WORKING PAPERS IN ECONOMICS

Industrial Sector Fuel Price Elasticities of Demand Following the First and Second Major Oil Shocks

by

V.B. Hall

No. 77 August 1984

DEPARTMENT OF ECONOMICS

The University of Sydney
Australia 2006

Industrial Sector Fuel Price Elasticities of Demand Following the First and Second Major Oil Shocks

by

V.B. Hall

[illegible] August 1984

National Library of Australia Card Number and ISBN 0 86758 167 0

INDUSTRIAL SECTOR FUEL PRICE ELASTICITIES OF DEMAND FOLLOWING THE FIRST AND SECOND MAJOR OIL SHOCKS*

In a previous paper (Hall, 1983a), which used a pooled time series/ cross section sample of 140 observations for 1960-1979 for the industrial non-energy producing sectors of the seven major OECD countries, it was demonstrated that:

(i) strict conditions for a two-stage translog expenditure shares model were *violated*; and

(ii) the preferred non-homothetic equality model could still produce "sensible" international own-price elasticities of demand for petroleum products, gas, coal, and electricity of -.26, -.81, -.97, and -.02 respectively.

Clearly, that data base incorporated a substantial number of annual *observations subsequent to the first major oil shock of 1973-74*, but could not capture responses following the second major oil shock of 1979.

This paper, with the assistance of observations through to 1982, and thereby including four years' data subsequent to the second major oil shock, has allowed that *previous work to be extended in three major ways:*

(i) it tests whether the omission of a fuel efficiency bias term from the previous model could have been a major factor in our having to reject all the expenditure shares restrictions imposed;

(ii) it tests all four individual fuel equations for possible structural breaks between 1973 and 1974, and between 1978 and 1979; and

(iii) it examines whether the own-price and cross-price elasticities of demand for individual fuels in the periods following the first and second major oil shocks have been substantially different from each other and from those for the full sample period.

Section 1 sets out the underlying petroleum price and individual fuel expenditure shares movements for the period 1960-82, section 2 summarises the range of expenditure shares models estimated and tested, section 3 presents the results obtained from testing a range of imposed model restrictions, and section 4 gives the outcomes from some simple tests for structural change. Section 5 contains the resulting preferred international own-price and cross-price elasticities of demand, while section 6 highlights how some of those elasticities have varied across the seven individual countries. Concluding remarks appear in section 7.

1. Petroleum Price and Individual Fuel Expenditure Shares Movements 1960-82

The empirical evidence presented in Hall (1983a) came from various translog expenditure shares energy sub-models[1], the least restricted of which is the following non-homothetic equality[2] model imposing neutral fuel efficiency bias[3]

$$SE_i = \sum_{k=1}^{7} \beta_{ik} D_k + \sum_j \beta_{ij} \log PE_j + \beta_{iE} \log E \qquad i,j = p,\ g,\ c,\ e \qquad (1)$$

where i, j are individual fuel types, k are the seven major OECD countries, SE_i is the expenditure share on fuel i, D_k is the individual country intercept dummy for country k, PE_j is the actual price of fuel j (in $US), and E is the aggregate real volume of industrial sector energy (in mtoe[4]). Fuel p is petroleum products, g is gas, c is solid fuels/coal, and e is electricity.

As this paper retains basically that previous theoretical framework, and as it is the responses of those expenditure shares to oil shocks that we are primarily interested in, we present in figures 1 to 7 and 8 to 14 movements in the expenditure shares and petroleum products price series over the full period 1960-82 for each of the seven countries. Table 1 gives the corresponding numerical magnitudes for the expenditure shares for years 1960, 1973, 1974, 1978, 1979, and 1982. Years 1960 and 1982 are the beginning and end of our full sample period, and the other four years reflect the situation immediately before and after the two major oil shocks.[5]

The first major oil shock can be taken to have its direct origin in outbreak of the Yom Kippur War on October 6th, 1973 and the subsequent price and supply decisions taken by various OPEC members. The period October 1973 to March 1974 saw oil prices quadrupled and supplies of oil to the United States and The Netherlands subject to embargo.

The second major oil shock had as its immediate catalyst the overthrow of the Shah of Iran's regime in December 1978, which led to a further doubling of oil prices and associated changes in supply by various countries.

Figures 1 to 7 and Table 1 show that in 1982, for six of the seven major OECD countries[6], the petroleum products share of total energy expenditure was around 100% higher than it was in 1960. Between those years, the basic pattern of movement was first a steady rise in share between 1960 and 1973, then a very substantial jump between 1973 and 1974, followed by a gradual decline until 1979, and finally another (but somewhat smaller) jump and subsequent decline.

The extent to which these changes in petroleum products share have been reflected in gas, coal, and electricity share changes has varied over time and between country. The general picture for the full period is that both oil and gas shares have increased at the expense of those for coal and electricity. For the 1970s and 1980s, oil and electricity movements have been close to mirror images. But in the United States, an increased oil share during 1960-73 has been at the expense of electricity and gas, and the decreased oil share over both 1974-78 and 1979-82 has been accompanied by decreased electricity and increased gas shares. The coal share varied little in the United States, as was the case for Italy and for gas in Japan. Experience in the United Kingdom was somewhat different from that in the United States. The dramatic fall in coal share from 1960 to 1973 was offset by increased expenditure shares for both oil and electricity, and the more gentle falls for coal in 1974-78 and 1979-82 were accounted for in the former instance by a dramatic oil fall and gas increase, and in the latter by gentle falls in both oil and electricity and a further increased gas share.

Any expenditure share change can, by definition, be the result of both own-price and own-volume movements, and it is clear from Figures 8 to 21 that the oil price[7] and real volume movements have been substantial over the period 1974-82 for all seven countries. However, continuing to employ a piecemeal "eyeball" approach can only take us so far towards a better understanding of the interfuel substitution process. In particular, it would fail to take into account share movements emanating from changes in the prices of complementary or substitute fuels, sectoral real energy demand increases or decreases, and longer term fuel efficiency biases. Nor would it enable us to obtain estimates for the corresponding comprehensive set of own-price and cross-price elasticities of demand.

We therefore now turn in section 2 to some appropriately specified theoretical models which can incorporate this wider range of influences and enable relevant degree of response measures to be estimated.

2. The Expenditure Shares Energy Sub-models

The non-homothetic translog expenditure shares energy sub-model (NHU) written above as equation (1) could have imposed on it the following restrictions:

$$\begin{aligned}
&\sum_i \beta_{ik} = 1 && \text{for all } k \\
&\sum_j \beta_{ij} = \sum_i \beta_{ij} = 0 && \\
&\beta_{ij} = \beta_{ji} && i \neq j \\
&\beta_{iE} = 0 && \text{for all } i
\end{aligned} \tag{2}$$

Imposing all restrictions contained in equation (2) would make it the well-known conventionally estimated homothetic symmetry/equality[2] model (HS), consistent with two-stage theory[1]. The corresponding partial own-price (ε_{ii}) and cross-price (ε_{ij}) elasticities of demand for individual fuels can be written[8] as:

$$\begin{aligned}
&\varepsilon_{ii} = (\beta_{ii}/SE_i) - (1-SE_i) && \\
&\varepsilon_{ij} = (\beta_{ij}/SE_i) + SE_j && i \neq j
\end{aligned} \tag{3}$$

The restrictions included or implied in equation (2) consist of a requirement that the expenditure shares sum to unity (i.e. $\sum_i \beta_{ik} = 1$, $\sum_i \beta_{ij} = 0$, $\sum_i \beta_{iE} = 0$), and the assumptions of homotheticity ($\beta_{iE} = 0$), homogeneity in prices ($\sum_j \beta_{ij} = 0$), symmetry ($\beta_{ij} = \beta_{ji}$), and neutral fuel efficiency bias. The degree of fuel efficiency bias was not tested for in Hall (1983a), but equation (1) can easily be modified to allow for the possibility of linear non-neutral fuel efficiency bias[9], and becomes the new least restricted model (NHUT)

$$SE_i = \sum_{k=1}^{7} \beta_{ik} D_k + \sum_j \beta_{ij} \log PE_j + \beta_{iE} \log E + \gamma_i t \tag{4}$$

where t is the linear time trend, and where the individual γ_i can be positive, negative, or zero, according to whether the bias is fuel using, fuel saving, or neutral. The expenditure shares summing to unity requirement would additionally need $\sum_i \gamma_i = 0$.

The estimation of six models less restricted than HS was sufficient for testing the fuel efficiency bias, homotheticity, homogeneity in prices, and symmetry assumptions. These six models are: a homothetic (HST) and a non-homothetic (NHST) symmetry/equality model allowing for non-neutral fuel efficiency bias; a non-homothetic symmetry unconstrained (NHSUT) model allowing for non-neutral fuel efficiency bias, a non-homothetic (NHU) equality model with neutral fuel efficiency bias, and a homothetic (HUT) and a non-homothetic (NHUT) equality model allowing for non-neutral fuel efficiency bias. The latter is, of course, equation (4).

Tests were conducted using the statistic $-2\log\lambda$, asymptotically distributed as χ^2 with degrees of freedom equal to the number of restrictions, and where λ is the ratio of the restricted to the unrestricted likelihood function.

Estimation with the pooled time series/cross section data has been with the iterative Zellner method referred to as LSQ in TSP (1980, pp. 51-52). No adjustment was made to default settings for either the maximum number of iterations (20) or the convergence criterion (.01). Convergence was quickly achieved in all cases, and results do not seem sensitive to the use of alternative starting values for the parameters.

All data come from published and unpublished OECD sources, and as implied at the beginning of the paper, estimates were obtained for each of the five periods 1960-82, 1960-73, 1974-82, 1974-78, and 1979-82.

3. Testing of Model Restrictions

Values for the log of the likelihood function for each of the seven models HS, HST, NHST, NHSUT, NHU, HUT and NHUT are presented for all five periods in Table 2, as are the results obtained from testing the relevant restrictions.

For none of the five sample periods is it possible to accept all restrictions taken together. That is, the HS model is not consistent with any of the data sets, and it is the least restricted model NHUT which in every case gives the highest likelihood function value. This model therefore allows not only for own and cross-prices to be significant in influencing each fuel share, but also for significance of the total volume of energy demanded by that sector and any degree of fuel efficiency bias. Individual country intercept dummies allow for autonomous individual fuel share level influences to be different for each of the seven countries.

For sample periods subsequent to the first oil shock, though, certain individual restrictions cannot be rejected. For example, the homogeneity in prices assumption cannot be rejected at the 5% level for 1974-82, 1974-78 and 1979-82; nor can homogeneity and symmetry together be rejected for 1974-82 at the 5% level of significance and for 1974-78 at the 1% level. In no case, however, can non-neutral fuel efficiency bias and homotheticity be individually accepted, nor can homotheticity, homogeneity and symmetry together.

Thus, although it is the least restricted model NHUT which has to be preferred for the overall sample period 1960-82, during the full 1974-82 period of substantial oil price and expenditure share movements following the first and second major oil shocks, a non-homothetic symmetry model (NHST) allowing for non-neutral fuel efficiency bias cannot be rejected. This non-rejection of combined homogeneity and symmetry can be seen as primarily due to the more greatly varying behaviour during the 1974-78 sub-period rather than to movements in 1979-82.

These results, while consistent in the case of 1960-82 with those presented in Hall (1983a) for 1960-79, tentatively suggest it is worthwhile to conduct formal tests for structural breaks in the various equations between 1973 and 1974, and between 1978 and 1979.

4. Some Simple Tests for Structural Change

One simple statistic, F, which enables testing for whether two sub-samples are drawn from the same or different populations can be written[10] as:

$$F = \frac{[RSS - (RSS1 + RSS2)]/K}{(RSS1 + RSS2)/(N-2K)} \sim (K, N-2K) \qquad (5)$$

where RSS, RSS1, and RSS2 are the residual sum of squares for the population and two subsamples respectively, N is the total number of observations in the population, and K is the number of regressors in the relevant equation.

This test was conducted on each of the individual fuel share equations belonging to the least restricted model NHUT, the empirical evidence in sections 1 and 3 having suggested structural breaks could lie between 1973 and 1974, and between 1978 and 1979. We are therefore testing first whether equations for the sub-periods 1960-73 and 1974-82 are consistent with those for 1960-82, and if not, then whether those for 1974-78 and 1979-82 are consistent with those for 1974-82. Should the null hypothesis of no structural change be rejected in all cases, then it would be the case that equations using data subsequent to the first major oil shock in 1973-74 would be significantly different from those incorporating earlier observations. Similarly, equations using data following the second major oil shock of 1978-79 could be significantly different from those for the five years immediately prior to it.

The empirical results presented in Table 3 show that in both cases, the hypothesis of no structural change must be rejected at the 5% level of significance, not only for petroleum products but also for the gas, coal, and electricity share equations as well.

Whether this in turn means that own-price and cross-price elasticities derived from NHUT equations will be substantially different for each of the periods 1974-78, 1979-82, and 1960-82, we shall see in the next two sections.

5. International Own-price and Cross-price Elasticities of Demand for Individual Fuels

International (i.e. sample mean) own-price and cross-price elasticities of demand and their t-ratios, derived from equations for the model NHUT[11], for the sample periods 1960-82, 1974-82, 1974-78 and 1979-82, are presented in Table 4.

Interpretation is focussed on the sample periods 1974-78, 1979-82, 1960-82, on the own-price elasticities for all four fuels, and on those cross-price elasticities involving petroleum products.

It is first useful to compare certain own-price elasticity results for 1960-82 with those derived in Hall (1983a) for 1960-79. An examination of the magnitudes presented immediately below can demonstrate two things.

Time Period	1960-79	1960-82	1960-82
Model	NHU	NHU	NHUT
ε_{pp}	-.26[4.20]	-.25[4.97]	-.25[4.97]
ε_{gg}	-.81[9.85]	-.74[7.59]	-.57[7.09]
ε_{cc}	-.97[5.01]	-1.05[6.50]	-.34[3.54]
ε_{ee}	-.02[.62]	-.04[1.01]	-.06[1.69]

The first is that conclusions derived from the model NHU do not differ a great deal when three extra years of data are added. Secondly, and much more importantly, results for 1960-82 for NHU and NHUT show that the allowance for a non-neutral fuel efficiency bias term has been crucial in reducing the coal elasticity from -1.05 to -.34, and not inconsequential for gas where the elasticity has fallen from -.74 to -.57. In contrast, it has had no influence on the petroleum products own-price elasticity of -.25,[12] and has affected little the insignificant electricity elasticity. Thus, the very substantial change in magnitude for the own-price elasticity of coal, from around unity to -.34 is an important new result.

The simple tests for structural change conducted in the previous section showed that results for 1960-82 need not necessarily be representative of those for its sub-periods. We therefore now turn to the elasticities for 1974-82, 1974-78 and 1979-82. Given the relatively small number of observations, these results are remarkably straightforward, especially for petroleum products. The own-price elasticity of demand for petroleum products in the period between the first and second oil shocks averaged -.6, approximately double that of -.3 for the period subsequent to the second oil shock. The latter, in turn, is not greatly different from -.25 for the full sample period. The electricity elasticity seems little changed (i.e. statistically insignificant at the 5% level and around -.1 to -.2), but those for gas and coal have changed markedly. The gas elasticity, around -.6 for the full period, was neither significant nor of correct sign during 1974-78, and had a value of around -.5 significant only at the 5% level over 1979-82. Coal elasticities in both oil shock sub-periods were no longer significant.

Turning to those cross-price elasticities involving petroleum products, the picture is less clear. We have just seen that a petroleum product price change has in each case had a statistically significant effect on the demand for petroleum. It has also significantly affected the demand for coal overall (ε_{cp} = .62) and in 1974-78 (ε_{cp} = .84), and the demand for electricity in 1974-78 (ε_{ep} = .19) and 1979-82 (ε_{ep} = .33). The positive signs indicate coal and electricity have, on average, been substitutes for oil. A statistically significant effect on gas demand has not been identified.

Summarising the effects of changes in the prices of the other three fuels on the demand for petroleum products is not as straightforward, except in the case of coal where price changes have not been statistically significant. Gas price changes indicate oil and gas to have been weak complements (-.15) overall and in 1974-78, but slightly stronger substitutes (.36) over 1979-82. Electricity price changes show oil and electricity to have been substitutes (.29) overall, more especially through 1974-78 (.52), but no longer of significance during 1979-82.

6. Individual Country Own-price Elasticities of Demand

Table 5 shows mean-over-time own-price elasticities[13] derived for each of the seven major OECD countries for 1960-82, and for the two major oil shock sub-periods 1974-78 and 1979-82.

For six of these countries, the petroleum price elasticity remains between -.2 and -.3 for 1960-82 and 1979-82, around half the value obtained for 1974-78. But for the United States, the contrast between 1974-78 and the other two periods, and hence with the other six countries, is even greater. The United States elasticity is not statistically significant for either 1960-82 or 1979-82, but its value of -.68 following the first major oil shock is the highest for all of the seven countries.

Gas results show that it is not possible to get a sensible own-price elasticity for any period for Japan, probably due to its very low and unchanging expenditure share. It is also confirmed that there are no sufficiently satisfactory values for 1974-78. However, for 1979-82, for the United States, the United Kingdom, and Italy, all of which recorded substantial rises in expenditure share over that period, the elasticity was in each case almost -.5.

No statistically significant correctly signed coal elasticities could be obtained for any period for the United States, Italy, and Canada, perhaps not surprisingly so, given that each recorded no major changes in expenditure share. Only West Germany could provide an elasticity which was significant for 1960-82 and for both sub-periods. This was remarkably stable in the interval -.48 to -.50. Data for Japan, France, and the United Kingdom provided elasticities in the range -.3 to -.5 for 1960-82, but were unable to produce statistically significant magnitudes for either oil shock sub-period.

Thus, for both gas and coal, it has been very difficult to get reliable individual country elasticities for sub-periods subsequent to the first major oil shock.

No country registered an electricity own-price elasticity which was statistically significant for any of the three sample periods.

7. Concluding Remarks

It has been shown that, for each of the sample periods 1960-82, 1960-73, 1974-82, 1974-78 and 1979-82, strict conditions for a two-stage translog expenditure shares model allowing for non-neutral fuel efficiency bias, are violated. This result is consistent with that obtained in Hall (1983a) for 1960-79 for a model imposing neutral fuel efficiency bias, and for which all restrictions had to be rejected. New findings, however, are that non-neutral fuel efficiency bias cannot be rejected for any sample period and that homogeneity and symmetry restrictions cannot be rejected for the periods 1974-82 (at the 5% level) and 1974-78 (at the 1% level).

It has also been established, through simple F tests for structural change on all four individual fuel equations, that equations for the sub-periods 1960-73 and 1974-82 are not consistent with those for the full period 1960-82. Nor is any equation for 1974-78 and 1979-82 consistent with its corresponding one for 1974-82. This means that one cannot reject equation structural breaks immediately following each of the first and second major oil shocks. Elasticities presented for the overall period 1960-82 are therefore likely to be no more than an average of potentially different behaviour patterns within that overall period.

Nevertheless, elasticity of demand results for the period 1960-82 have provided some interesting new evidence. The preferred international own-price elasticities presented in Hall (1983a) for petroleum products, gas, coal, and electricity were -.26, -.81, -.97 and -.02; while the preferred corresponding values from section 5 are -.25, -.57, -.34, and -.06. The most dramatic change has been for coal, from around unity to a relatively inelastic -.34, thereby giving an elasticity far less than gas [illegible] possible. This result is primarily due to the introduction of [illegible] allowing fuel efficiency bias to be non-neutral. An equally important result, though, is that the petroleum products elasticity has remained remarkably stable in light of both the specification change and additional observations.

As might have been expected from our having to reject the hypothesis of no structural change following both the first and second oil shocks, [illegible] of our preferred sub-period elasticities provide further evidence that such elasticities do not necessarily remain constant[25] nor statistically [illegible] over time. In particular, the first oil shock seems to have led to [illegible] in the petroleum elasticity to around -.6 over 1974-78, very clearly [illegible] -.3 for 1979-82 following the second shock, and the -.25 for the 1960-82 [illegible] as a whole.

If this evidence from the estimation of various price elasticities is any guide, then reactions following the second major oil shock have been significantly different from those to its predecessor. In turn, behaviour during both sub-periods is insufficiently represented by that for 1960-82 as a whole.

FOOTNOTES

* Nguyen Van Anh and Maurice Peat have provided excellent research and computing assistance. I am also grateful to Tony Phipps for his comments on an earlier draft, and to Aristea Doumbos for first-class typing.

1. Derivations of such energy models are available in Fuss (1977), Griffen (1977), Hall (1983b), Magnus and Woodland (1980), Pindyck (1979), and Turnovsky, Folie and Ulph (1982).

2. Terminology is as in Griffen (1977, pp. 763-764).

3. As shown in equation (4) below, imposing neutral fuel efficiency bias, would involve imposing $\gamma_i = 0$ for all i, were the term $\gamma_i t$ to have been added to equation (1). The only restrictions then remaining are the adding-up restrictions $\sum_{k=1}^{7} \beta_{ik} = 1$, $\sum_i \beta_{ik} = 0$, and $\sum_i \beta_{iE} = 0$. A restriction that the individual country intercept dummy terms be replaced by a term common to all countries (i.e. $\beta_{ik} = \beta_i$ for all k) was rejected in Hall (1983a), and is not further imposed or tested for in this paper.

4. Million tons of oil equivalent.

5. Taking the breaks to be between 1973 and 1974, and between 1978 and 1979 is further confirmed by examining percentage changes in such broader series as the IEA's (1982, p. 63) real price of landed crude oil and real price of energy to final users, e.g.

	Landed Crude Oil	Energy to Final Users
1960-73	1.0	0.6
1973	3.2	-0.6
1974	166.1	25.9
1975	-4.2	6.9
1978	-6.3	-2.0
1979	27.6	11.3
1980	55.3	15.9

6. The exception is Italy.

7. Prices shown in these particular graphs are all in domestic currency.

8. Further details on the derivation and interpretation of these elasticities are available in Hall (1983b, p. 7 and Annex I).

9. See, for example, the equivalent equations and accompanying restrictions for a homothetic factor shares model allowing for linear technical progress, presented in Turnovsky, Folie and Ulph (1982, pp. 63-64).

10. See, for example, Intriligator (1978, p. 194, fn. 57).

11. Despite non-rejection of the models NHSUT and NHST for some sub-periods, all results presented in this and the following section are for NHUT, so as to assist comparing elasticities across different sample periods.

12. This stability is confirmed for the sub-periods 1974-82, 1974-78, and 1979-82, with values of -.29 and -.23, -.58 and -.57, and -.33 and -.28 respectively.

13. Note that these own-price elasticities of demand reflect only those explanatory influences directly and indirectly incorporated within equations (4). In particular, they may not sufficiently fully reflect factors like government regulations, price controls, non-price policy

initiatives to reduce energy consumption, other political and institutional constraints, and explicit behavioural characteristics within individual country industrial sectors.

14. See, for example, the evidence presented in Mittelstädt and Hall (1981).

REFERENCES

Fuss, Melvyn A., (1977), "The Demand for Energy in Canadian Manufacturing", Journal of Econometrics, 5, pp. 89-116.

Griffen, J.M., (1977), "Inter-fuel Substitution Possibilities: A Translog Application to Intercountry Data", International Economic Review, 18, pp. 755-770.

Hall, V.B., (1983a), "Industrial Sector Interfuel Substitution following the First Major Oil Shock", Working Paper No.67, Department of Economics, University of Sydney, January; and published in reduced form as pp. 377-82 in Economics Letters, 12.

Hall, V.B., (1983b), "Major OECD Country Industrial Sector Interfuel Substitution Estimates: 1960-79", Working Paper No.69, Department of Economics, University of Sydney, August.

International Energy Agency, (1982), World Energy Outlook (OECD, Paris).

Intriligator, Michael D., (1978), Econometric Models, Techniques, and Applications (Prentice-Hall).

Magnus, Jan R. and Alan D. Woodland, (1980), "Interfuel Substitution Possibilities in Dutch Manufacturing: A Multivariate Error Components Approach", Discussion Paper No.80-39, Department of Economics, University of British Columbia, November.

Pindyck, Robert S., (1979), "Interfuel Substitution and the Industrial Demand for Energy: An International Comparison", Review of Economics and Statistics, 61, pp. 169-179.

TSP, (1980), "Time Series Processor", Version 3.5 User's Manual, CDC CYBER 73, by Bronwyn H. Hall and Robert E. Hall, Fourth Edition, December.

Turnovsky, M., M. Folie and A. Ulph, (1982), "Factor Substitutability in Australian Manufacturing with emphasis on Energy Inputs", Economic Record, 58, pp. 61-72.

Mittelstädt, Axel, and Viv Hall, (1981), "Price and Income Elasticities of Final Energy Demand in OECD Countries", presented at the Third Annual International Association of Energy Economists' Conference, University of Toronto, June.

TABLE 1

INDIVIDUAL FUEL EXPENDITURE SHARES

	1960	1973	1974	1978	1979	1982
Petroleum Products						
US	.08	.13	.22	.17	.21	.16
Japan	.22	.42	.48	.46	.47	.43
W. Germany	.14	.30	.37	.29	.36	.33
France	.25	.35	.48	.43	.49	.46
UK	.14	.31	.42	.25	.27	.25
Italy	.32	.45	.45	.33	.38	.31
Canada	.17	.26	.37	.33	.33	.35
Gas						
US	.27	.25	.21	.26	.28	.38
Japan	.02	.01	.01	.01	.01	.01
W. Germany	.01	.08	.08	.10	.09	.14
France	.05	.09	.09	.13	.12	.13
UK	.14	.16	.15	.33	.33	.40
Italy	.08	.09	.10	.18	.19	.23
Canada	.03	.08	.08	.12	.13	.14
Coal						
US	.05	.05	.05	.05	.04	.04
Japan	.24	.09	.09	.07	.07	.09
W. Germany	.39	.15	.16	.13	.12	.14
France	.27	.11	.11	.08	.06	.05
UK	.46	.17	.11	.09	.10	.08
Italy	.06	.04	.06	.04	.04	.05
Canada	.13	.05	.04	.08	.08	.07
Electricity						
US	.61	.57	.52	.53	.47	.42
Japan	.51	.47	.43	.47	.45	.46
W. Germany	.45	.47	.40	.48	.43	.40
France	.43	.45	.35	.36	.33	.36
UK	.26	.37	.32	.33	.31	.27
Italy	.55	.42	.38	.45	.40	.41
Canada	.66	.62	.50	.46	.45	.44

Source: Compiled from published and unpublished OECD data.

TABLE 2

TESTING OF MODEL RESTRICTIONS

Sample Period	1960-82	1960-73	1974-82	1974-78	1979-82
Values for Log of Likelihood Function					
Model: HS	907.1	705.3	496.3	316.9	256.0
HST	976.1	758.0	510.9	323.1	263.9
NHST	1079.5	798.7	538.1	341.6	278.6
NHSUT	1148.1	827.3	539.0	345.6	289.5
NHU	1060.8	800.3	531.9	338.3	285.1
HUT	1053.4	797.1	512.9	328.3	270.6
NHUT	1154.9	835.9	539.2	348.0	291.9
Testing of Restrictions					
Homotheticity, homogeneity, symmetry, and neutral fuel efficiency bias					
$-2\log\lambda$ for HS-NHUT	495.6	261.2	85.8	62.2	71.8
Accept/Reject[1]	Reject	Reject	Reject	Reject	Reject
Neutral fuel efficiency bias only					
$-2\log\lambda$ for NHU-NHUT	188.2	71.2	14.6	19.4	13.6
Accept/Reject[4]	Reject	Reject	Reject	Reject	Reject
Homotheticity only					
$-2\log\lambda$ for HUT-NHUT	203.0	77.6	52.6	39.4	42.6
Accept/Reject[4]	Reject	Reject	Reject	Reject	Reject
Homogeneity only					
$-2\log\lambda$ for NHSUT-NHUT	13.6	17.2	0.4	4.8	4.8
Accept/Reject[4]	Reject	Reject	ACCEPT	ACCEPT	ACCEPT
Homogeneity and symmetry					
$-2\log\lambda$ for NHST-NHUT	150.8	74.4	2.2	12.8	26.6
Accept/Reject[3]	Reject	Reject	ACCEPT	Reject[5]	Reject
Homotheticity, homogeneity and symmetry					
$-2\log\lambda$ for HST-NHUT	357.6	155.8	56.6	49.8	56.0
Accept/Reject[2]	Reject	Reject	Reject	Reject	Reject

1 Based on a critical $\chi^2_{0.05}$ of 21.0 from 12 restrictions
2 " " " " " " 16.9 " 9 "
3 " " " " " " 12.6 " 6 "
4 " " " " " " 7.8 " 3 "
5 Can be ACCEPTED for a critical $\chi^2_{0.01}$ of 16.8

TABLE 3

TESTS WITH THE MODEL NHUT FOR STRUCTURAL CHANGE

Testing for a structural break between 1973 and 1974, within the period 1960-82

Equation	Petroleum Products	Gas	Coal	Electricity
RSS[1]				
1960-82	.136826	.126614	.086425	.062078
1960-73	.050735	.014988	.040837	.013719
1974-82	.023105	.023553	.007411	.017270
Value of test statistic, F[2]	2.43	6.50	2.25	2.86
Accept/Reject[3] for $F_{0.95}$ (13,135) = 1.80	Reject	Reject	Reject[4]	Reject

Testing for a structural break between 1978 and 1979, within the period 1974-82

Equation	Petroleum Products	Gas	Coal	Electricity
RSS				
1974-82	.023105	.023553	.007411	.017270
1974-78	.007799	.006726	.001715	.002243
1979-82	.003823	.003500	.001170	.003679
Value of test statistic, F	2.81	3.71	4.47	5.45
Accept/Reject[3] for $F_{0.95}$ (13,37) = 2.00	Reject	Reject	Reject	Reject

1 RSS = residual sum of squares.

2 The test statistic, F, has been calculated using equation (5) in section 4. If $F > F_{0.95}$ it is necessary to reject the hypothesis of no structural change at the 5% level of significance.

3 The critical F values have been interpolated from values published in Intriligator (1978, pp. 622-627).

4 At the 1% level of significance, i.e. for $F_{0.99}$ (13,135) = 2.26, the F value of 2.25 gives neither clear acceptance nor rejection. However, the hypothesis is clearly rejected at the 1% level for the other seven results.

TABLE 4

INTERNATIONAL (i.e. SAMPLE MEAN) OWN-PRICE AND CROSS-PRICE ELASTICITIES* OF DEMAND AND T-RATIOS FOR THE MODEL NHUT

	Petroleum Products	Gas	Coal	Electricity		Petroleum Products	Gas	Coal	Electricity
1960-82					1974-78				
Petroleum Products	-.25[4.97]	-.15[4.61]	.01[.11]	.29[3.52]		-.57[4.85]	-.14[1.83]	.15[1.58]	.52[3.30]
Gas	.02[.13]	-.57[7.09]	-.11[.83]	.54[2.68]		.42[1.41]	.22[1.16]	-.07[.29]	-.70[1.76]
Coal	.62[6.19]	1.06[16.3]	-.34[3.34]	-1.01[6.24]		.84[3.52]	.48[3.14]	-.26[1.42]	-.53[1.65]
Electricity	-.00[.11]	-.03[2.24]	.11[4.96]	-.06[1.69]		.19[3.56]	-.05[1.35]	-.05[1.22]	-.12[1.69]
1974-82					1979-82				
Petroleum Products	-.23[4.21]	.02[.25]	.07[.96]	.16[1.45]		-.28[4.09]	.36[3.50]	.12[1.15]	-.15[1.11]
Gas	.01[.09]	.16[1.09]	.14[.83]	-.24[.94]		-.16[1.31]	-.46[2.41]	-.01[.05]	.69[2.81]
Coal	.41[2.86]	.54[3.25]	-.68[3.66]	-.38[1.32]		-.01[.07]	.28[.98]	-.25[.89]	.04[.10]
Electricity	.12[2.90]	-.18[3.70]	.02[.32]	.02[.28]		.33[5.53]	-.16[1.79]	-.06[.63]	-.19[1.68]

* For each *sample* period, elasticity values presented across the first row give the degree of response of petroleum products demand to a change in the price of each of petroleum products, gas, coal, and electricity. Similar interpretations follow for the remaining three rows.

TABLE 5

INDIVIDUAL COUNTRY OWN-PRICE ELASTICITIES OF DEMAND AND T-RATIOS FOR THE MODEL NHUT

		1960-82	1974-78	1979-82
United States	Petroleum Products	-.11[1.37]	-.66[3.14]	-.13[1.07]
	Gas	-.60[16.5]	-.14[1.24]	-.47[4.33]
	Coal	.49[1.79]	.16[.52]	.27[.53]
	Electricity	-.06[1.54]	-.11[1.85]	-.19[1.85]
Japan	Petroleum Products	-.25[7.56]	-.48[5.29]	-.26[4.94]
	Gas	1.50[2.30]	14.1[5.30]	4.85[1.53]
	Coal	-.30[2.66]	-.26[1.38]	-.29[1.08]
	Electricity	-.06[1.62]	-.12[1.75]	-.19[1.88]
West Germany	Petroleum Products	-.27[6.41]	-.61[4.52]	-.28[4.22]
	Gas	-.39[2.79]	.63[2.33]	-.31[.99]
	Coal	-.48[7.71]	-.49[4.65]	-.50[3.30]
	Electricity	-.04[1.07]	-.12[1.76]	-.19[1.68]
France	Petroleum Products	-.23[7.66]	-.49[5.26]	-.24[5.00]
	Gas	-.49[4.54]	.43[1.84]	-.36[1.26]
	Coal	-.38[4.21]	-.29[1.67]	-.02[.05]
	Electricity	-.00[.04]	-.10[1.12]	-.18[1.31]
United Kingdom	Petroleum Products	-.22[3.36]	-.59[4.66]	-.24[2.63]
	Gas	-.62[12.7]	-.15[1.33]	-.45[4.80]
	Coal	-.49[8.85]	-.37[2.45]	-.31[1.21]
	Electricity	.05[.95]	-.09[.94]	-.15[.96]
Italy	Petroleum Products	-.26[5.99]	-.53[5.11]	-.28[3.96]
	Gas	-.56[6.56]	.18[.97]	-.48[2.73]
	Coal	.45[1.69]	.18[.56]	.08[.18]
	Electricity	-.05[1.27]	-.12[1.59]	-.19[1.75]
Canada	Petroleum Products	-.26[6.22]	-.59[4.75]	-.28[4.10]
	Gas	-.50[4.72]	.38[1.71]	-.38[1.41]
	Coal	-.15[1.05]	-.09[.37]	-.28[1.03]
	Electricity	-.06[1.55]	-.12[1.86]	-.19[1.85]

Figure 1 : Individual Fuel Expenditure Shares : U.S.A.

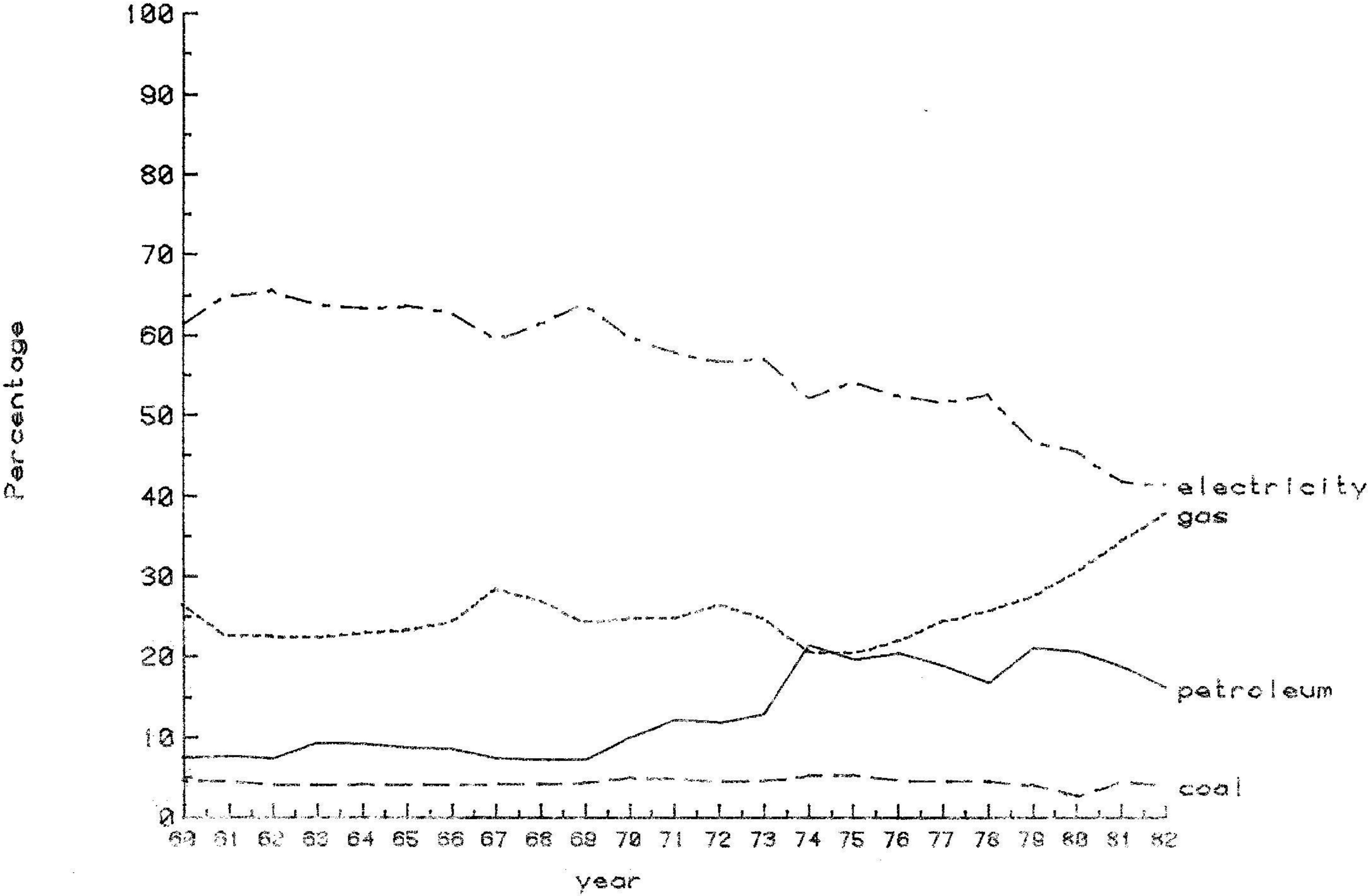


Figure 2 : Individual Fuel Expenditure Shares : JAPAN

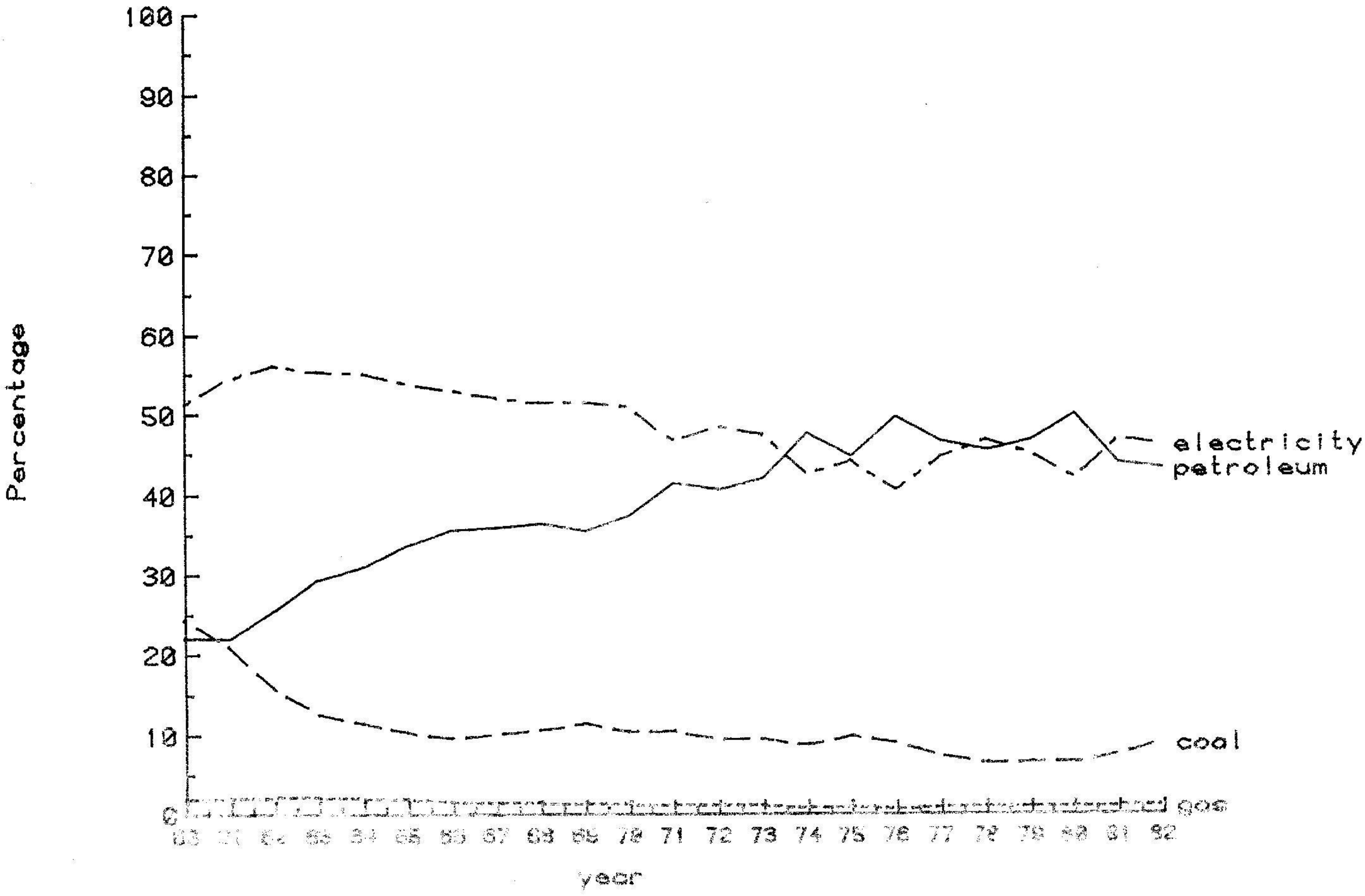


Figure 3 : Individual Fuel Expenditure Shares : GERMANY

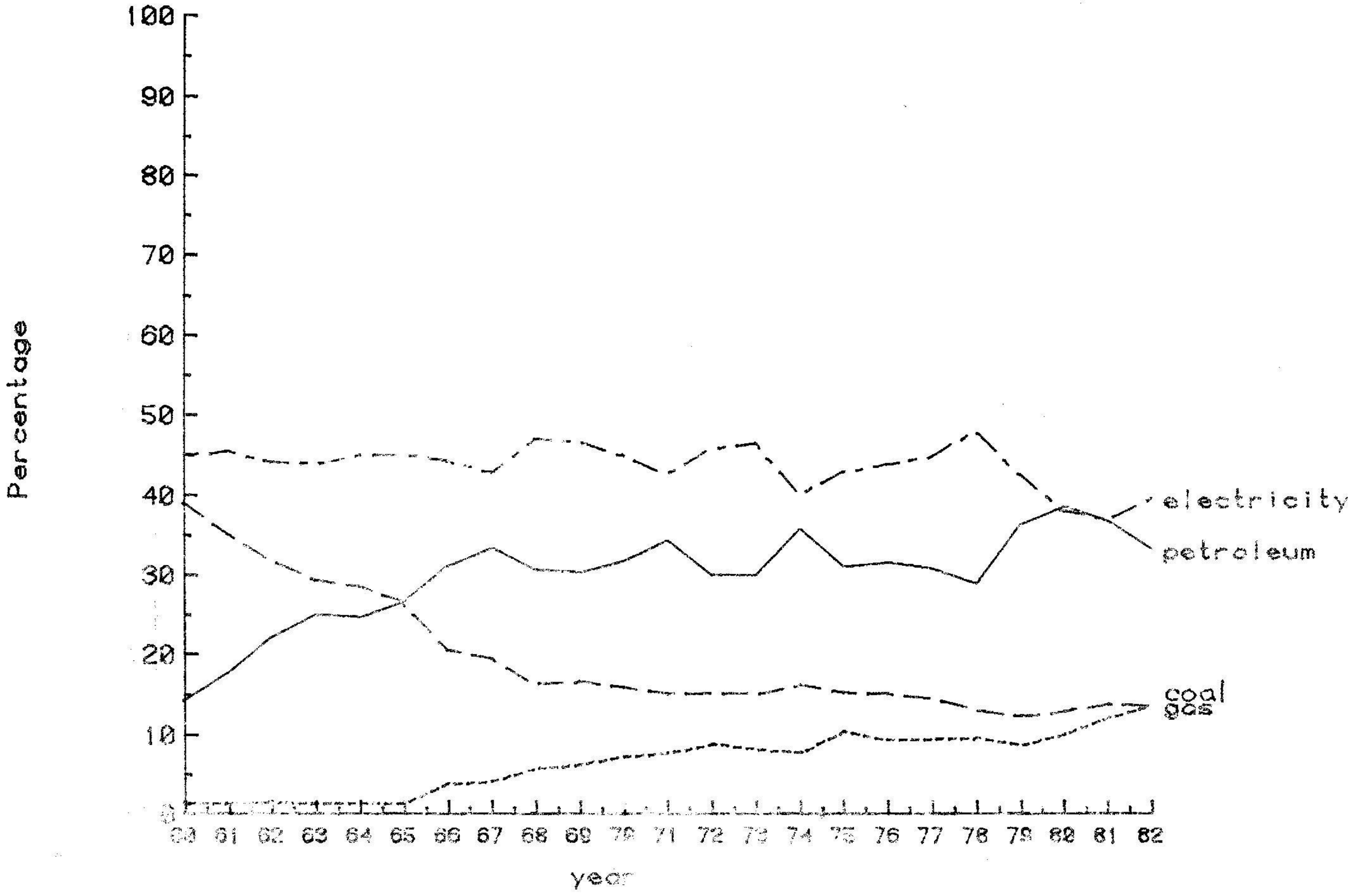


Figure 4 : Individual Fuel Expenditure Shares : FRANCE

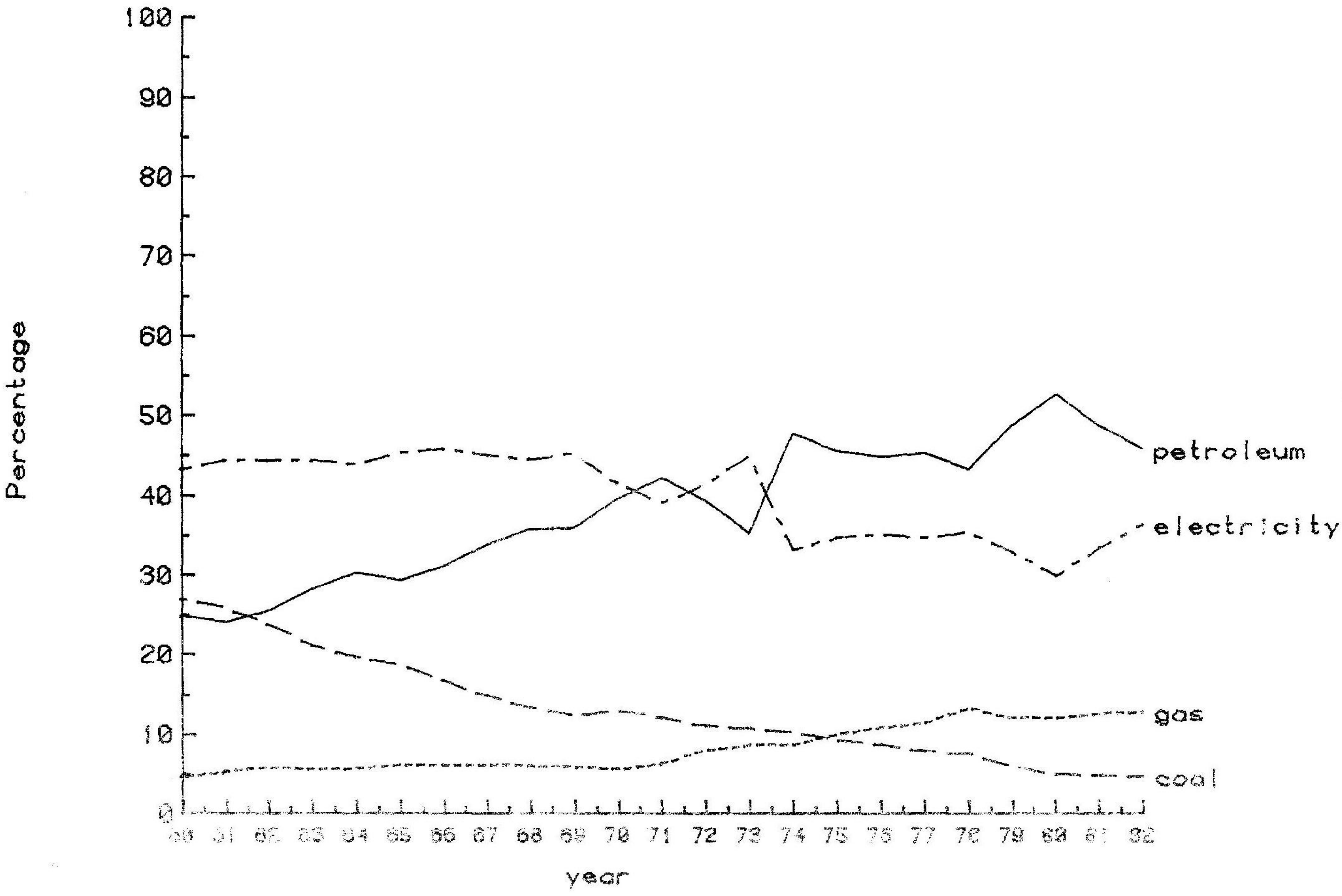


Figure 5 : Individual Fuel Expenditure Shares : UNITED KINGDOM

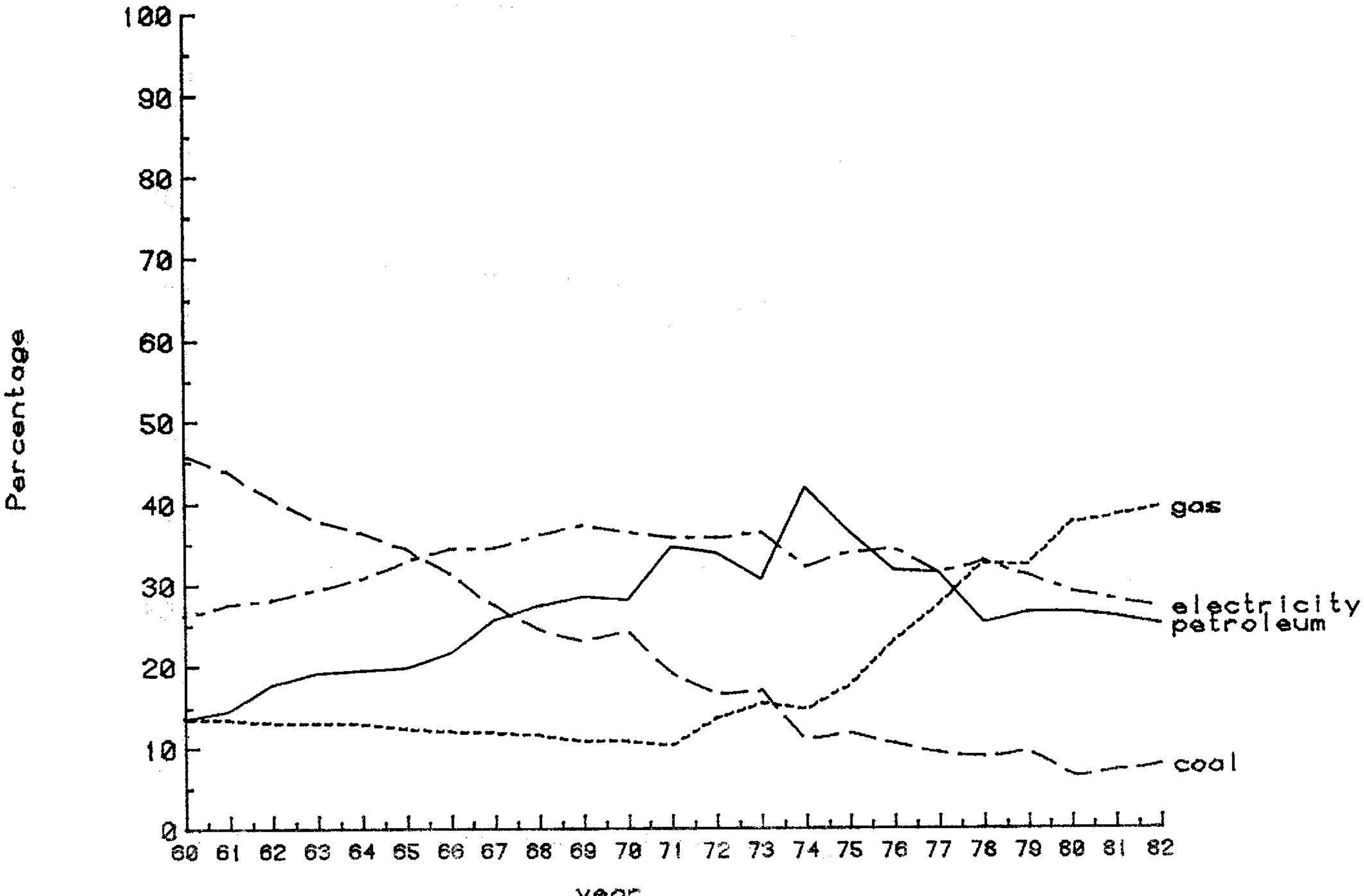


Figure 6 : Individual Fuel Expenditure Shares : ITALY

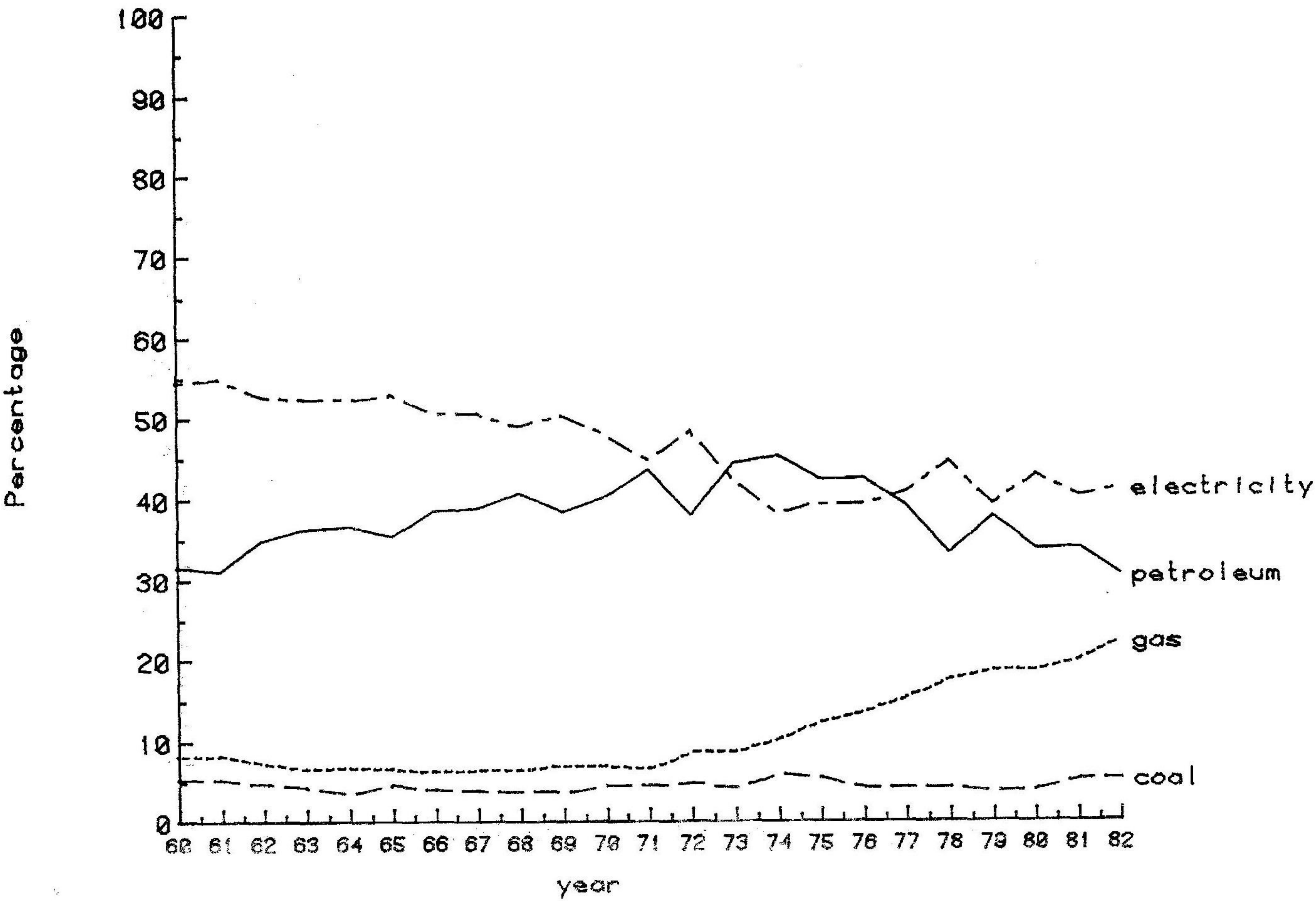


Figure 7 : Individual Fuel Expenditure Shares : CANADA

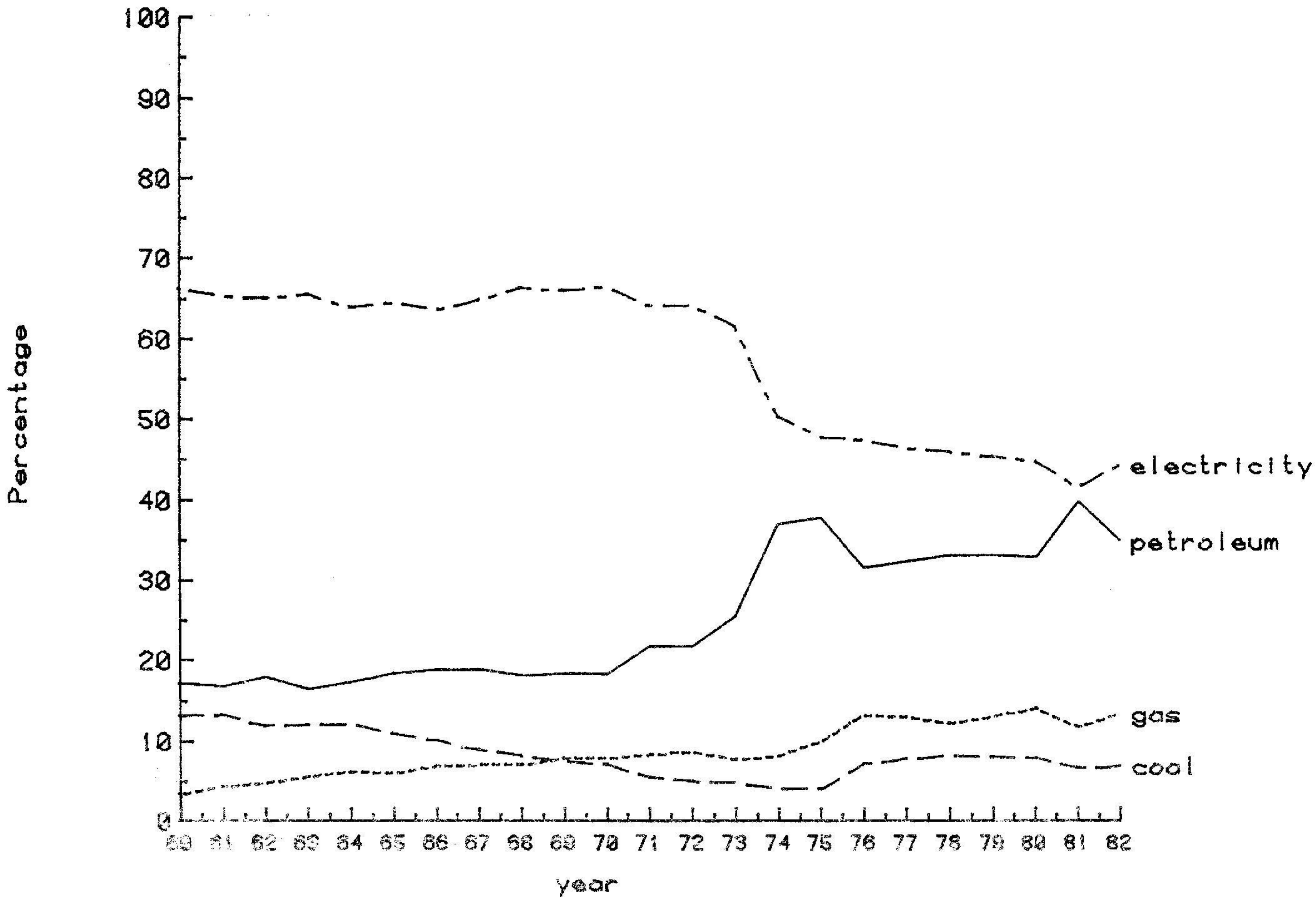


Figure 8 : Petroleum Products Price : U.S.A.
U.S.dollars per t.o.e.

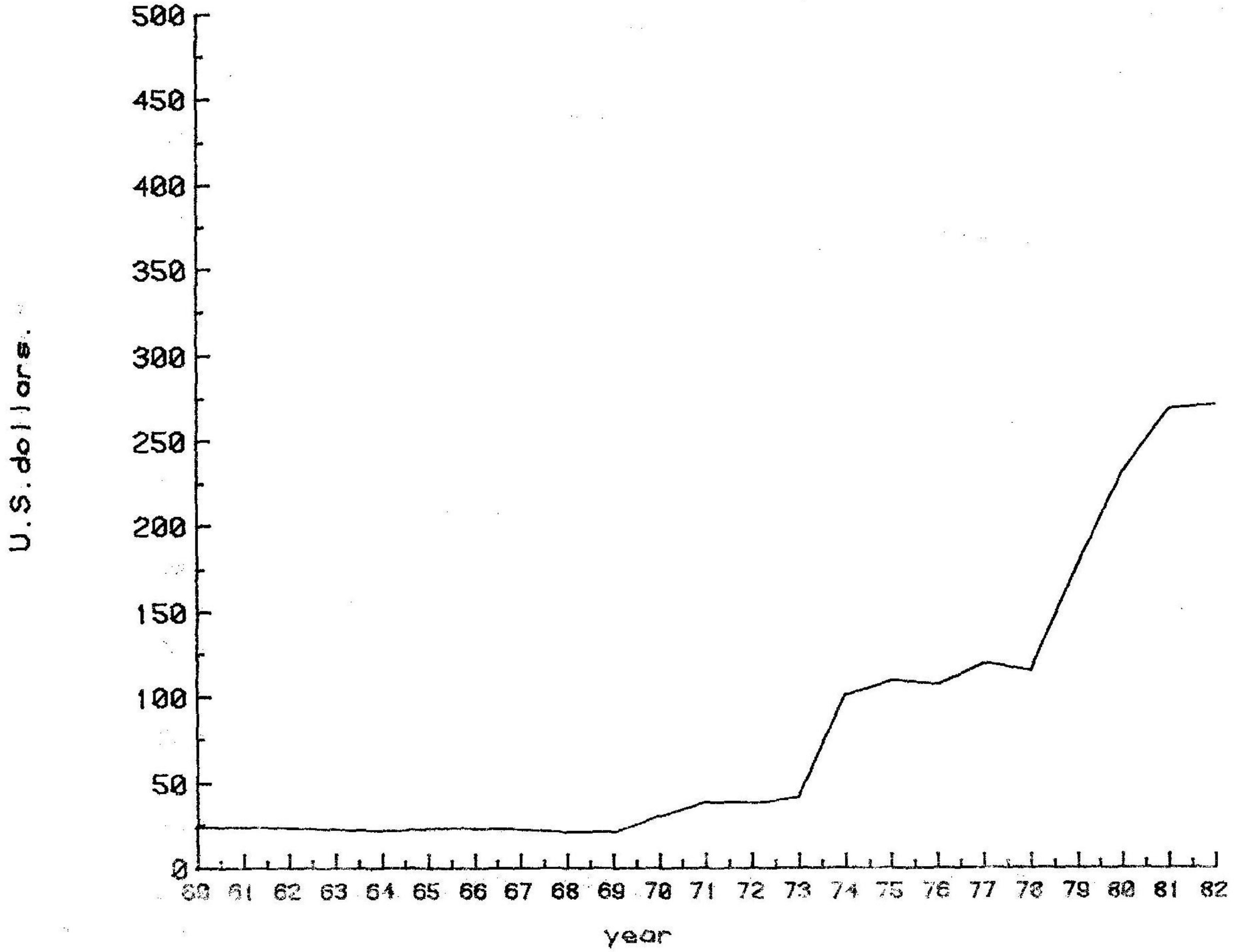


Figure 9 : Petroleum Products Price : JAPAN
yen per t.o.e.

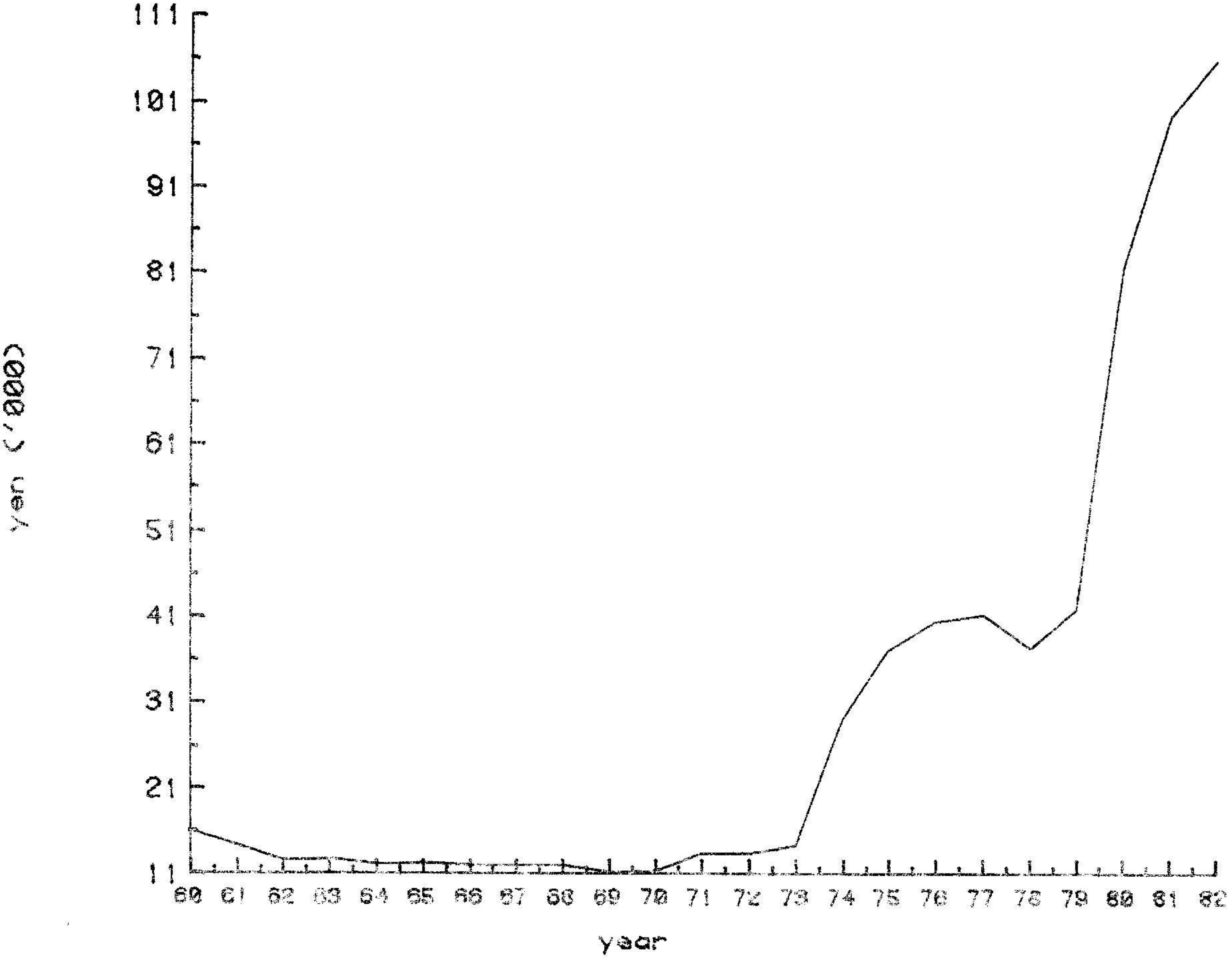


Figure 10 : Petroleum Products Price : GERMANY
marks per t.o.e.

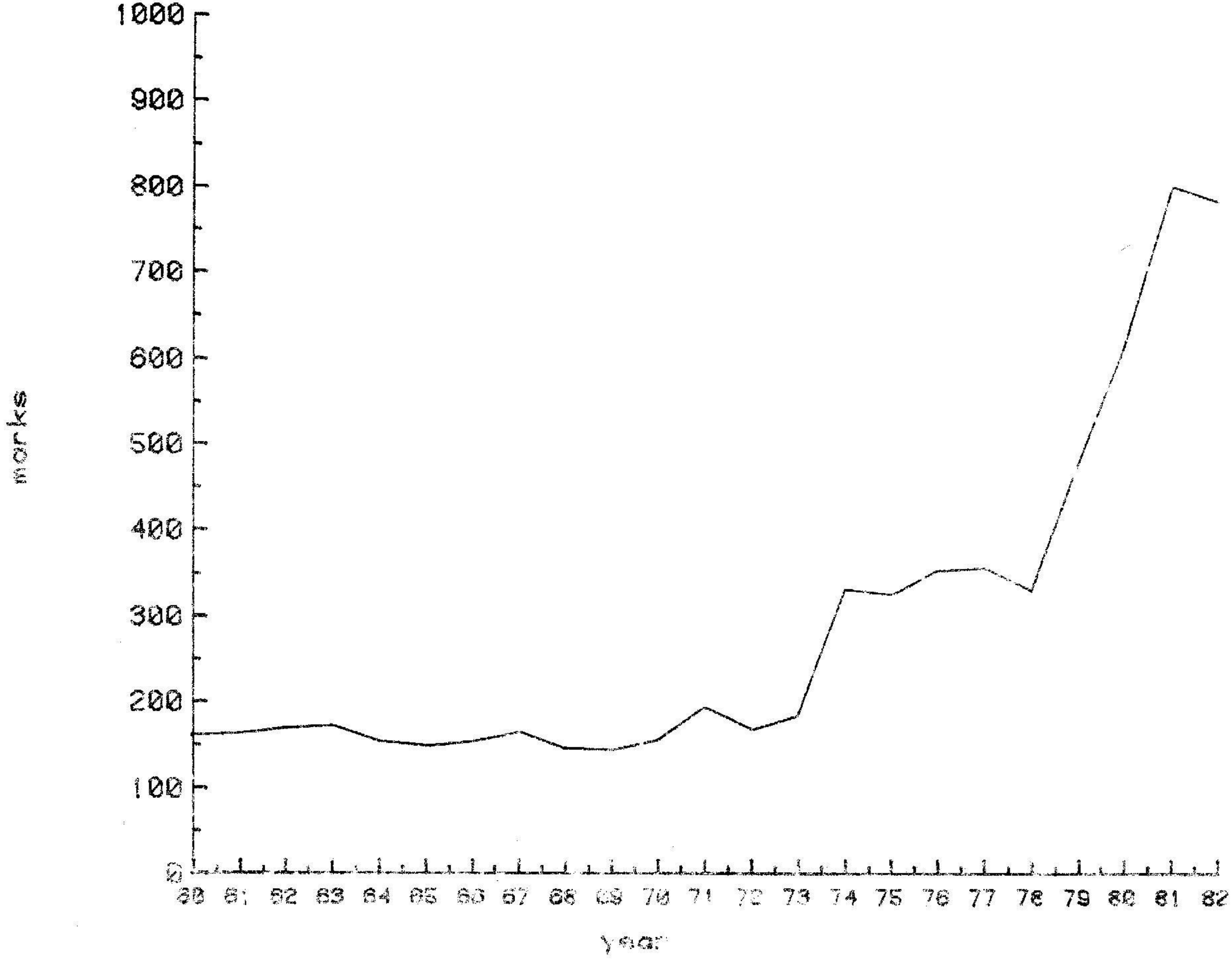


Figure 11 : Petroleum Products Price : FRANCE
francs per t.o.e.

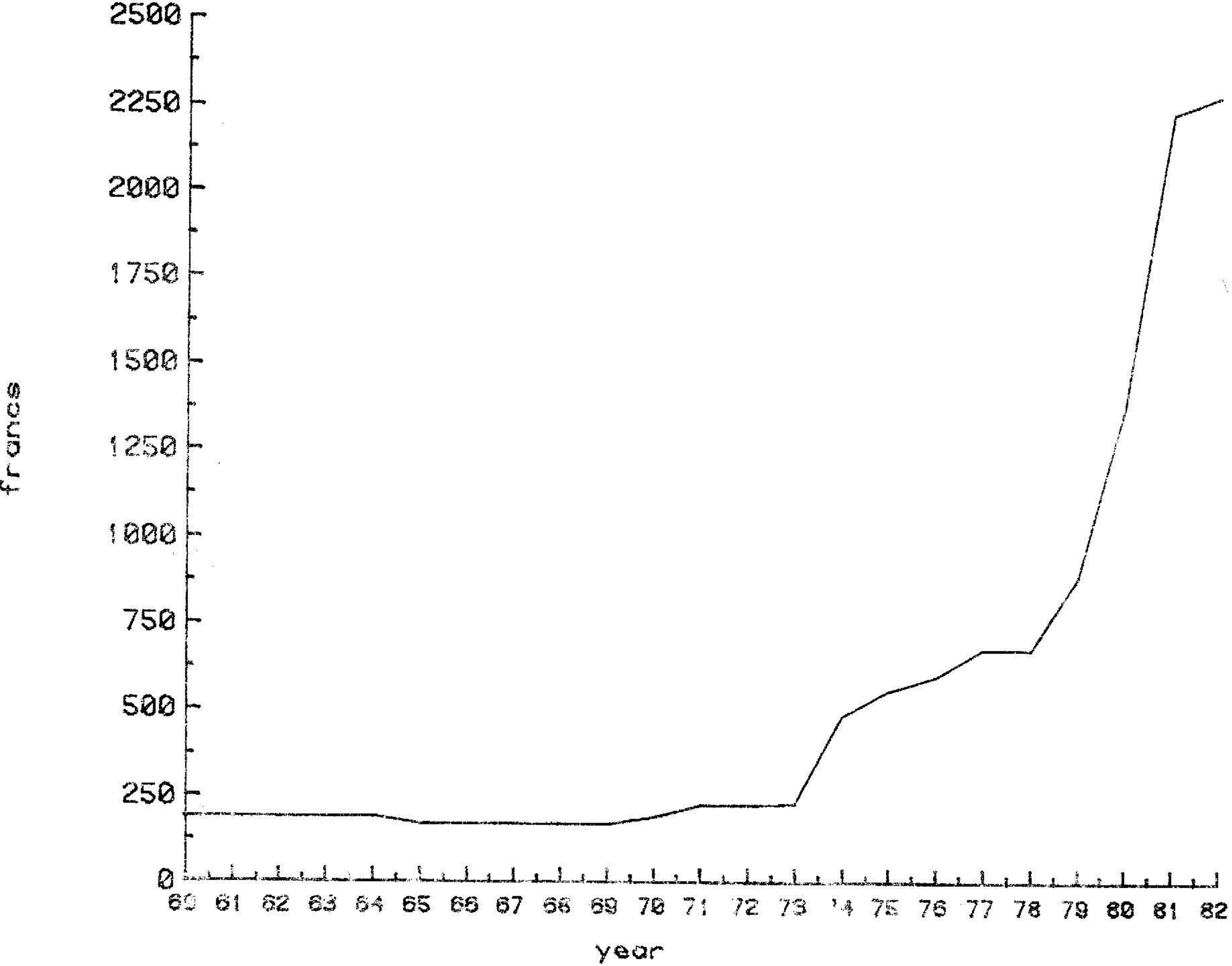


Figure 12 : Petroleum Products Price : UNITED KINGDOM
pounds per t.o.e.

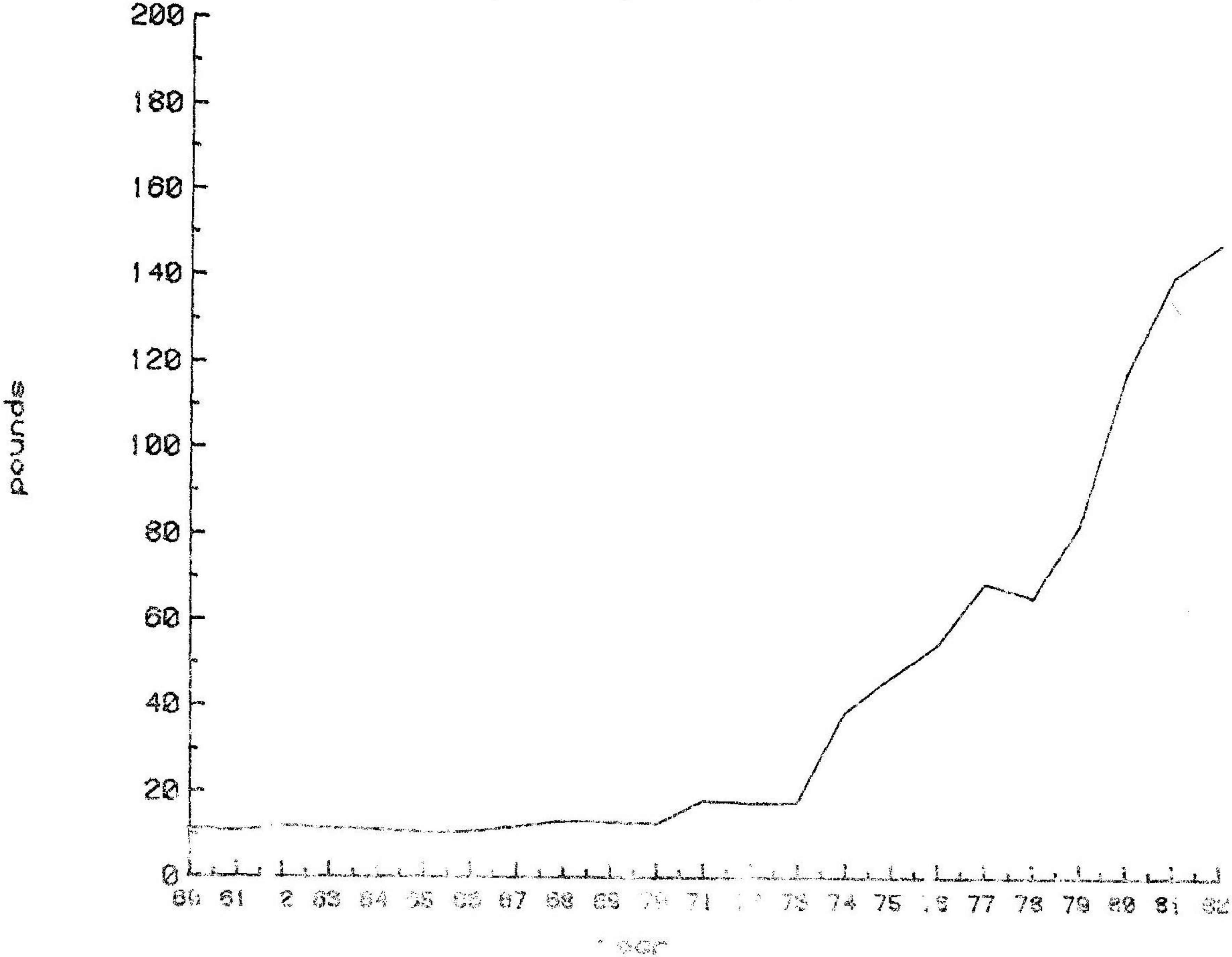
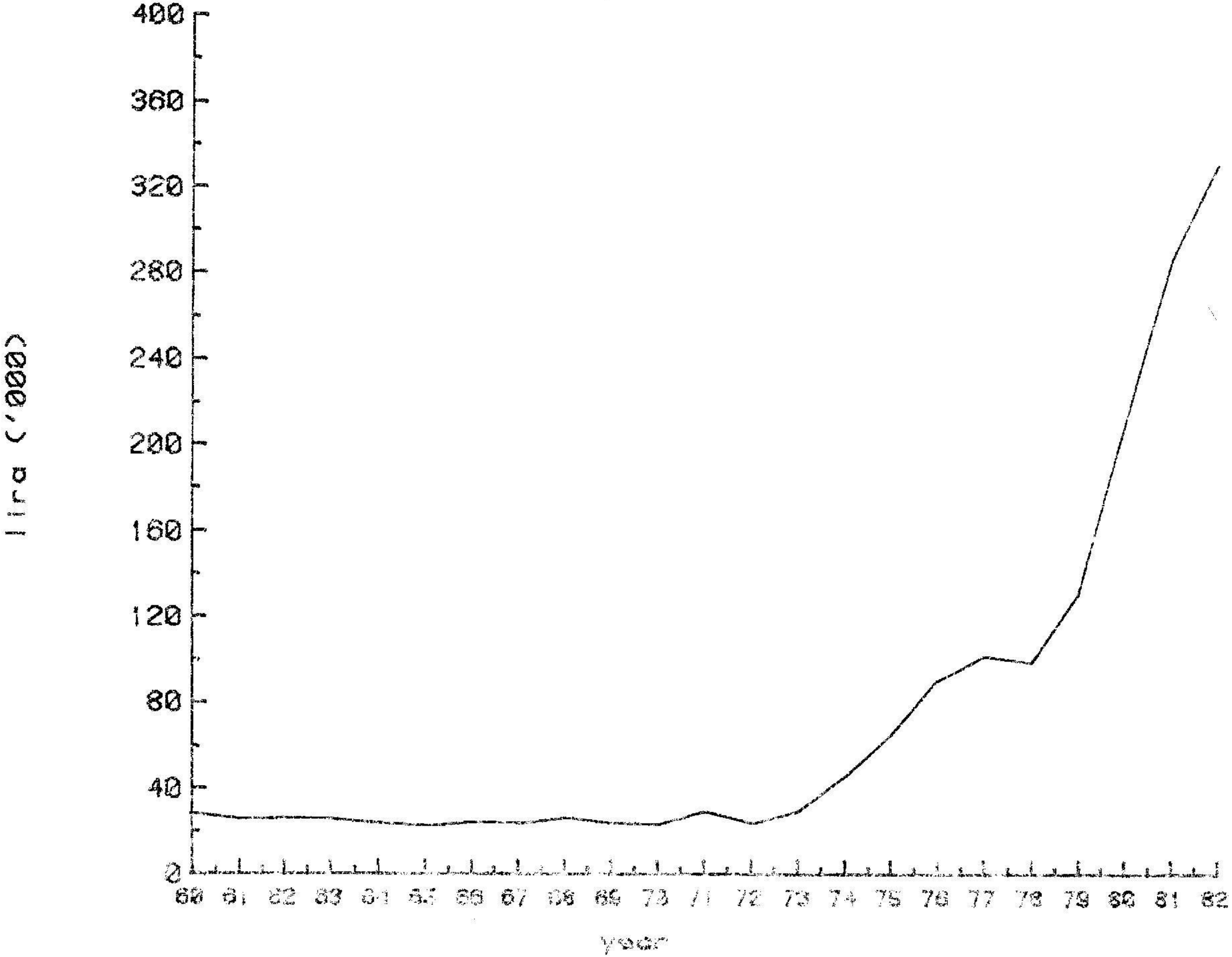


Figure 13 : Petroleum Products Price : ITALY
lira per t.o.e.



Figur : 14 : Petroleum Products Price : CANADA
Canadian dollars per t.o.e.

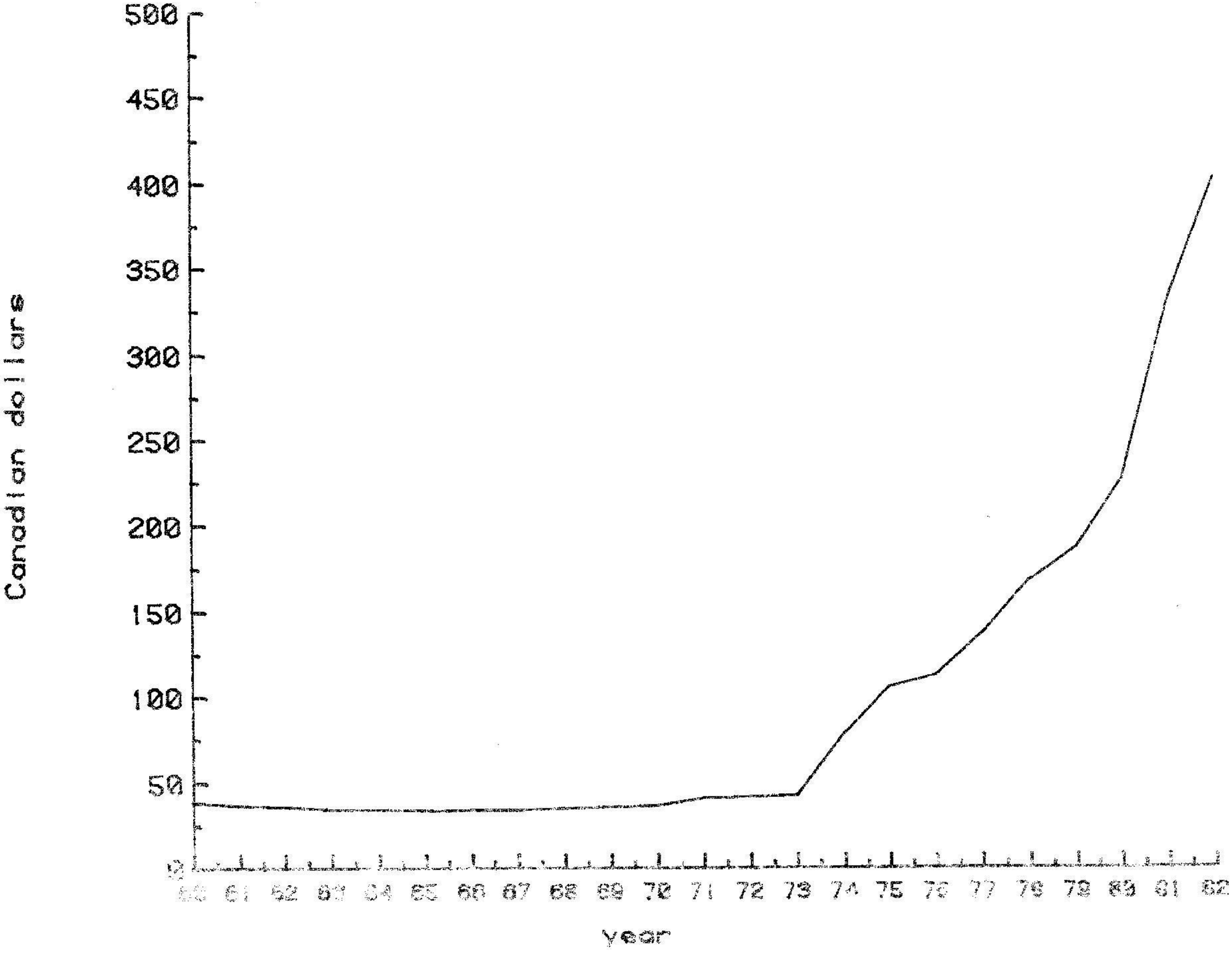


Figure 15 : Energy Consumption : U.S.A.

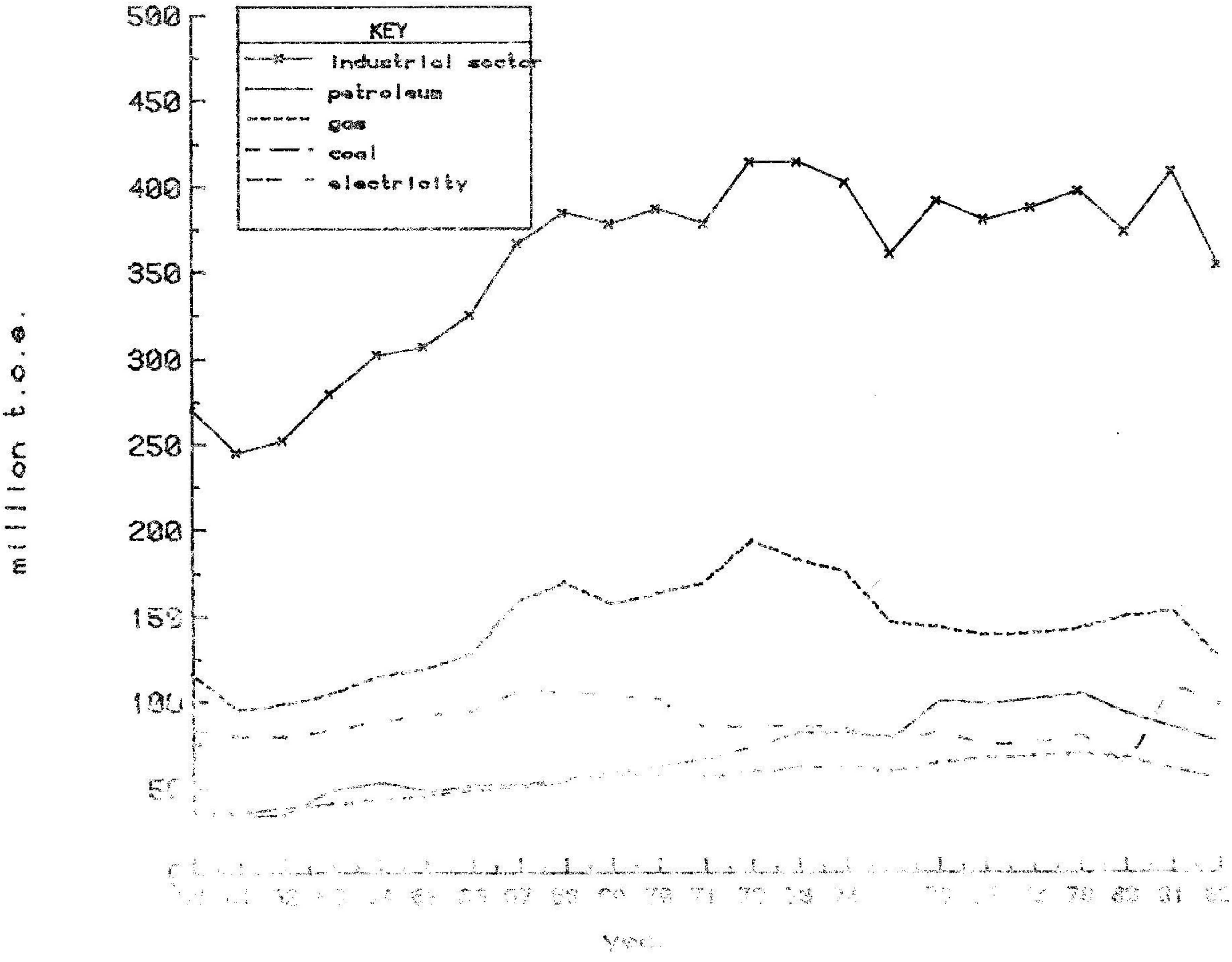


Figure 16 : Energy Consumption : JAPAN

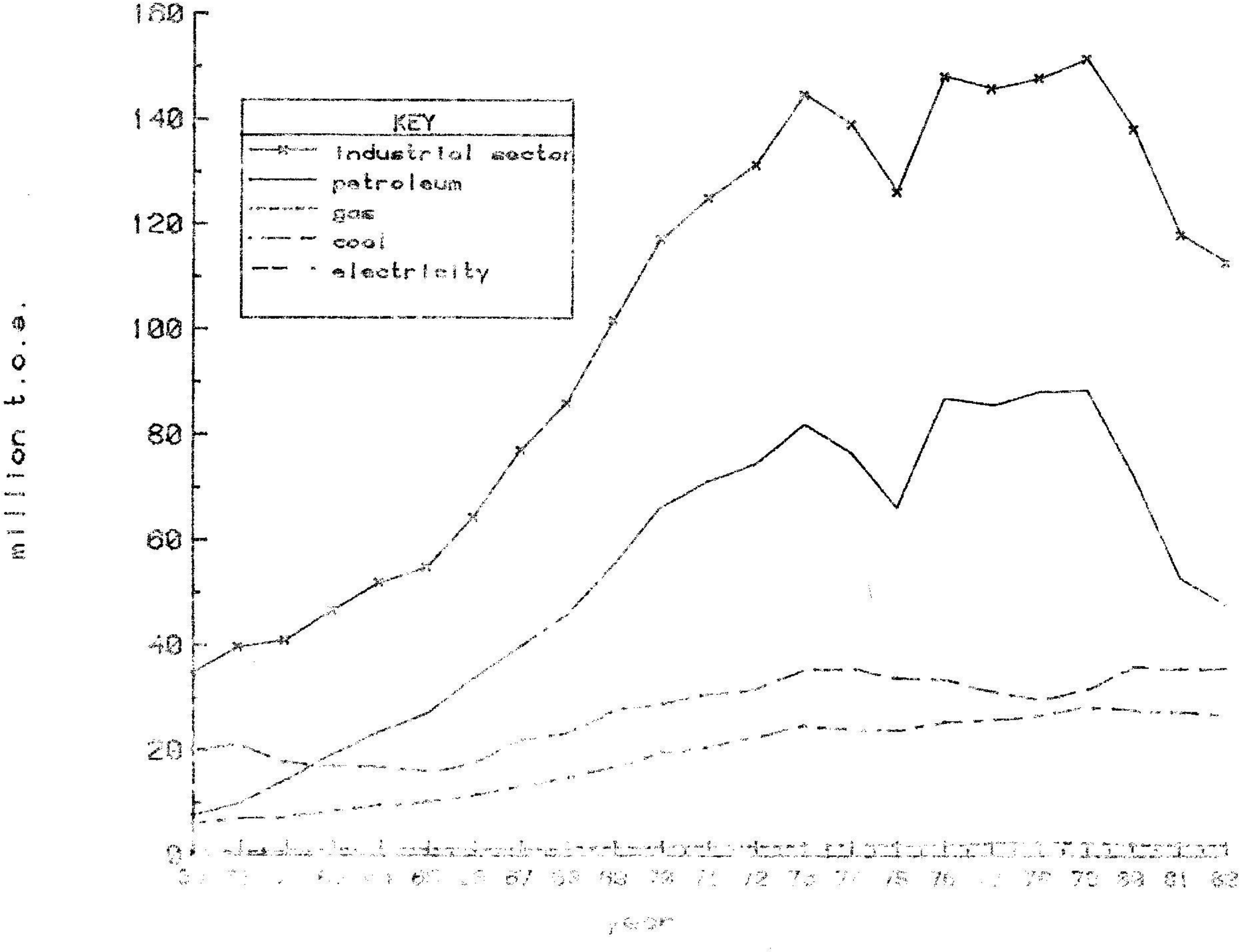


Figure 17 : Energy Consumption : GERMANY

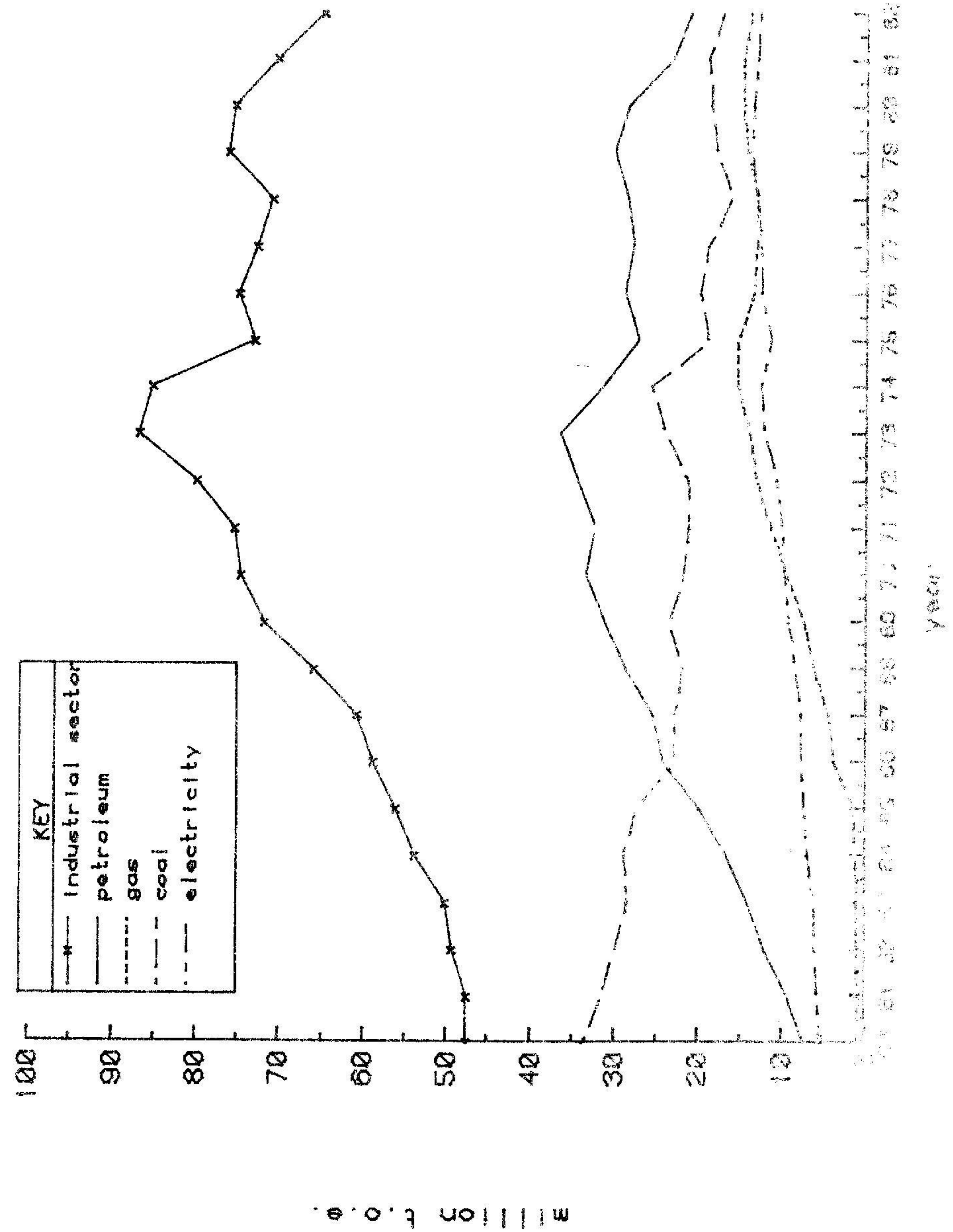


Figure 18 : Energy Consumption : FRANCE

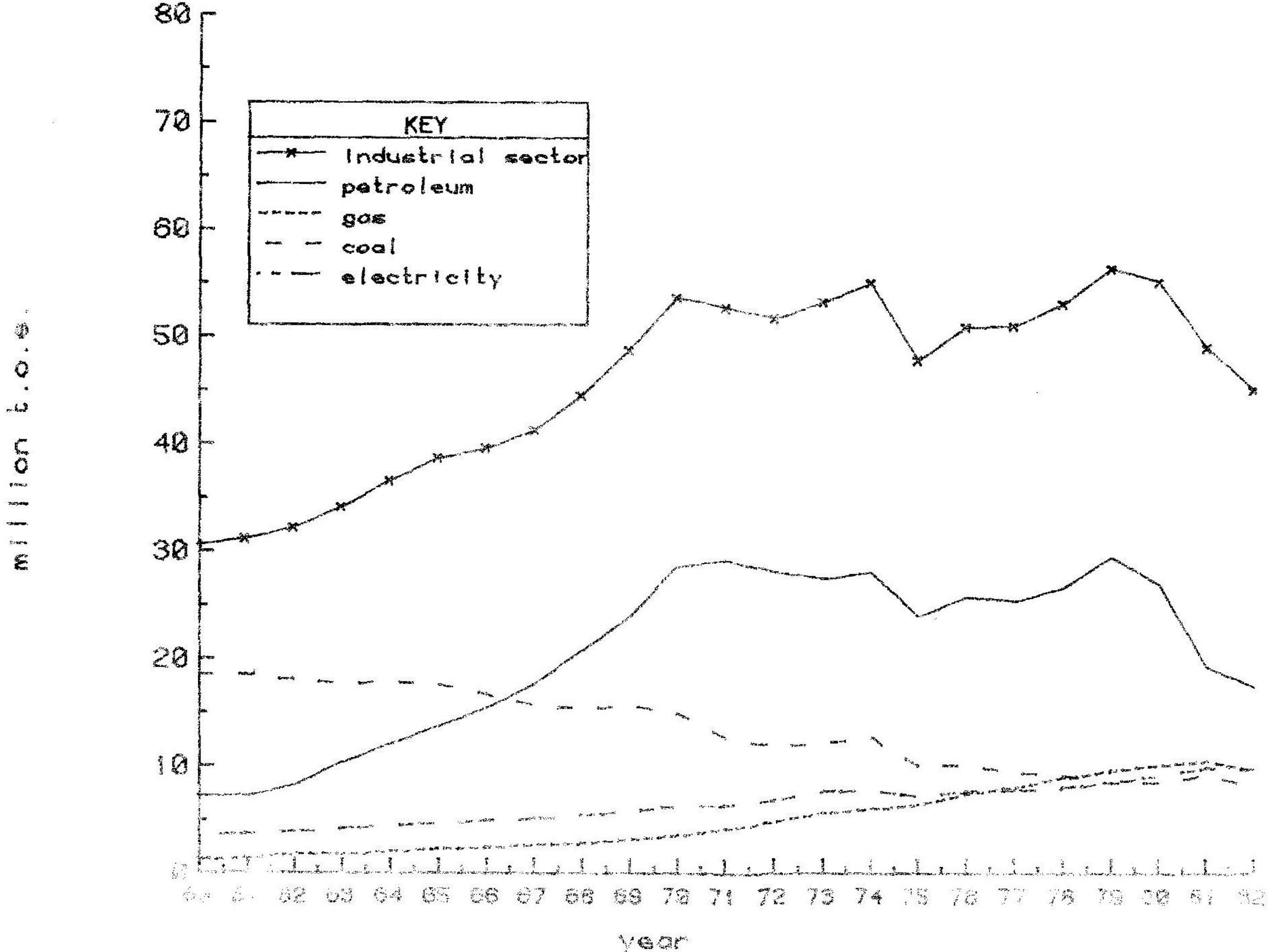


Figure 19 : Energy Consumption : UNITED KINGDOM

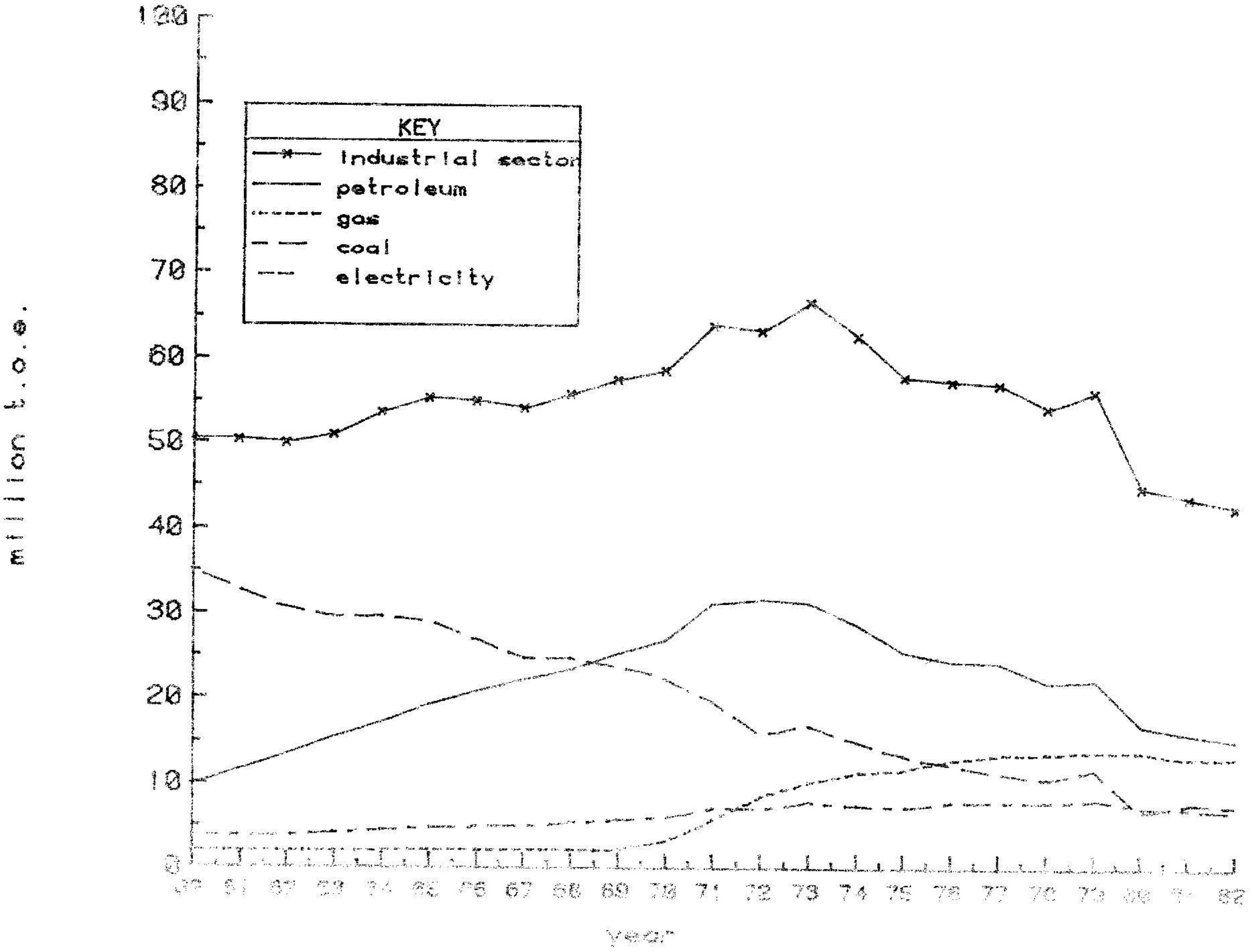
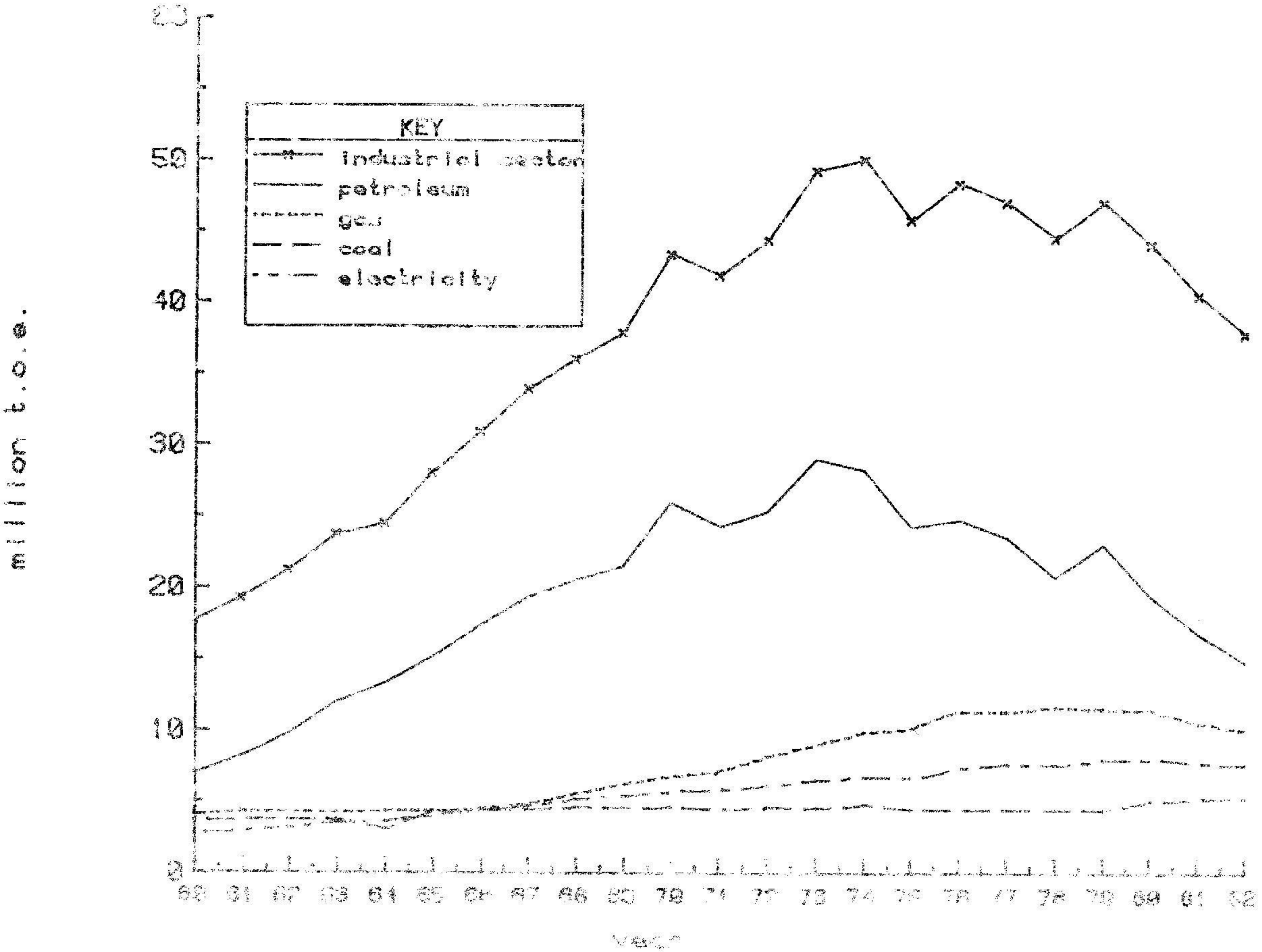
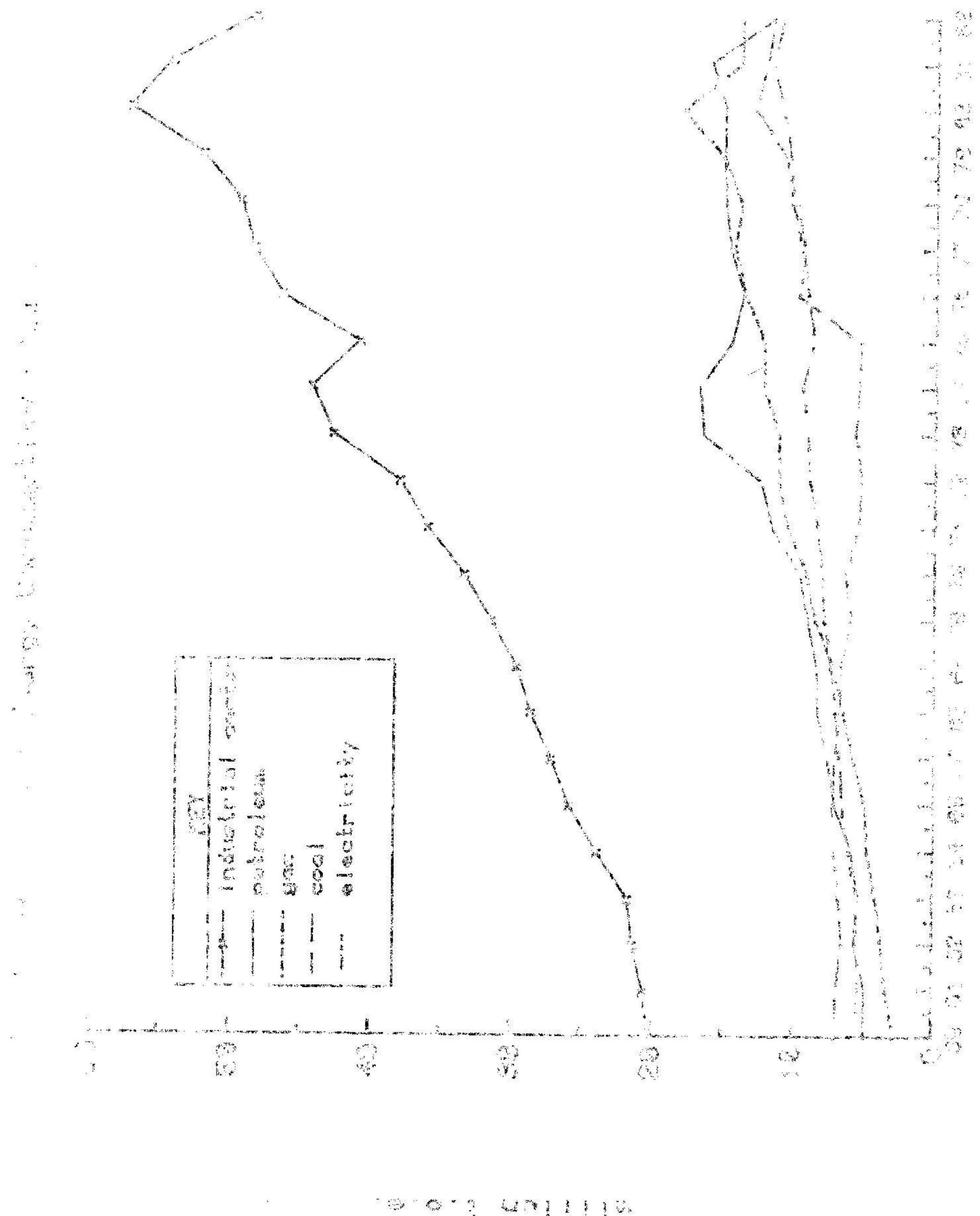


Figure 20 : Energy Consumption : ITALY




industrial
petroleum
gas
coal
electricity

Working Papers in Economics

* 1	I.G. Sharpe	A Framework for Analysis of the Money Supply Process in Australia
* 2	I.G. Sharpe R.G. Walker	Asset Revaluation and Stock Market Prices
* 3	N.V. Lam	Incidence and Stabilization Impact of Tin Export Taxation in West Malaysia
* 4	V.B. Hall & M.L. King	Inflationary Expectations in New Zealand: A Preliminary Study
* 5	A.J. Phipps	Strike Activity and Inflation in Australia
6	N.V. Lam	Incidence of the Rice Export Premium in Thailand
* 7	I.G. Sharpe	Secondary Reserve Requirements, the Monetary Base and the Money Supply in Australia
8	P. Saunders	Labour Demand Functions and the Quasi-Fixity Hypothesis: Some Empirical Results for U.K. Manufacturing Industries, 1963-1974
9	W.P. Hogan	Economic Strategies for Recovery
10	T.P. Truong	Asset Revaluation and Share Prices: A Study using the M.S.A.E. Regression Technique
*11	S. Kim	Instability of Primary Exports, Income Stabilization Policies and Welfare
*12	I.G. Sharpe & P.A. Volker	Institutional Change, Specification Error, Inflation and the Stability of the Demand for Money Function in the United States, 1901-1974
*13	I.G. Sharpe & P.A. Volker	The Impact of Institutional Changes on the Australian Short-Run Money Demand Function
*14	W.P. Hogan	The Connections Between Foreign Trade and Economic Development: An Empirical Study
*15	F. Gill	The Case of the Black Exodus from the Southern U.S., 1910-1970: Some Lessons for Theory and Applied Theory
*16	A.J. Phipps	The Impact of Wage Indexation on Wage Inflation and Strike Activity in Australia
*17	V.B. Hall	Pricing Behaviour in Australia: A Data Evaluation Study
*18	I.G. Sharpe	Australian Money Supply Analysis: Direct Controls and the Relationship between the Monetary Base, Secondary Reserve and the Money Supply
*19	L. Haddad	Economic Systems: Towards a New Classification
20	G. Lewis	A Strategy for Winning at Roulette
21	R.L. Brown	A Test of the Black and Scholes Model of Option Valuation in Australia
*22	V.B. Hall	Pricing Behaviour in Australian Manufacturing Industry: Hypothesis Testing 1955-1956 to 1967-1968
*23	I.G. Sharpe & P.A. Volker	The Selection of Monetary Policy Instruments: Evidence from Reduced Form Estimates of the Demand and Supply of Money in Australia
*24	V.B. Hall	Excess Demand and Expectations Influences on Price Changes in Australian Manufacturing Industry
*25	I.G. Sharpe & P.A. Volker	The Tradeoff Between Improved Monetary Control and Market Interest Rate Variability in Australia: An Application of Optimal Control Techniques
*26	Evan Jones with the assistance of Mary MacDonald	An Examination of Earnings Differentials in Australian Manufacturing Industry
27	W.P. Hogan	Questions on Structural Adjustment Policies
*28	P. Saunders	Price and Cost Expectations in Australian Manufacturing Firms
*29	W.P. Hogan, I.G. Sharpe & P.A. Volker	Regulation, Risk and the Pricing of Australian Bank Shares 1957-1976
30	W.P. Hogan	Quicksands of Policy-Making
*31	C. Emerson	Taxing Natural Resources Projects
32	R.W. Bailey, V.B. Hall & P.C.B. Phillips	A Small Model of Output, Employment, Capital Formation and Inflation, applied to the New Zealand Economy
33	W.P. Hogan	Eurofinancing: Currencies, Loans and Bonds
34	S. Adei	The Growth of Foreign Investment and Economic Nationalism in Post Independence Ghana: 1957-1975

*35	W.P. Hogan	The 40 Per Cent Investment Allowance
*36	W.P. Hogan	Controlling Eurocurrency Markets
37	R.T. Ross	Disaggregate Labour Supply Functions for Married Women: Preliminary Estimates in New Zealand
38	U.R. Kohli	Beginning and End-of-Period Specifications of Asset Market Equilibrium in Balance-of-Payments
39	G. Mills	Government [illegible] Private Companies: Some Lessons from the Channel Tunnel
40	C.G.F. Simkin	Closer Economic Relations Between Australia and New Zealand
41	U.R. Kohli	Relative Price Effects and the Demand for Imports
42	W.J. Merrilees	Alternative Models of [illegible]: With Special Reference to the British Engineering Industry
*43	P. Saunders	Price Determination in Australian Manufacturing Industry: A Cross-Section Study
*44	W.P. Hogan	Immigration Policies and Issues
45	W.J. Merrilees	Labour Market Segmentation in Canada: A [illegible] Approach
46	W.J. Merrilees	Pricing Strategies in the Newspaper Industry
47	J.L. Whiteman	The Micro-Foundation of Layoffs and Labour-Hoarding
48	U.R. Kohli	On the Duality between Fixed and Flexible Exchange Rates
49	U.R. Kohli	Nonjoint Technologies
50	P. Saunders	Price Determination, Expectations Formations and some Tests of the Rationality of Australian Price Expectations
51	J.L. Whiteman	Rational Choice, Learning-by-Doing and the Personal Distribution of Income
52	J.L. Whiteman	Firm-Specific Human Capital, Experience and the Differential Incidence of Unemployment
52	J. Yates	An Analysis of Asset Holdings in Australia by Income Class
54	J. Yates	An Analysis of the Distribution Impact of Imputed Rent Taxation
55	G. Mills	Investment in Airport Capacity - A Critical Review of the MANS Study
56	V.B. Hall & P. Saunders	Pricing Models in Australian Manufacturing - The Evidence from Survey Data
57	P. Saunders	How Rational are Australian Price Expectations?
58	F. Gill	The Costs of Adjustment and the Invisible Hand with Special Reference to the Labour Market
59	G. Mills & W. Coleman	Peak Load Pricing and the Channel Tunnel: A Re-Examination
60	J. Yates	Access to Housing Finance and the Campbell Report: the Implications of Implementing the Recommendations of [illegible]
61	S.S. Joson	The Gatt Agreement on Government Procurements: Canada and Australia
*62	R.T. Ross	General Report of the 1980 Survey of Work Patterns of Married Women in the Sydney Metropolitan Region
63	W.J. Merrilees	Pension Benefits and the Decline in Elderly Male Labour Force Participation
*64	W.P. Hogan	Industry, Employment and Inflation
*65	A.J. Phipps	Australian Unemployment: Some Evidence from Industry Labour Demand Functions
*66	E.M.A. Gross & W.P. Hogan	Short Term Management of the Australian Exchange Rate, 1977-82
67	V.B. Hall	Industrial Sector Interfuel Substitution following the First Major Oil Shock
68	J. Yates	Access to Housing Finance and Alternative Forms of Housing Loans in the 1980's
69	V.B. Hall	Major OECD Country Industrial Sector Interfuel Substitution Estimates: 1960-79
70	F. Gill	Inequality and Arbitration of Wages in Australia: An Historical Perspective
*71	W.J. Merrilees	Do Wage Subsidies Stimulate Training? An Evaluation of the Craft Rebate Scheme
72	Michael G. Blad	Economic Policy and [illegible]

73	C.G.F. Simkin	Does Money Matter in Singapore?
74	J. Yates	Home Purchase Assistance for Low Income Earners
75	C.G.F. Simkin	Long-Term Aspects of New Zealand's External Deficits

Papers marked with an asterisk are out of stock. Copies of the others are available upon request from:

Department of Economics
The University of Sydney
N.S.W. 2006

Working Papers in Economics Published or Accepted for Publication Elsewhere

2	I.G. Sharpe & R.G. Walker	Journal of Accounting Research, Fall, 1976, 293-310
3	N.V. Lam	Journal of the Developing Economies, vol. 17, No. 1, March, 1979
4	V.B. Hall & M.L. King	New Zealand Economic Papers, 1976
5	A.J. Phipps	Economic Record, September 1977, 297-319
6	N.V. Lam	Journal of Development Studies, vol. 14, No. 1, October 1977
7	I.G. Sharpe	Australian Journal of Management, April 1976, 85-106
9	W.P. Hogan	Economic Papers, No. 53, The Economic Society of Australia and New Zealand, 29-57
12	I.G. Sharpe & P.A. Volker	Economics Letters, 2, 1979, pp.45-49
13	I.G. Sharpe & P.A Volker	Kredit und Kapital, vol. 12, No. 1, 1979
14	W.P. Hogan	Some Calculations in Stability and Inflation, A.R. Bergstrom et.al. (eds), John Wiley and Sons, 1978
15	F. Gill	Australian Economic Papers, vol. 19, No. 35, December 1980
18	I.G. Sharpe	Journal of Banking and Finance, 4, 1980, pp. 283-300
21	R.L. Brown	Australian Journal of Management, vol. 3, No. 1, April 1978, 17-36
23	I.G. Sharpe & P.A. Volker	The Australian Monetary System in the 1970s, M. Porter (ed.), Supplement to the Economic Record, 1978
24	V.B. Hall	Economic Record, vol. 56, No. 152, March 1980, 69-81
25	I.G. Sharpe & P.A. Volker	Australian Journal of Management, October 1979, pp. 119-134
27	W.P. Hogan	Malayan Economic Review, vol. 24, no. 1, April 1979
28	P. Saunders	Australian Economic Papers, vol. 19, No. 34, June 1980
29	W.P. Hogan, I.G. Sharpe & P.A. Volker	Economic Letters, 6, 1980, 373-377
29	W.P. Hogan, I.G. Sharpe & P.A. Volker	Economics Letters, 7, 1981, 69-74
30	W.P. Hogan	Australian Economic Papers, vol. 18, No. 33, December 1979
38	U.R. Kohli	Australian Economic Papers, vol. 21, No. 39, December 1982, 332-344
39	G. Mills	Journal of the Operational Research Society 33 (1982), 505-514
41	U.R. Kohli	Canadian Journal of Economics, vol. XV, No. 2, May 1982, 205-219
42	W. Merrilees	Applied Economics, vol. 15, February 1983, pp. 1-22
43	P. Saunders	Australian Economic Papers, vol. 19, No. 35, December 1981
45	W. Merrilees	Canadian Journal of Economics, vol. XV, August 1982, pp. 458-473
46	W. Merrilees	Journal of Industrial Economics, vol. XXXI, March 1983, pp. 291-311
49	U.R. Kohli	Review of Economic Studies, vol. L(1) No. 160, January 1983, 209-219
50	P. Saunders	Economic Record, vol. 57, December 1981, 368-378
55	G. Mills	Seventh Australian Transport Research Forum-Papers Hobart, 1982, pp. 171-210
59	G. Mills & W. Coleman	Journal of Transport Economics and Policy, vol. XVI, No. 3, September 1982
65	A.J. Phipps	Australian Economic Papers, vol. 22, No. 41, December 1983
67	V.B. Hall	Economics Letters, 12, 1983, 377-382