

FORECASTING CONSUMER EXPENDITURE

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INTRODUCTION

Consumer expenditure is the biggest component of national income and expenditure. Good forecasts of this item are important for rational planning by both public authorities and private enterprise. It is, however, not enough to forecast the total amount. One must also be able to forecast the details of consumption expenditure — how much will be spent on food, alcohol, clothing and the other consumption categories. Without such information, reasonable planning of taxation and investment policy by the public authorities will not be possible and the private sector will be at a disadvantage in deciding on the likely profitability of any given project. There is, for instance, no point in expanding capacity in a sector where demand is likely to decline as income increases. Yet, while economists have spent a good deal of effort on the analysis of consumer demand, little attention has been given to the forecasting problem. This article attempts to answer the question 'Which of the methods available to us provides the best forecasts of the *pattern* of consumer demand'.

Predictions are of two kinds, unconditional and conditional. In the case of the former, one simply says that something will happen; weather forecasts are predictions of this kind. In the latter case one says that, given certain conditions, something will happen. This is the kind of prediction considered here. It is assumed that use will be made of forecasts of income and prices, such as those issued by the Economic and Social Research Institute. The principal purpose of the article is to discover how such forecasts can be transformed into predictions of consumer expenditure. Short term forecasts (one year ahead) and medium term ones (five years ahead) are considered. The next section below considers such theory as is relevant; subsequent sections describe the estimating methods, set out the results and draw conclusions and provide some forecasts for the pattern of expenditure in the economy.

THEORY

How does one go about making a forecast of consumer expenditure? Consumption theory is one of the best-developed areas of economic

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science as may be seen from any of the excellent reviews of the subject, the most accessible of which is probably that by Brown & Deaton (1972).¹ The main conclusion is that consumption expenditure is a dependent variable resulting from the values taken on by other variables, notably income and prices. If we accept this, our forecasting method must make use of a model or theory which will transform future values of income and prices into consumption expenditures. Such a procedure involves, of course, the difficulty that one can only forecast consumption if one can first forecast income and prices. In other words, the forecasts considered here are conditional ones. Naturally, unconditional forecasts are more useful if one can form them but conditional forecasts are often needed; they are precisely the kind required by public administrators for policy decisions, and in the private sector they are needed to explore the effects of price and investment changes within a postulated business environment.

One must, of course, begin with a theory which relates consumption expenditure to the variables on which it depends like income and prices. The literature is rich in such theories (or models) but there is little or no agreement on their practical merits and certainly no consensus as to their forecasting abilities. The models used in this exercise are of three types which are representative of the main categories used in consumption analysis and are also by far the most commonly used. They are as follows (the mathematical forms are given in the appendix):—

(a) The linear expenditure system (LES) and the indirect addilog system (IAS). Economic theory lays down a number of conditions which, logically, must be satisfied by a consumer who is spending his income in such a way as to get the greatest satisfaction from it. The two consumption models referred to here satisfy these conditions and so have a good deal of theoretical appeal. The differences between them are caused by different theories about the way in which the consumer's satisfaction increases as he consumes more goods. Unlike the next model, the LES and the IAS use the actual values of the variables in their calculations.

(b) The Rotterdam System (RS) is also based on the theory of consumer expenditure and is consistent with the actions of a consumer who is trying to get the maximum satisfaction from his income. The main difference between it and the two systems mentioned above is that it is not calculated in terms of the actual values of the variables but in their first differences — that is in terms of their changes from one period to the next. For example, if consumption on food took on the values:—

Period	1	2	3	4
Food	20	22	27	25

the values used in the calculations would be

Food +2, +5, -2

The variables are treated in this way because many researchers feel that one can get a more accurate estimate of the relationship between variables from such first differences. Unfortunately, the differencing procedure often increases the degree of error in the model. It should also be mentioned that from a theoretical point of view the Rotterdam model is slightly unsatisfactory but there is no conclusive evidence that this makes the model invalid.²

(c) Finally, two systems are tried which are not based on any economic theory. Economic theory can lay down fairly clear rules about the behaviour of an individual consumer who acts rationally. However, one normally deals with demand data which reflect the actions of an entire community — for example the data used here represent consumption expenditure by the entire population of the Irish Republic. There is no compelling reason why a group of consumers should obey the same rules as a single individual. It is often argued that a community's actions are determined by those of the typical 'individual' but this ignores, for instance, the possibility that the actions of one group may affect those of another. For example, apart from exceptional circumstances which we need not consider here, when the price of a good falls, a rational consumer will buy more of it. However, the situation may be more complicated when we are considering the behaviour of a community. A commodity may be bought because it has 'snob-value' — it may be desired because it is expensive. A fall in price could rob it of its appeal and cause the quantity bought by the community to fall.

Thus, a community may not act like an individual and the 'laws of consumer demand' may not apply to the former. It is reasonable then to test demand systems which are not based on any particular theory but which simply express expenditure as depending on income and prices. The two used here are a simple linear regression (LR) and a regression which is linear in the logarithms (LGR). These are chosen simply because they are the most often used, frequently with results that seem acceptable.

In summary then, the forecasting power of five systems is tried, namely the Linear Expenditure System (LES), the Indirect Addilog System (IAS), the Rotterdam System (RS), the Linear Regression System (LR) and the Logarithmic Regression System (LGR). Three are based on economic theory (LES, IAS, RS) and two have no such base (LR, LGR). One is calculated in first differences (RS) and the others in the original variables. Virtually all practical demand estimation uses one or other of these methods.

It is necessary to say a little about the variables involved. The quantity which is being predicted is consumption expenditure. Total consumption is broken into nine categories and all the models provide predictions of each of these nine categories. The most obvious of the independent variables (those which cause changes in expenditure) are income and prices. For technical reasons the LES, IAS and RS models use total consumption expenditure instead of income but this substitution is a minor one as there is a very high degree of correlation between income and total expenditure. The nine prices for the nine consumption categories are used as independent variables in all the models. Many other independent variables might be considered for inclusion, the most obvious of which are:—

(i) population size; (ii) changes in tastes; and (iii) population structure.

The first of these is clearly important — for a given level of national income the pattern of consumption must clearly depend on the number of people who share it. The easiest way of taking account of this factor is to consider expenditure per head. So in all the models both total expenditure and expenditure on each of the categories is divided by population. There is no obvious way of quantifying changes in tastes so one cannot introduce a variable to account for it. However, it is not unreasonable to believe that in a community a substantial part of these changes will be induced by the rising level of income so that their effect will be covered by the total expenditure variable. Finally, it would be desirable to include a variable to represent population structure, a useful measure of which is the ratio of those between the ages of 15 and 65 (working age) to total population. However, the LES, IAS and RS models cannot accommodate this variable and it can only be included in LR and LGR.

In summary, the general form of all five models is

$$E_i = f(C, P_1 \dots \dots P_g)$$

where E_i is expenditure per head on good i , C is total consumption expenditure per head and the P 's are the prices of the nine categories of goods. Each model contains nine such equations, one for each consumption category.

It is necessary to decide how one will determine which forecasting method is the best. The usual criterion used is the correlation coefficient (R). The forecaster tries a number of models, calculates the R -value (that is the correlation between the true values within the sample and the values calculated by the model) for each and selects the model with the highest value and uses it to form forecasts for the future period in which he is interested. However, the correlation coefficient is, at best,

a doubtful indicator of the predictive power of a model for it merely measures the goodness-of-fit within the sample period. We can only guess at the mathematical form of the 'true' underlying demand model and it is quite possible that some particular specification may fit quite well within the sample but diverge rapidly thereafter. For example, a quadratic form may fit quite well to part of a cubic equation but the difference between the two would grow dramatically if they were projected.

It seems more reasonable to select the forecasting technique by reference to its ability to forecast. If we have a sample of reasonable size it is possible, by using only some of the observations for the estimation of the coefficients, to form a set of 'forecasts' which can then be compared with the actual values. Suppose that we have three forecasting methods A, B and C and that 25 observations are available. The variable to be forecast is Y and it is believed to depend on a set of variables X. Assume that we are interested in producing five-year forecasts. We start with, say, the first 16 observations of X and Y and apply each of the three methods to them to obtain three sets of coefficients. We then apply these coefficients to the X-values of observation 21 to get a 'forecast' of Y by each of the three methods A, B and C. We then repeat the calculations with the first 17 observations and use the results to derive 'forecasts' of Y in observation 22 by the three methods. In the same way, we can obtain 'forecasts' for observations 23, 24 and 25. We then have 5 'forecasts' by each of methods A, B and C which we can compare with the known Y-values in the sample to assess the forecasting accuracy of each of the methods. Obviously a good deal of calculation is involved but with a modern computer that is of little importance. The real difficulty lies in setting up suitable programmes.

What criterion does one use to select the most accurate forecasting method? Unless one is unusually lucky, the sample size will limit the number of forecasts rather drastically, so one is unlikely to be able to use sophisticated criteria whose validity usually depends on relatively large amounts of data. It is clear that the coefficient of correlation between the true and forecast values is not appropriate.

In the following schedule A and B are perfectly correlated ($R = 1$) but A is not a good forecast of B.

A :	51	63	75	81	94
B :	102	126	150	162	188

The better a forecast is, the closer the forecast value is to the actual realised value of the variable in question. Obviously the difference between forecast and actual ($F - A$) is an indicator of the forecasting accuracy of the model. If one were concerned with a single category of

expenditure the mean value of $(F - A)$ over the sample would provide a good simple indicator of the quality of the forecasts. However, in this exercise we are concerned with nine different categories of expenditure and the amount spent per head on food is about ten times bigger than the amount spent on fuel. Thus an error of one unit in the case of fuel is much more significant than a similar error in the case of food. For such comparisons it seems reasonable to use the proportional error because it makes the forecasting error independent of the value of the variable. For each category we average this quantity over the number of forecasts obtained. More formally, we may express it as

$$MPE = \frac{1}{N} \left(\frac{F - A}{A} \right)$$

where N is the number of forecasts (9 for the one-year forecasts and 5 for the five-year forecasts).

An indicator of the overall forecasting value of the whole system may be found by taking the mean value of MPE over all 9 consumption categories.

THE DATA

It is fortunate that the Central Bank has recently published a set of tables for most important economic variables.³

At the time of writing, most of these tables cover the period 1953–1975, giving 23 observations. The series have the great advantage of being as consistent as is practicable for the entire period, the effects of changes in definitions and errors in compilation having been removed as far as possible. All the data for expenditures and prices are taken from this source. Population figures are, however, not available there and the series used is taken from the Report on Vital Statistics (1973)⁴ brought up to date by Keating (1977).⁵ As the sources are readily available there is no need to reproduce these series here.

TECHNIQUES

There are five models namely LES, IAS, RS, LR and LGR. The mathematical forms are given in the appendix. Each model consists of nine equations in each of which the dependent variable is constant price expenditure on one category of consumer expenditure per head of population. The independent variables are total consumer expenditure per head and the nine prices. The nine categories are:— food, alcohol, tobacco, clothing, fuel, petrol, durables, transport equipment and residual expenditure (mainly services).

The purpose of the exercise is to see which model will best forecast the pattern of consumer expenditure given the level of total expenditure and prices. Twenty-three observations of the variables are available. The strategy is to use part of the sample to calculate the coefficients of each system, then use these coefficients in combination with the observed values of total expenditure and prices from a succeeding observation to calculate a 'forecast' of the expenditure for that observation. This is then compared with the known expenditure to judge the accuracy of the 'forecast'. The criterion of success used is the proportional error (the difference between the 'forecast' and the actual values divided by the actual). Absolute values of these errors are used so that negative and positive values do not cancel each other.

It was found that 14 observations was the smallest number with which the LES and the IAS would run with reasonable satisfaction. Thus, with 23 observations, 9 one-year 'forecasts' and 5 five-year 'forecasts' can be made. The proportional error was averaged over the 9 and 5 estimates to produce an indicator of forecasting accuracy for each category. These mean proportional errors are finally averaged over the nine categories to give a statistic which indicates the accuracy of the whole system.

The estimating methods used are as follows:—

- (1) The LES is estimated by an iterative maximum likelihood programme devised by Carlevaro and Rossier (1970).⁶
- (2) The IAS is estimated by a similar programme devised by Carlevaro and Sodoulet (1973).⁷
- (3) The LS and LGS are both estimated by ordinary regression methods. The EAS programme of the Oklahoma State University was used.
- (4) The LS was estimated by a special programme compiled by the author at University College Dublin.

THE RESULTS

The main results for the one-year forecasts are given in Table 1 and those for the five-year forecasts in Table 2.

Table One: Mean Absolute Proportional Error for 9 One-Year Forecasts

Consumption Category	Estimating System				
	LES	IAS	LR	LGR	RS
Food	.0135	.0326	.0244	.0221	.0581
Alcohol	.0490	.0596	.0373	.0567	.0836
Tobacco	.0888	.1621	.1875	.1097	.2387
Clothing	.0689	.0888	.0517	.0943	.1483
Fuel	.0439	.0172	.0710	.0949	.1382
Petrol	.0696	.0834	.0808	.0940	.1946
Durables	.0464	.0473	.0516	.0920	.1406
Transport Equipment	.0838	.1085	.1193	.1705	.2847
Residual Expenditure	.0216	.0311	.0266	.0436	.0991
Total	.0539	.0701	.0722	.0864	.1540

The main results are clear enough. The difference between the systems is not very great in the case of the one-year forecasts. It seems that any system — except the RS — will forecast reasonably well in a one-year period. However, the LES has superiority over all the others in six out of the nine categories and the mean for the whole system (5.39%) is well below the next lowest (IAS — 7.01%). In the five-year forecasts the LES and the IAS both perform quite well — indeed the deterioration in quality between the one-year and five-year forecasts is unexpectedly small. The other three systems perform so badly that they do not merit serious consideration. There may well be some merit in economic theory after all! Once again, the LES out-performs all the others in six out of the nine cases and its overall performance is the best. It is reasonable to conclude that if one wants to make forecasts of the pattern of

Table Two: Mean Absolute Proportional Error for 5 One-Year Forecasts

Consumption Category	Estimating System				
	LES	IAS	LR	LGR	RS
Food	.0210	.0195	.0758	.1506	.3342
Alcohol	.1329	.0543	.0801	.3372	.5161
Tobacco	.1452	.2487	.5050	.5436	.8048
Clothing	.1126	.1271	.3402	1.3108	2.8827
Fuel	.0509	.0814	.4314	.5267	2.0304
Petrol	.0945	.1355	.3052	.4492	.7391
Durables	.0436	.0409	.0740	.3808	.6827
Transport Equipment	.1076	.1306	.3307	4.8405	2.8065
Residual Expenditure	.0594	.0642	.1352	.2938	1.1932
Total	.0853	.1002	.2531	.9815	1.3322

consumer expenditure, one would be justified in believing that the LES is the best system to use. This result is consistent with a recent study by the author⁸ which found that the LES is the best estimator of demand elasticities within the sample period. It should be stressed that this result may apply to the Irish economy only — there is no reason why the demand structure in another country should not favour a different system.

As a final exercise we may use the LES to provide forecasts for the year 1982, five years from the time of writing. Table 3 gives the coefficients of the LES which are calculated using all the data available, that is, for the period 1953–1975.

Table Three: Coefficients of LES 1953 – 1975

Category	C_i	b_i
Food	8.654	.1369
Alcohol	1.884	.1675
Tobacco	2.699	.0010
Clothing	2.194	.0932
Fuel	0.940	.0487
Petrol	0.643	.0899
Durables	0.770	.0764
Transport Equipment	0.323	.0704
Residual	7.068	.3160

These are inserted in the demand system:—

$$P_i Q_i = c_i + b_i \left[Y - \sum P_j c_j \right]$$

(b_i and c_i are the given constants, Q_i is the 'quantity' of good, i – actually constant price expenditure – and P_i is the price of good i). This gives forecasts of expenditure on each of the nine goods. We need as inputs values for total money expenditure (Y) and for each of the prices. Two forecasts are formed on the following assumptions.

Forecast 1:— Real income will rise by 4% per annum in each year in the period 1978–1982 and all prices will rise by 7% per annum.

Forecast 2:— Real income will rise by 4% per annum and each price will increase by half the amount of its increase in the period 1970–1975.

These expenditures may be expressed as budget shares for purposes of comparison. A budget share is the fraction of total expenditure devoted to the good in question.

It is clear that expenditure on all categories will increase substantially as one would expect with substantial increases in prices and income. It is also obvious that the variation in price between forecasts 1 and 2

The results are as follows:—

Table Four: Consumer Expenditure £ per head: Actual 1975 and Forecasts 1982			
	<i>Actual 1975</i>	<i>Forecast 1</i>	<i>Forecast 2</i>
Food	210	396	401
Alcohol	98	203	207
Tobacco	41	66	57
Clothing	64	152	154
Fuel	39	79	86
Petrol	52	103	107
Durables	37	92	93
Transport Equipment	26	73	75
Rest	227	486	491

do not cause very great differences. It would appear that price differences have a relatively small effect on the pattern of consumer expenditure. Table 5 gives the better insight into the likely development of the demand categories. Food and tobacco will take a smaller fraction of the consumer's £1. Alcohol, fuel and petrol may be expected to expand at about the same rate as total expenditure. Clothing, durables, transport equipment and the residual category (mainly the services) should take an increasing share of total expenditure. It is in these categories that the most rapid expansion of demand may be expected.

This article has dealt with the general problems of forecasting and so has used large aggregates like 'Food' and 'Clothing'. In practice, a firm is likely to be more interested in the demand for particular commodities like margarine or men's suits. There would be little difficulty in adapting the model to provide such forecasts. Suppose, for example, that a five-year forecast of the demand for margarine is required. One would need information about the price and total expenditure on margarine over the period being used in the model — this could well be the most difficult step but such information can be found for a great many commodities. Since margarine forms part of the 'Food' category, ex-

Table Five: Budget Shares; Actual 1975 and Forecasts 1982			
	<i>Actual 1975</i>	<i>Forecast 1</i>	<i>Forecast 2</i>
Food	.2648	.2401	.2398
Alcohol	.1232	.1232	.1239
Tobacco	.0519	.0399	.0340
Clothing	.0805	.0920	.0922
Fuel	.0495	.0480	.0512
Petrol	.0654	.0625	.0640
Durables	.0467	.0555	.0559
Transport Equipment	.0326	.0441	.0450
Rest	.2853	.2946	.2939

penditure on margarine would have to be subtracted from total 'Food' expenditure. A small adjustment in the 'Food' price index might also be necessary because the price of margarine is no longer included in the larger index. However, in practice this price adjustment is usually so trivial that it can be ignored.

Our model would now contain ten categories, namely the nine used in this paper plus margarine. The ten-category model would then be re-estimated using LES and the co-efficients for margarine would be used in conjunction with forecast income and price to form the expenditure forecasts in the manner explained above. The fact that expenditure on margarine might be much smaller than the other categories will not cause any difficulties. This matter has been investigated by the author⁹ and it was found that the LES can operate quite satisfactorily when the smallest expenditure category is of the order of one hundredth of the largest.

APPENDIX – MATHEMATICAL FORMS

In all the expressions below Q_i is constant-price expenditure on good i , Y is total money expenditure, P_i is the price of good i and a , b , c are constants.

1. Linear Expenditure System

$$P_i Q_i = c_i + b_i [Y - \sum P_j c_j]$$

2. Indirect Addilog System

$$Q_i = a_i R_i (b_i + 1) / \sum a_j R_j b_j$$

where R_i is $Y \div P_i$

3. Linear Regression System

$$Q_i = a_i + b_i Y + c_{i1} P_1 + \dots + c_{i9} P_9$$

4. Logarithmic Regression System

$$\log Q_i = a_i + b_i \log Y + c_{i1} \log P_1 + \dots + c_{ig} \log P_g$$

5. Rotterdam System

$$W_i \ln Q_i = b_i \ln M + c_{i1} \ln P_1 + \dots + c_{ig} \ln P_g$$

Where $W_i = \frac{\text{expenditure on good } i}{\text{total expenditure}}$

(i.e. the average budget share) and 'ln' is the change in the natural logarithm. M is total constant-price expenditure.

REFERENCES

1. A. Brown and A. Deaton, "Models of Consumer Behaviour, A Survey", *Economic Journal*, No. 323, Dec. 1972 pp. 1145-1237.
2. D. McFadden, *Existence Conditions for Theil-type Preferences*, Social Systems Research Institute, University of California, Berkeley Discussion Paper, 1964.
3. Central Bank of Ireland, *Data Bank of Annual Economic Time-series*, Dublin 1977.
4. Central Statistics Office, Dublin, *Report on Vital Statistics*, 1973.
5. W. Keating, "Analysis of Recent Demographic Trends", *Statistical and Social Inquiry Society of Ireland Journal*, 1976/7, Vol. XXIII Part IV, pp. 113-150.
6. F. Carlevaro and E. Rossier, *Le Programme LINEX*, Centre d'Econometrie, Universite de Geneve, 1970.
7. F. Carlevaro and E. Sadoulet, *Trois Programmes d'estimation d'une classe generale de fonctions de consommation additives*, Centre d'Econometrie, Universite de Geneve. 1973.
8. W. K. O'Riordan, "The Accuracy of Demand Estimators", *The Economic and Social Review*, Vol. 9, No. 2, 1978, pp. 125-146.
9. W. K. O'Riordan, "The Demand for Food in Ireland", *The Economic and Social Review*, Vol. 7, No. 4, July 1975, pp. 401-415.