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ECONOMIC MODELS AND THE U.K. PAPER INDUSTRY

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Synopsis Models of the behaviour of national economies have been developed and popularised for some time. The economic behaviour of whole industries has also been examined and statistical analysis has uncovered at least the main features of the working of a number of industries. There is no difficulty in principle in carrying this process of analysis on to the examination of individual products. The paper discusses these topics and illustrations are provided of national and industrial economic models and the behaviour of several product groups in the U.K. paper industry are examined. The results show that statistical analysis can reveal important economic influences at work, but that it is necessary to beware of special factors, technical, political and social, which can be of overriding importance for particular products at particular times.

Introduction

THE very concept of economic modelling needs more introduction than does most subjects. This arises from the fact that there is a good deal of disagreement on what an economic model is (or should be, if it existed) and of how an economic modeller approaches his work. It is, perhaps, a sign of the rudimentary state of economic science that this sort of philosophical debate should have such an important place in the activity of its practitioners: alternatively, it may be the intimate personal significance of economics that leads people to philosophise on it.

Recently, Coen, Gomme & Kendall[1] read a paper at the Royal Statistical Society, describing some striking empirically discovered relationships among a number of economic series, generally in lagged form. The object of the work was to obtain relationships that could be used for prediction, hence, for control. The evidence and the relationships were not disputed, but the approach was. As on a number of other occasions, the absence of an acceptable theoretical framework that can be utilised in interpreting the results was criticised. This kind of criticism raises the question of the proper nature of a model.

Under the chairmanship of M. I. MacLaurin

In practical work, the division between those who look for relationships first, then (as an option) go on to rationalise them and those who like to have the explanations first before setting up tests of the relationships implied by these explanations is often somewhat artificial. There will be no need to emphasise to those concerned with controlling systems that no model can or need be complete. A model, which is often set out in mathematical terms, sets out the relationships that determine the behaviour of the system to be studied. Only those relationships that are relevant to the purpose of the study (say, the control of the national economy) need to be set down and, if only a single relationship is needed, then the modeller is fortunate. *Explanation* is never complete and there is a sense in which the very well established and rigorously tested laws of physical science cannot be explained. Certainly, one cannot explain why the law of gravitation is what it is and not something else.

The economist, demanding a theoretical framework, is usually generous in his readiness to accept explanations: for example, naïve psychological suppositions about human nature suffice, so it is very doubtful whether the theoretical framework of economics is based on sound theories of individual and social behaviour. Even if the assumptions made were soundly based, it is certain that no prior reasoning indicates the functional form of economic relationships or the length of lag with which the relationships operate. Thus, the economist must rely on a statistical approach in order to bring his theoretical anticipations into a form of use for practical purposes (or tested, for that matter). Of course, once such a relationship has been set out, an unlimited number of explanations (in the sense of rationalisations) can be provided of why it exists in this form. No doubt, the reader will be able to rationalise the skewed pattern of income and wealth that has prevailed in many countries for as long as data are available.

Those interested in control theory, however, will be prepared to concentrate their attention on the relationships found to hold in the economic system and to relegate explanation to a lower place. It follows from these considerations that statistical methods are needed to obtain economic relationships in a form useful for control purposes. I shall not attempt to cover questions of statistical methodology or technique in this paper; I shall, in fact, refer almost entirely to regression methods. This reflects the concentration of statistical economic work in this area. The paper will proceed through a number of examples at different levels of economic generality, without engaging in a full discussion of the economic theories that the relationships so obtained suggest. The bibliography appended contains a list of books and articles that provide full descriptions of the statistics and economics to which the paper refers.

National economic control

THE most aggregate level for which I shall present an example is the national one. This is not because the international level is unimportant: recent events have shown us all how important these are and the paper industry has historically been open at the international level. There is not much of a record of international economic control and, however, for political rather than economic or even industrial reasons, attention has been focused on the problem of national economic control. Speculating, I would not expect the choice of relationships used for economic control to change much if multi-national bodies such as the European Economic Community were to become the units of economic management rather than individual countries.

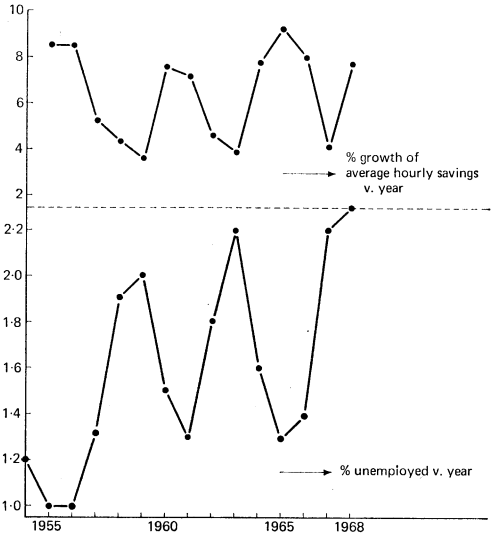


Fig. 1

Economic and statistical analysis of the national economy came to take up a large part of the attention of those interested in economic matters in the thirties. This was partly due to the academic and proselytising work of Lord Keynes at that time, also to the economic, social and political circumstances. Since the second world war and, most particularly, recently, attention has swung from the problem of combating unemployment to reducing the rate of inflation. A simple control mechanism has been suggested here: wage increases (among other things) cause price increases, the rate of wage inflation depends inversely on the level of unemployment; so, if the national economic managers create high levels of unemployment, they will slow the rate of

inflation. New devaluation and tax increases raise prices even in the absence of wage increases, so in this paper I shall concentrate on the link between the level of unemployment and the rate of wage inflation. If such a relationship were established, the level of unemployment could be used to predict and control inflation. I believe that it is fair to say that such a relationship (of unspecified form) fits the theoretical framework of most economists. It is known as a Phillips' curve and the U.K. annual data on which an empirical study could be based are shown in Fig. 1 (the data are obtained from the *D.E.P. Gazette*). At first sight, a good relationship appears to exist between the movements of these series. A couple of years ago, the conventional wisdom held that the high level of unemployment prevailing in 1967 and expected to be maintained in later years would hold down increases of earnings and so help to reduce inflation and increase our international competitiveness. I do not know what the Cabinet (our economic managers) thought, but it is reasonable to believe that they had this control mechanism in mind.

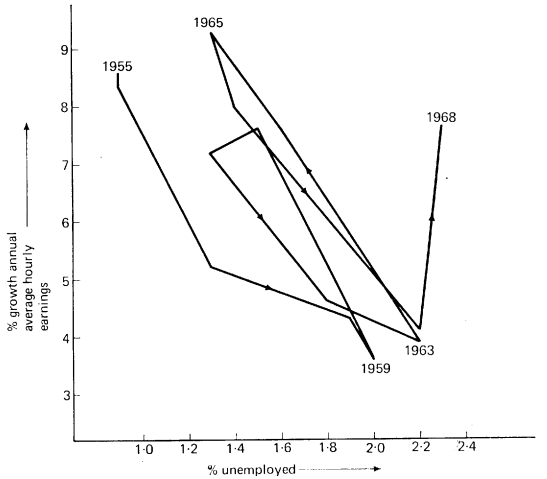


Fig. 2

An examination of Fig. 2, however, indicates that the control mechanism does not operate in the simple way suggested. The regression results relating earnings growth to the unemployment level are of no interest: the long-term factors driving up both the level of unemployment and the rate of wage inflation are sufficiently important to negate the apparent short-term effects of cycles of economic activity. For example, the short-term anti-inflationary effect of the economic downturn 1955–59 evident in Fig. 2, is not repeated so effectively in later cycles when higher levels of unemployment failed to keep

earnings growth to the 1959 rate. A trend variable is needed to account for the persistent movement of the short-term Phillips' curve to the right. Now, the search for an economic variable that simply trends over time is all too easy: the greater proportion of all economic variables do this. Yet there are two that conform to notions acceptable to some economists anyway—the price level and the stock of money in existence.

Unfortunately, for this approach, the reader will recall that the object of controlling the growth of earnings was to control the growth of prices. A theory that reverses this order is no use to the price controller. Nor is he compelled to accept that it is the price level that plays this determining role, for, as has been suggested, a book of economic statistics will provide many other variables with the required characteristic of trending either up or down over time and their choice could be justified with an effort of rationalisation. At the time of writing, U.K. money supply data are not adequate to test this variable's performance as a controller of the rate of wage inflation, though recent theoretical and political interest in this aspect of economics means that preparation of such data is being given priority. Coen, Gomme & Kendall[1] have shown that U.K. money supply, as currently rather poorly measured, appears to control the behaviour of equity share prices on the London Stock Exchange, so one may hope that improved data will permit this line of research to be extended to more central fields of economic policy. Although inflation is an intensively studied area of economics and one in which a great deal of policy experience has been gained, no well-known and proven control mechanism yet exists for restraining the rate of wage inflation.

Industrial economic control

IT SHOULD not be assumed that all aspects of national economic control are as refractory as the control of wage inflation, though experience indicates that economic management is no easy task at the national level. It is possible that this is because the quantities being studied and (hopefully) controlled are very aggregate ones. Thus, one might reasonably expect the earnings of miners, hairdressers, civil servants and car salesmen to behave quite differently: it may be necessary to disaggregate to the industry level before progress can be made.

In the examples put forward here, the control implications that are drawn are of the most simple-minded type. For economic systems, this may not be a great disadvantage, as knowledge of the individual pieces of the system's make-up is not yet sufficiently refined to give one confidence in a control operation that relies on an intricate pattern of responses at several removes from the initial act. This section of the paper is split into two parts to discuss examples of two very simple kinds of control action suggested by the economic relationships obtained. I have called these *passive* or indirect and *active*

or direct control and hope that these terms do not clash with conventional control theory usage. Active control situations are those in which the manager responds to a problem by influencing the variable of concern directly; passive situations are those in which the manager is unable or unwilling to influence the variable directly and is reduced to making the best provision he can for the inevitable. This will probably involve the active control of other parts of the system over which the manager has more power.

Passive industrial economic control

There is an almost unlimited number of aspects to the work of an industrial manager, varying in their relative importance from industry to industry. Yet the course of demand over the planning period ahead is of universal interest in setting the framework for wage bargaining, buying raw materials, determining the rate of production and the level of stocks held, price-setting and so forth. No example for one industry can be taken to apply as it stands to another, but the method and notions involved are often of general application. A couple of years ago, Mr Hughes and I wrote a paper for *The Statistician*,[2] in which we presented some results obtained from an examination of the monthly history of the registration of new cars in Great Britain over the period 1959–66; this is presented here as providing an example of when a simple economic model can be of great value.

The number of cars registered in a month varies for all sorts of reasons. We are still examining a quantity that is the result of aggregating the actions of hundreds of thousands of relationships, in the face of which any type of control would be quite impracticable, but it turns out that a very good fit can be obtained for the car registration data using only one equation, with three types of predicting variable—

1. Some auto-regressive terms, whose main function is to fit the very jagged seasonal pattern evident in the data. If the data had been de-seasonalised, most of these terms would have been unnecessary, though trend and constant terms may have remained. These may be taken as summarising the fact that no attempt has been made to examine the network of social, psychological and other factors that persistently tended to push up the rate of new car buying over this period.
2. Two lagged values of bank rate, which indicate that a 1 per cent rise in bank rate reduces the monthly rate of new car buying by stages by almost 10 000 cars, 10 per cent of the total registrations nine months later.
3. The effectively unlagged value of bank advances outstanding to personal and professional borrowers. An increase in the volume of such advances is reflected in increased new car buying: a result that corresponds with the general experience of many bankers.

The course of the actual car registrations made and those predicted by this model are shown in Fig. 3.

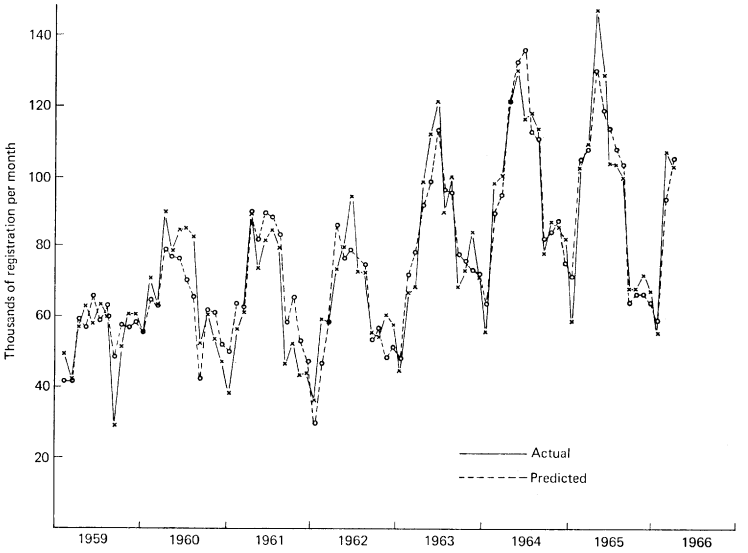


Fig 3.—New car registrations in Great Britain 1959-66 monthly (*source Monthly Digest of Statistics*)

From the point of view of national economic managers, an active control operation is possible. If the Chancellor of the Exchequer judges the level of domestic car buying to be too low or too high, this simple model suggests a way in which he can act to obtain the level he desires. The data to which the model has been fitted run up to February 1966. Let us say that the Government judged the level of new car buying to be too high in mid-1966 (as it did) and so raised bank rate and made a number of other financial and economic moves of a restrictive nature. It may be remembered that the imposition of a wage freeze was thought at that time to be something of a novelty, but Table 1 (largely reproduced from *The Statistician* article) shows that the model was able to predict the very substantial consequences of the 'July measures' in depressing the car trade the following winter without making any allowance for incomes policy or any other such innovations.

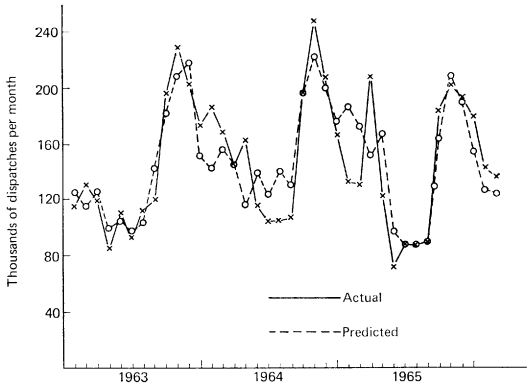
This table, incidentally indicates that national economic management is not a hopeless task, as the discussion in the section on national economic control may have implied. Nor is the individual industry's passive control problem

TABLE 1—FORECAST NEW CAR REGISTRATIONS OVER THE YEAR MARCH 1966 TO FEBRUARY 1967 (THOUSANDS): ERRORS COMPARED WITH ANNUAL CHANGES

Month	*Actual registrations*	*Predicted registrations*	*Percentage errors (actual–predicted divided by actual)*	*Percentage actual change from same month previous year*
March 1966	137·2	135·4	+1	−7
April	137·1	115·4	+16	+15
May	120·3	100·0	+17	+15
June	102·7	99·7	+3	−1
July	99·7	95·5	+4	−1
August	59·4	57·6	+3	−14
September	54·6	59·3	−9	−21
October	53·0	56·7	−7	−27
November	52·8	49·6	+6	−23
December	39·3	46·4	−18	−30
January 1967	103·6	89·3	+14	−4
February	92·9	92·9	=	−10

unmanageable. It may be that the car industry could do nothing to avoid the domestic slump of sales; certainly bank rate is beyond its control, but it could have been in a position to take defensive action. To determine the best form of such action would require a very thorough knowledge of the industry; each manufacturer and even each plant may require different strategies—to export more, to cut prices, to invest less, to be tougher in wage negotiations and so forth. The single economic relationship between the rate of interest and the rate of new car buying, however, sets the framework for all this, perhaps very complex, internal management analysis.

Details of the ways in which the car industry can react in the way which I have called *passive* to this change in their market situation are not of interest to an audience of papermakers, nor do I have the knowledge of the control systems operating in that industry that will differ anyway from plant to plant. Two general points hold—(*1*) nine months' notice is better than none and permits a wider range of responses to be considered and implemented; (*2*) it is not appropriate to make long-term decisions on the basis of the relationship obtained, for the Government can act to reverse or intensify their interest rate policy at any time. This has little immediate effect in the car industry, but the industry's one-year view should change at once. A very simple-minded view suggests that investment decisions should not be changed in such a situation; instead, more or less shift and overtime working and other short-term measures should be used. Of course, if an examination of the broader, national or international situation suggested that credit would remain expensive and in restricted supply for some years ahead, then investment decisions should be changed.



F g. 4—Comparison of T.V. dispatches

It is of some interest that similar results may be obtained from an examination of the history of manufacturers' dispatches of television sets. Once again, a 1 per cent increase in bank rate leads to a fall in dispatches of about 10 per cent of their total volume, some half a year later. In both these cases, cars and television, there were many technical innovations over the period studied and one might expect growing affluence and heavy advertising to have had an effect in changing consumers' tastes; nevertheless, in both these consumer durable industries, the national credit situation continued to set the framework for more detailed management policy-making.

Active industrial economic control

Although the behaviour of the car market may be predictable, there is less reason to believe that this is so of any particular manufacturer's range of cars, less still of any single model. At this level, economic factors often play a smaller part being swamped by technical and stylistic developments. Examples of an individual firm coinciding with the market arise in the cases of the U.K.'s television companies. Each of these companies is granted the temporary monopoly of the right to televise advertisements in a particular region and its income comes from selling this facility to advertisers. The amount of advertising time that can be sold to the potential advertisers is limited by law in a rather intricate way, but which may be taken as making it a constant quality. Nevertheless, the price at which this time is sold may be varied freely and a great deal of involved price changing and negotiation goes on. Although a large number of management problems exist for a television company, it is clear that determining the general price structure of the time

that it has to sell is the key one. Conventionally, this structure is reset at six-monthly intervals (spring and autumn) and, since this variable is certainly under the company's control, the central management problem is simply formulated—set the general price level so as to maximise revenue.

Of course, the monopoly that a television company has is restricted. If it is too aggressive in its pricing, advertisers will tend to use the press or posters instead or to shift their expenditure to another region whose television company is offering better value, at least for a while. In economists' jargon, the problem is to estimate the position of the demand curve for the company's advertising time. Demand for this time was still trending upwards at the time of the study, as advertisers were still shifting from the older media—the press, magazines and so forth. Consequently, there was a steady tendency for all the television companies to raise prices during this period. In practice, a rather humbler objective than maximising revenue is acceptable: the company would be pleased to know whether it should raise its prices by more or less than the other companies, without necessarily setting the very optimum price.

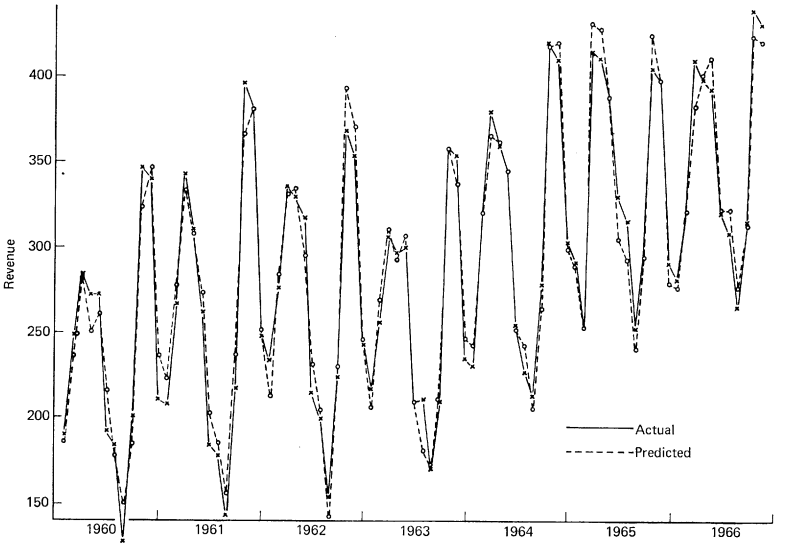


Fig. 5—Actual and predicted monthly revenue of a U.K. television company

After the previous discussions in this paper, the reader will not be surprised that a simple one-equation regression model was used as the basis of the approach to this problem. Seven years' monthly data on the company's revenue were available, together with corresponding information on the price

of its advertising time, the number of television sets able to receive its programmes and advertisements and a number of economic variables measuring conditions external to the company. Analysis of these data obtained the fit for the revenue series shown in Fig. 5. The data are confidential and so the units are disguised and anonymity is preserved: the results are presented in proportional form.

The terms selected by the regression method used may be put into three categories—

1. Some autoregressive terms, whose interpretation is as for those in the car registrations equation discussed above—that is, they fit the sharp seasonal pattern and provide for the upward trend present in the series.
2. Some terms linking the prosperity of the company directly, but with a lag, to that of its region and the nation. These are of significance for the passive control problem discussed above, but not for active control.
3. Some terms linking revenue to variables that the company has at least some ability to control: its 'set count' and the price of its time. In the statistical analysis, the influence of these two factors is confounded, for the number of sets and the price of television time have both risen historically, though the number of sets had almost stabilised by the end of the period studied. There is scarcely any control relationship between the two: only a small proportion of advertising time is sold directly on the basis of set count. One approach would have been to conduct the analysis in terms of the revenue per set in the region rather than the revenue unadjusted in any way. Yet, as the analysis was carried out, the effect of a 10 per cent rise in the price of time was found, after allowing for the persistent growth in the set count, to build up over a year to a 4 per cent rise in company revenue. In the experience of the company, the demand for its time was inelastic and the control implication was obvious—to raise its prices rather more than the other companies at the next six-monthly round of price revisions.

In the two parts of this section, the two parts of the economic manager's problem have been discussed. First, the framework in which he must operate is predicted and, second, the effect of the items under his control is assessed. In the cases examined, there are substantial time lags before the full effects are felt of the initiatives taken. Of course, this may not always be the case, but the presence of such lags indicates that very substantial problems will exist in controlling such systems in a delicate way, though rough control may be more practical.

Application of these methods to the U.K. paper industry

THE field of paper manufacture is a new one to me, but, with the help of people in the industry, I have obtained a certain amount of background

information and data. Only a small part of this is presented here, the analysis of which was carried out with the assistance of Mr Naqvi of Scientific Control Systems Ltd. A full survey of the whole industry has not been attempted; instead, three cases have been selected for presentation here. The U.K. experience has been studied of—

1. Consumption of food wrappings.
2. Consumption of kraft wrapping paper.
3. Consumption of good quality printing and writing papers.

Now, the paper industry has a number of features that make it somewhat different from those discussed above. It is an international market; it is a stable product; it is a key product in the economy and, more especially, the international trade of many of the important producers; it has a fast-growing output and heavy investment in technologically advanced and large plants; and is often in receipt of Government assistance and subsidy in one form or another; it does not have a large trade cycle. Although the full set of its characteristics is probably unique, it shares each of these features with some other industries: chemicals, man-made fibres and shipbuilding come to mind. In the remainder of this paper, it will be seen that some of the paper industry's features, at least, can be subjected to a statistical form of economic analysis.

Consumption of food wrappings

The first case to be considered from the paper industry is the consumption of food wrappings. At first, we tried to relate this to the growth of personal income after taking account of taxes and such items and inflation—the quantity known as real personal disposable income—but this proved quite inappropriate. Real personal disposable income increases year by year, whereas Fig. 6 shows that the consumption of food wrappings paper fell in the U.K. after 1963–64. This suggests the introduction of a technical or institutional factor at that period. Personal observation and discussion with people in this field suggested that the use of polythene bags and wrappings had become more widespread associated with the spread of self-service stores. The most convenient variable was found to be the number of supermarkets, which shows a strong growth from the early sixties.

The effect of fitting an equation using these two terms to the data on consumption of food wrappings for the years 1954–68 is shown in Fig. 6. Growth in disposable income has the effect of increasing food wrappings consumption, whereas a growth in the number of supermarkets has the opposite effect. Of course, the growth of supermarkets and of income are correlated, even if not causally related. Taking the two effects together, one expects a simultaneous 3 per cent growth of real personal disposable income and 10 per cent growth

in the number of supermarkets per annum to have a balancing effect on food wrappings consumption at present levels of these variables. As this growth of income is slightly greater than usual and the growth in the number of supermarkets has often been of the order of 20 per cent in a year, one must expect the future trend of this class of paper consumption to continue to be downward.

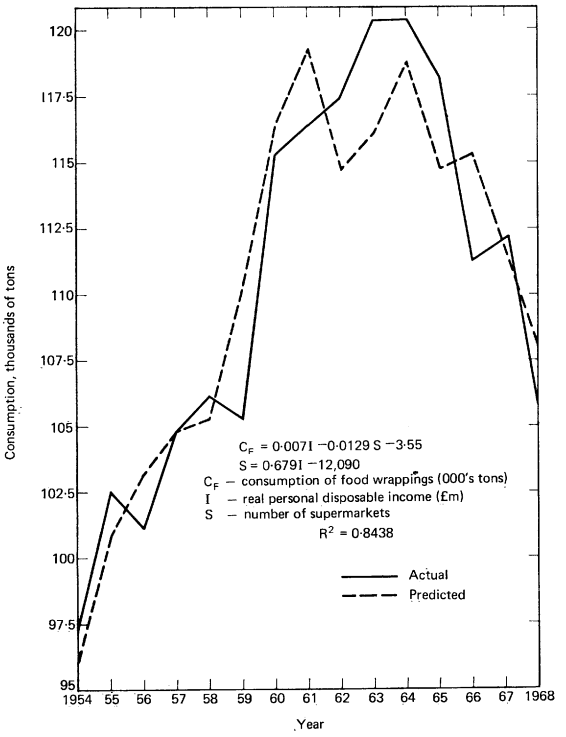


Fig. 6—Consumption of food wrapping paper—source B.P.M.A. Directory of Super Markets & Self Service Institute and National Income and Expenditure Blue Book

Presumably, supermarkets could play a larger part in the economy without increasing their numbers; for example, by increasing their average size or their turnover per unit of area. Furthermore, I see no automatic reason that they should be opposed to the use of paper for wrapping. The reader will be better able than I to judge what the future resultant of these conflicting factors discussed above may be and the export retailer whether there is a causal

relationship between the growth of incomes and supermarkets. For interest, a very simple, two-equation linear model is given in Table 2. The second equation is derived from the period 1961–68 only. A fuller study could examine more complex functional forms and more variables. In particular, it appears that the actual behaviour is lagging behind that predicted in the last few years: this suggests that consumption of food wrapping paper now lags behind real personal disposable income by a year. We have not considered the very wide range of possible models, for the simple structure set out below is able to predict the 1968 consumption to within 7 per cent.

TABLE 2—CONSUMPTION OF FOOD WRAPPING PAPER MODEL

$$C = 0{\cdot}007I - 0{\cdot}0129S - 3{\cdot}55$$
$$S = 0{\cdot}679I - 12{\cdot}090$$

where C = Consumption of food wrapping paper ('000 tons),
I = Real personal disposable income (£m.),
S = Number of supermarkets.

For 1968, this gives $C = 113$, which is 6·8 per cent different from the actual value.

Consumption of kraft wrapping paper

The second case considered was another industry group, kraft wrapping paper, but this time one without any dramatic reversals of fortune in the U.K. market, at least. In earlier sections, the difficulty of analysing a smooth series has been discussed. As many economic series have this form, it is easy to achieve a very good fit with any of a wide range of explanatory variables and very hard to select which of this range is the best. A method of overcoming this difficulty is to take differences in the series to be explained (in this case, to take the annual differences in the consumption of kraft wrapping paper) and to perform the usual regression analyses with this form of the variable. The results of this transformation are displayed in Fig. 7, in which it can be seen that any trace of a trend in the series has been eliminated.

Consumers' expenditure with the effects of inflation removed was tried first for food wrapping paper. Since the kraft paper consumption variable has been differenced, annual consumption is differenced too. I think that the reader will agree that this gives a very good fit, in which all the turning points are identified (though the extent of the sharp down-turn in 1958 is substantially underestimated). Of course, kraft paper is not all sold to individual consumers directly; on an annual view, the evidence is that the firms and organisations buying kraft paper are geared in their activity to the level of individuals' spending.

An interesting feature of the result is that kraft paper consumption appears to have been more volatile with respect to general consumption in the fifties than it has been in the sixties. In each of the boom years of 1955, 1957 and

1959, the increase in consumption was greater than that predicted; in the intervening slump years of 1956 and 1958, it was even smaller or more negative than predicted. The fit is almost perfect for 1960–62, after which the actual behaviour of kraft paper consumption was less exuberant in the boom years of 1963, 1964 and 1968 than predicted. The reader may be able to provide an explanation of this phenomenon.

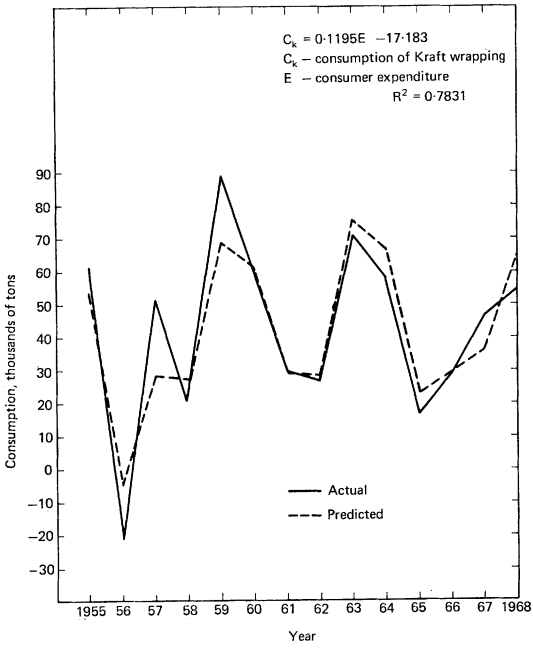


Fig. 7—Consumption of kraft wrapping paper—annual differences (Sources B.P.M.A. & National Income and Expenditure Blue Book)

Consumpt on of good quality printing and writing papers

The third and last case to be presented here was of a narrower group. It has been suggested above that aggregates often behave in a more regular way than their components, whose performance may be significantly effected by shifts of fashion and such factors. The case selected for discussion here represents a further stage of disaggregation and is another one that requires that the data be differenced to avoid having to analyse a trend-dominated series. The consumption of good quality printing and writing papers has risen in almost every year since 1957. On taking the annual differences in the consumption of these items, however, a trendless series is obtained, as can be seen in Fig. 8.

Once again, the annual differences in real personal disposable income were related to this series and it can be seen from Fig. 8 that a generally good fit is obtained with this single, simple explanatory variable. Although the turning points are still picked out, the quality of fit is somewhat reduced from the standard of the previous example. Furthermore, the analysis of the remaining qualities of printing and writing papers was unable to find a statistically significant fit with this explanatory variable. It may be that we have come to the end of the road with simple, economic variables and that more intricate marketing studies paying due attention to changes in taste, the impact of advertising campaigns and technological changes will be needed for studies of more detailed sections of the paper market.

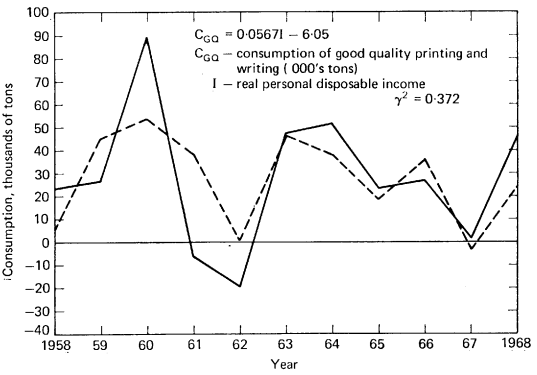


Fig. 8—Consumption of good quality printing and writing paper—annual differences (Sources B.P.M.A. & National Income and Expenditure Blue Book)

In each of the three cases from the paper industry that have been discussed, the control implications are of the variety I have called passive—that is, it is impossible for paper industry managers to influence real personal disposable income, consumers' expenditure or the growth of supermarkets to a significant degree. They must therefore simply adjust to the expected outcome for their industry. Long-term, this income variable is expected to grow by about 3 per cent per annum in the U.K., but this will vary from one year to another in the range of 1–7 per cent, partly as a result of Government action to curb inflationary tendencies in the economy. Consumers' expenditure is expected to grow at a similar, hopefully slightly slower rate. I have not the expertise to assess whether or when the current, rapid growth of supermarkets will reach its ceiling, but the trade association may be able to do so. Generally, the relationships obtained may be used to provide a broad framework for long-term planning and control.

The Government and a number of private agencies produce forecasts of many economic quantities for a year or so ahead at frequent and regular intervals. Although these have often been proved wrong in detail, they can be used to make up tentative medium-term plans. Then, as hard information from the national budget and other sources becomes available, these can be revised. For control purposes, it is unfortunate that no long lags exist to give warning of coming booms or slumps, though a study using quarterly or monthly data might be able to provide some help.

The techniques of economic model building have been and are extremely useful in other industries. In these cases, however, the economists working on the problem have had the opportunity of spending considerable time doing research and investigating the factors affecting the industry in question. The examples I have discussed from the paper industry were chosen from the point of view of readily obtainable data in the limited time available for preparation of the paper. For this reason, they are open to some obvious criticism and I expect this to become apparent during discussion.

The point I hope to have made is that, given a concentration of effort and availability of data, it should be possible to obtain some really useful results. This is despite the international nature of the paper business and its susceptibility to economic policies outside its control.

The way in which the paper industry should respond to this knowledge of their situation requires an understanding of the internal character of the industry. A later stage of a full rather than illustrative study of economic models applied to the paper industry would involve an examination of the detailed interrelationships among stock levels, production processes, investment plans and so forth. The paper by Mr Anderton is a contribution to this field. I hope that enough has been said in this one to indicate the extent to which very simple models can assist in understanding the economic framework within which the paper industry operates.

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Discussion

The Chairman Your preprint has aroused considerable interest and, in order to contain the session to some extent, I will now call upon Mr D. L. Cooper of Pira, who has kindly agreed to present another point of view on your topic. After giving you a chance to answer Mr Cooper, I will ask Mr Anderton to speak, then we will take questions on the whole of this session.

Mr D. L. Cooper I think we should all thank Mr Morgan, coming as he does from outside the industry, for the work that he has put in to postulating models for some of the industry's products. He indicates in his paper that he may expect criticism from more informed sources. I have not the experience of economic modelling in the industry to qualify for such a description, but I should like to make one or two comments on some of the statistical aspects of his paper. I intend to discuss none of the technical aspects of the statistical models that are proposed.

I should first like to make a brief comment on the model of TV company revenue. I find it difficult to understand why the 'set count' should be a variable over which the company can be regarded as having control. I am not surprised that, when set count reaches saturation point, there is no correlation between it and revenue, but I would have thought that some term in the model might be worth keeping. At some stage, TV companies are going to be concerned with colour TV advertising and the charges for advertising are almost certainly then going to depend on set counts of colour TV reception. The experience of using set count in the black and white model might well be useful.

I should also say that I am not surprised to find a significant relationship between charges and revenue in situations where monopoly conditions for that medium exist.

Turning to the paper industry models and the consumption of food wrappings, although I can see some degree of relationship between real disposable income and use of food wrap, I find it more difficult to accept a model that postulates a causal relationship between food wrap and supermarkets. I am not disputing the fact that there is a statistically significant relationship, but is it meaningful? To me, a more reasonable explanation that the last few years is not such a good fit is not because food wrap has become out of step with

real disposable income, but because the supermarket variable is not in fact a causal relationship. Indeed, even accepting that it may be, it is unlikely to be linear, since the rate of increase in supermarkets is likely to slow down as they account for more and more of consumer purchasing power. I suggest that any phenomena that accelerated in the year in which the down-turn of wrap production started would yield a correlation coefficient of appropriate magnitude.

I am also slightly concerned to know why Mr Morgan should choose real personal disposable income for explaining food wrap and consumer expenditure for explaining kraft wrapping. Why is it necessary to take out trends in one case and not the other?

I am pleased to see that he emphasises the impact of technological changes, marketing and other local variables. I can think of two examples from our industry in the recent past; tissue production and coated papers would have related more to these than to dependent variables from the national economy.

The point I want to make most strongly is the difference between statistical relationship and a causal relationship. Whereas regression techniques can establish the regression coefficients that give the best estimate of the value of a dependent variable from a set of data, unless there is a permanent causal relationship, we may lose our way if we use such techniques to predict the future. In such circumstances, I wish there were a way of indicating not only the degree of significance between relationships, but also the degree of irrelevance.

This paper contains some stimulating ideas and I should not wish to seem only destructive in my criticism. The problem of forecasting, particularly long-term forecasting of economic models, must be a particularly intractable problem and intuitively one feels that in the welter of data available such well-founded models must exist. The only advice I can offer is to establish very clearly the aims behind building the model at all—whether forecasts are to be for short-term, long-term, company-based, nationally or internationally based, then to settle for dependent variables for which some causal relationship can be reasonably advanced.

Mr N. B. Morgan I will try to answer your points in sequence. The first one deals with the set count variable in television. In the late fifties and early sixties, in the U.K., there was a persistent growth in the ownership of television sets, particularly to receive commercial stations. It was possible for television companies to stimulate such growth, firstly, by putting on appropriately attractive programmes and, secondly, by advertising. Even now, it is possible for companies (in this country at any rate) to expand their set count by putting in bids for other television transmitting masts. Various regional

companies have done this and, consequently, they have expanded: thus, the set count has historically been under the influence of the television companies to some extent. This has become a control problem for them, because every now and again they get the opportunity of putting in a bid for a particular mast. There is competition among the various companies. This is a variable, they are making decisions. There are also a second channel ITV or a colour channel.

I am not really sure that I can say much about the causal relationship between food wrappings and supermarkets. I am sure that there may be confusing features of the data.

On the general question of causality, I must confess that the philosophy of the nature of cause always gives me difficulty. It seems to me that most people, by saying there is a cause and effect relationship, mean that there is a statistical relationship that holds in many different situations. Moreover, they mean that it holds over a reasonable period of time, in one part of the country and another, for one class of people to another, bad and good economic conditions alike and so on. I agree about the supermarket's case. Unfortunately, the data is not complete enough to test in full causal sense. It seems fair to say that some of the cases I have presented from outside the paper industry have a relationship that is more or less causal, tested over 15 years or so. With unemployment, money supply and earnings in slumps and booms, the relationship continues to hold. I think therefore that a reasonable causal relationship does hold in some cases. I am not saying that it could not be improved by better testing. The physical sciences have been working on causal relationships for 300 years or more, using techniques that are still improving and still being tested. We should not be surprised that economic models are still at a relatively rudimentary stage, though I have to confess that the paper industry models I have presented are extremely simple.

We use PDI in the food wrapping relationship, because it gives better results than the other explanatory variables tried, but I have no explanation why it should be better.