 (000 acres)

	1976 Actual	1985 Projected
Wheat	125	80
Oats	100	40
F. Barley	514	645
M. Barley	126	145
S. Beet	85	70
Potatoes	117	60
Other tillage	120	90
	1,186	1,130
Grassland 1/	12,814	12,850
Pasture	N.A.	7,280
Silage	2/	2,000
Hay	2,632	1,000
Rough grazing 3/	N.A.	2,570

1/ Assumed to be approximately 14.0 m. acres less tillage

2/ 1975

3/ Assumed to be 20 per cent of grassland in 1985

Sources: 1976 (and 1975), Central Statistics Office, 1985, NESC Ibid, Chap. 3.

This pattern of land-use was then combined with (a) a set of projected fertiliser rates for 1985 and (b) a projection of the percentages of each crop receiving fertiliser. The latter was assumed to be 100 per cent for all crops except roots (75%) and pasture (90%). The average rates per acre on the fertilised area were assumed to reach the levels shown in Table 6 by 1985.

Table 6. Projected average rates of fertiliser on fertilised crop and grassland area in 1985 (lb/ac)

	N	P	K
Wheat	40	25	50
Oats	25	25	50
F. Barley	40	25	50
M. Barley	25	25	50
S. Beet	100	100	300
Potatoes	100	100	200
Roots (60,000 ac.)	50	100	150
Other (30,000 ac.)	80	80	220
Pasture	45	15	30
Silage	100	30	130
Hay	80	25	75
R. Grazing 1/	0.1	1.0	0.1

1/ Average rate on total area

Source: NESC, Ibid, Table 5.2

By combining these three sets of separate projections, total requirements of N, P and K in 1985 were estimated. The results are shown in Table 7

Table 7 Projected use of N, P and K in 1985 compared with the 1976 and 1977 levels (000 tonnes)

1985:	N	P	K
Tillage	23	20	42
Pasture	134	45	89
Silage	91	27	118
Hay	36	11	34
R. Grazing	-	1	-
Total	284	104	283
1976	153	59	120
1977	168	65	142

Sources: NESC, Ibid Table 5.4 and Dept. of Agriculture.

Thus, an increase of almost 70 per cent over the 1977 level was projected for N, 60 per cent for P and 100 per cent for K. A number of factors emerged from the calculations. The total tillage requirements were sufficiently low relative to those of grassland as to render the [illegible] tillage : grassland acreage balance relatively unimportant. The most critical factors and the most difficult to project were (1) the silage area and (2) the rates per acre for silage and pasture. The total area assumed for hay plus silage was such as to provide sufficient winter feed for the projected livestock population. It allowed 0.4 acres per LU at a projected stocking rate of 1.4 acres per LU.

One method used to assess the projected increase in the per acre rates for grassland was to relate the change to cross-sectional farm

data on per acre rates and stocking rate from the Far Management Survey (FMS)[1/]. The diagram used is reproduced in Figure 4. The point marked X_1 represents the volume per acre of grassland (at 1974 prices) projected in Table 7. The dotted line represents the cross-sectional relationship shown in the FMS for creamery milk farms. It suggests that the 1985 projection bears a correct relationship to the 1972 - 1975 observations.

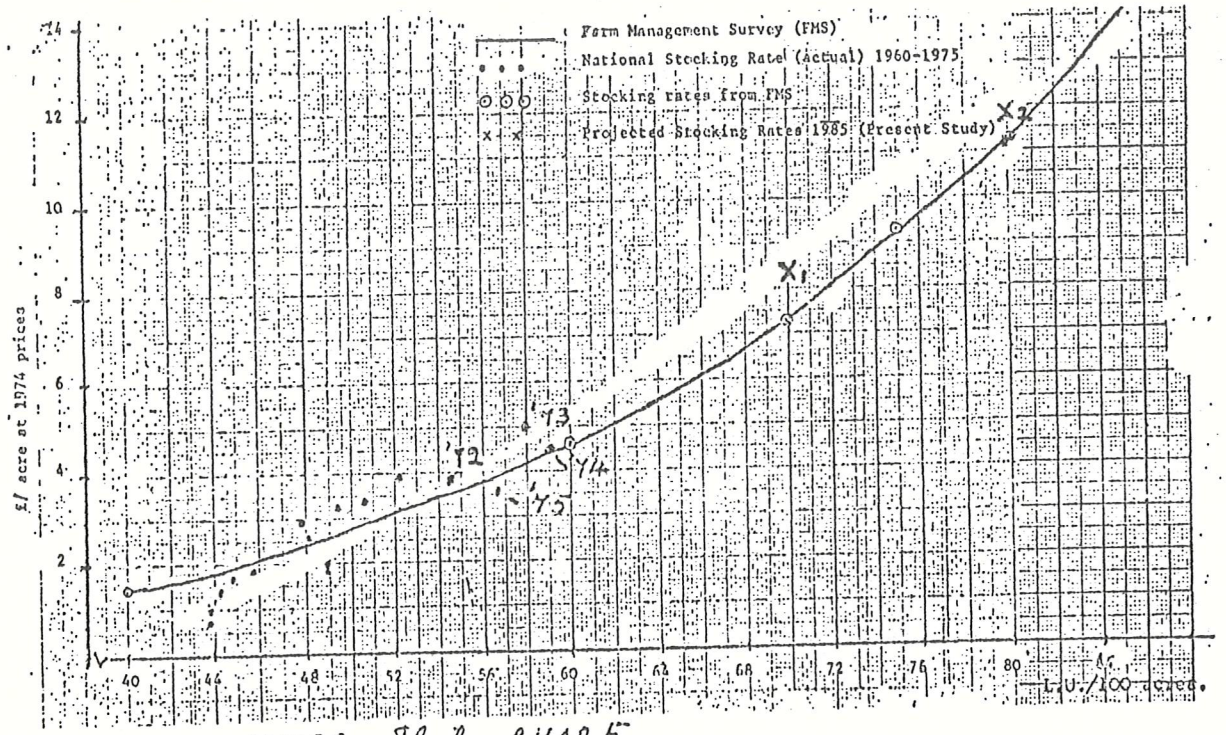
The N projection at 284,000 is considerably below the ~~experimental~~ exponential trend projection of 520,000 tonnes. The big issue here relates to the fact that, in the past, N increased at an average of 15 per cent per annum in association with a 2 per cent average rise in stocking rate. While one can find no undue pessimism in the rates for grassland projected in Table 6 it is difficult to see how a 2 per cent growth in stocking rates can be combined with such a significant reduction in the growth for N.

Perhaps the biggest issue in the projections of Table 7 however, was the assumption regarding the degree of recycling of farmyard manures and the effect of this on purchases of artificial manures. The view was taken that the totals shown in Table 7 need not be altered for this factor. One reason for this conclusion was that many of the per acre rates shown in Table 6 were based to a large extent on the past Fertiliser Use Surveys in which the rates given are for artificial manure and therefore in addition to nutrients derived from farmyard manure. Furthermore, it was the authors' belief that even in the past a very high proportion of the nutrients from farmyard manures have been recycled.

1/ As presented by W.E. Murphy and J.C. Brogan, "Review : The Use and Value of Fertiliser and Lime", Paper presented at An Foras Taluntais, Johnstown Castle, Sept. 1975.

FIGURE L

Relationship between fertilizer expenditure per acre of Grassland and Stocking Rate



SOURCE. NESC Ibid CHAP 5

The remarks in section 2 of the paper about the effect of recycling on demand for artificial manures in the Netherlands might appear to contradict this approach. This is not the case because the continuation of trends in Irish agriculture would result in stocking rates and meal feeding rates which even in 1985 would still be very much lower than the average levels achieved in the Netherlands at the present time[1/].

An alternative set of projections were derived in the NESC study under the assumption of a doubling of the growth rate compared to the past trend[2/]. This involved an extra 200,000 acres in tillage over the trend projection with the stocking rate on grassland raised from .7 to .8 LU per acre. It was estimated that this would raise the total requirements for N to 410,000 tonnes along with 116,000 tonnes for P and 354,000 tonnes for K. The volume per acre of grassland is marked X_2 in Figure 4. The high growth rate involved in this model, however, must be considered highly speculative and in spite of EEC entry the trend position appears to be the most likely outcome.

In the event of the trend course continuing, a linear extrapolation of the 1977 and 1985 fertiliser levels shown in Table 7 would suggest a figure of approximately 220,000 tonnes of N in 1980, 80,000 tonnes of P and 200,000 tonnes of K. These projections for N and K are exactly in line with the 1975-77 increases. It would appear to be more likely, however, that P will reach 90,000 tonnes by 1980.

1] The NESC study projected 11.5 cwts of meal per cow and 0.7 LU per acre in 1985

2] 5.5% p.a. for GAO in 1974-85 compared to 2.8% p.a. in 1960-'76

5. Conclusions

The statistics for the two most recent fertiliser seasons indicate that the pre-1973 upward trend in fertiliser use has been firmly re-established. This is a welcome turn of events after the sharp decline in 1974 and 1975 when the fertiliser volume index fell by 24 per cent. Although the post 1973 decline was substantial indeed, it should be observed that the volume in 1973 had increased approximately 25 per cent over the previous year and was 50 per cent above the 1970 level. This increase was mainly on grassland and while stocking rates rose by about 15 per cent in 1970-1973 this would hardly seem sufficient to warrant the 50 per cent increase in fertiliser. Viewed in that light the low levels of 1974 and especially 1975 should be seen more as a problem of nutrient balance and less as a problem of total fertiliser volume than is usually allowed. In fact it appears likely that the actual applications in 1974 were bolstered by a carry-over of stocks from the previous season and thus were higher than the volume index would suggest.

When assessed by European standards the Irish farmer's reaction to the adverse price shifts in 1974 and 1975 seems rather moderate. For him the price changes relative to product prices were the worst experienced in the Nine and, although Ireland tied with Denmark in terms of cut-back in volume, on a pro-rata basis the reduction was no worse than that of the other countries and may in fact have been somewhat better.

The analysis in section 3 of the paper has shown that it is possible to attribute the most of past changes in fertiliser use to movements in the prices of fertilisers relative to agricultural product prices and incomes. The product prices and estimated income changes for 1977 coupled with the very moderate fertiliser price increases apparent at the moment suggest that a volume increase of about 8 per cent may be achieved in the 1977/8 season and possibly more. This is in addition to an estimated 12 per cent increase in the past season.

For the long-term position it would appear that unless a strong development programme is initiated by the government Irish agriculture will progress at about the same rate as in the past decade and a half. Translating this into fertiliser requirements it would appear that the consumption of N will be close to 300,000 tonnes by 1985, P slightly over 100,000 tonnes and K about 280,000 tonnes. The nitrogen figure however, is somewhat a case of the forecaster refusing to believe what he ~~says~~ sees. The average rate of increase for N over the period 1958 to 1977 amounted to about 15 per cent per annum which if continued would result in an annual consumption of 500,000 tonnes by 1985! The lower level projected in this paper certainly begs the question as to how the past rate of growth in stocking rates (2% p.a.) can be sustained with a greatly diminished rate of increase in nitrogen use.

Appendix Table A. Indices of Volume of gross agricultural output, volume of fertiliser consumption, agricultural prices and fertiliser prices, 1955 - 1976.

Year 1/	Volume, 1968 = 100		Prices 1953 = 100	
	GAO	Fertiliser	Ag. Products	Fertiliser
1955	75.1	36.1	103.1	99.5
1956	75.8	36.0	93.5	101.7
1957	79.1	38.7	99.8	102.5
1958	73.1	41.4	102.5	99.8
1959	77.9	45.6	102.4	80.2
1960	80.4	50.6	99.6	71.4
1961	83.9	54.8	100.0	66.2
1962	86.4	64.3	101.7	67.7
1963	86.7	71.2	102.2	67.4
1964	90.0	73.6	113.1	69.0
1965	90.8	72.7	117.7	72.8
1966	90.6	73.3	115.9	73.1
1967	93.5	89.8	118.3	74.8
1968	100.0	100.0	130.4	81.8
1969	100.2	109.8	134.1	83.0
1970	103.1	116.1	140.3	83.7
1971	109.7	130.2	150.1	90.4
1972	113.8	130.3	182.3	100.0
1973	116.6	163.1	238.2	109.2
1974	116.2	156.6	241.6	173.5
1975	124.4	124.5	309.5	258.0
1976	118.7	149.1	392.7	266.9

1/ The fertiliser volume index for year t relates to consumption in the fertiliser year t-1/t. It includes lime.

Sources: Irish Statistical Bulletin. The fertiliser volume indices for the years 1958 to 1968 were kindly provided by the Central Statistics Office.

Appendix Table B. Income arising in agricultural (INCAR), agricultural income from self-employment and other trading (INCSE) and expenditure on fertiliser, 1955 to 1976.

Year	INCAR 1/ £m	INCSE 1/ £m	Fert. expend. 2/ £m
1955	123.4	102.4	8.30
1956	116.7	95.8	8.59
1957	128.3	107.0	9.10
1958	114.0	93.1	9.57
1959	116.3	95.1	8.47
1960	128.5	110.1	8.28
1961	139.6	121.5	8.41
1962	136.1	117.9	10.24
1963	134.6	116.9	11.22
1964	151.3	131.9	11.93
1965	142.2	121.1	12.43
1966	148.7	126.8	12.58
1967	173.3	156.2	15.82
1968	185.4	163.4	19.24
1969	188.1	165.4	21.58
1970	193.1	168.6	23.04
1971	220.0	194.0	28.17
1972	267.9	237.5	30.85
1973	332.0	299.4	42.01
1974	364.6	328.0	55.01
1975	570.0	528.1	68.77
1976	559.0	513.0	88.38

1/ Both INCAR and INCSE exclude the value of stock changes.

2/ Fertiliser expenditure in year t relates to the t-1/t fertiliser year. It includes the value of lime.

Source: Irish Statistical Bulletin.

Appendix Table C. Consumption of Fertilisers in Ireland 1957/8 to 1976/7

Year	N	P	K
		(ooo tonnes)	
1957/8	18.3	27.4	44.2
1958/9	20.9	33.5	44.4
1959/60	22.0	36.6	49.2
1960/1	25.0	35.4	55.5
1961/2	29.5	41.4	67.0
1962/3	31.0	49.5	75.4
1963/4	34.7	51.4	76.8
1964/5	29.7	49.6	76.3
1965/6	31.9	43.9	70.1
1966/7	47.8	56.1	93.1
1967/8	53.8	64.6	104.1
1968/9	64.0	69.5	111.6
1969/70	71.3	73.8	117.6
1970/1	87.1	79.7	128.5
1971/2	98.3	77.8	119.6
1972/3	131.8	91.7	155.3
1973/4	130.2	84.3	151.0
1974/5	133.0	50.5	93.1
1975/6	152.7	58.7	120.2
1976/7	168.2	65.2	141.6

Source: Farm Bulletin. 1976/7 Dept. of Agriculture.

Appendix Table D. Prices per 100 lbs of N, P and K, 1955 - 1977.

Year	N £/100 lb.	P £/100 lb.	K £/100 lb.
1955	5.15	7.53	2.00
1956	5.29	7.72	2.11
1957	5.04	7.90	1.98
1958	4.80	7.81	1.87
1959	4.28	4.88	1.79
1960	3.73	4.19	1.70
1961	3.66	4.09	1.33
1962	3.74	4.45	1.37
1963	3.52	4.57	1.38
1964	3.73	4.74	1.36
1965	4.48	4.83	1.41
1966	4.39	4.83	1.47
1967	4.37	5.09	1.47
1968	4.69	5.61	1.71
1969	4.74	5.75	1.65
1970	4.72	5.75	1.67
1971	4.72	6.27	1.87
1972	5.03	7.32	2.08
1973	5.41	8.01	2.31
1974	8.03	15.98	3.59
1975	10.88	24.78	5.44
1976	10.90	25.82	5.73
1977	12.05	27.83	6.68

Note: These prices relate to (a) elemental N, P and K and (b) the end of March of each year. They were derived from the following published prices:

1955 - 1959 Sulphate of Ammonia (21%), powder Superphosphate (8%) and Muriate of Potash (42%).
1964 - 1977 CAN (20.5%, 23% and 26%), granular Superphosphate (8%) and Muriate of Potash (50%)
1960 - 1963 weighted combinations of the two fertilisers listed above for each nutrient. Weights, 80 - 20, 60 - 40, 40 - 60 and 20 - 80. for the years 1960, '61, '62 and 1963 respectively.

Source: Irish Statistical Bulletin.

Appendix Table E. Indices of the volume and price of fertilisers, 1973 - 1975 and agricultural prices, 1972 - 1975 in the nine EEC Countries.

1973 = 100 (1972 = 100 for agr. prices)

		1972	1973	1974	1975
Germany	Fert. Vol.	97.2	100.0	103.9	94.2
	Fert. prices		100.0	109.4	131.6
	Agr. prices	100.0	106.3	102.8	116.4
France	Fert. Vol	86.2	100.0	96.2	79.6
	Fert. prices		100.0	144.3	162.4
	Agr. prices	100.0	112.0	117.5	128.0
Italy	Fert. Vol.	93.1	100.0	95.0	87.4
	Fert. prices		100.0	170.9	199.5
	Agr. prices	100.0	124.9	147.5	165.8
Netherlands	Fert. Vol.	105.6	100.0	101.3	94.5
	Fert. prices		100.0	116.8	133.6
	Agr. prices	100.0	111.1	104.6	117.9
Belgium	Fert. Vol.	98.2	100.0	102.9	98.2
	Fert. prices		100.0	126.6	150.2
	Agr. prices	100.0	113.9	112.2	127.1
Luxemburg	Fert. Vol.	103.2	100.0	83.2	86.8
	Fert. prices		100.0	136.8	155.5
	Agr. prices	100.0	109.4	110.1	123.5
Denmark	Fert. Vol.	92.0	100.0	114.0	85.8
	Fert. prices		100.0	122.5	210.0
	Agr. prices	100.0	129.1	130.7	142.5
U.K.	Fert. Vol.	151.7	100.0	143.4	115.4
	Fert. prices		100.0	115.4	179.9
	Agr. prices	100.0	128.6	144.8	180.0
Ireland	Fert. Vol.	79.8	100.0	96.0	76.3
	Fert. prices		100.0	158.9	236.3
	Agr. prices	100.0	130.7	132.5	169.8

Sources: Vol. index; Eurostat: Agricultural Accounts 1975 and 1976 SOEC (Constant price series for fertiliser expenditure). Fert. price index; Eurostat, Agricultural Price Statistics. 1969 - 1975. SOEC. Luxemburg index from Table F.2 p122. Agr. price index; Eurostat, EC - Index of Producer Prices of Agricultural Products. 1969-'76 SOEC. All Irish indices are from the Irish Statistical Bulletin.