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The role of macro-economic models in short-term forecasting

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1. Setting of the problem.

The application of econometric models to short-term forecasting, that is to say, forecasting up to one year ahead, has naturally enough been extensively discussed. Some of the discussion has centred on the usefulness of econometric models in general for this purpose as against other forecasting methods. It is clearly realised that short-term forecasting by means of non-econometric methods is not only possible but may give better results than are obtained by the use of econometric models. It is therefore quite legitimate to argue against the use of models in the realm of short-term forecasting. If, on the other hand, one believes that econometric models can make a useful contribution in this field, then the question arises what kind of models are most appropriate for this purpose.

In this context, the argument brought forward by Friend and Jones [2] and reiterated by Friend and Taubman [3] is of interest. The thesis of the authors is that for forecasting the gross national product and its major componentsup to one year ahead, a small-scale model consisting of a few equations is at least as suitable as a large and detailed model.

The size of a model, as measured by the number of equations and endogenous variables, is of course an important practical consideration, but it is not the only one that is relevant. If the task in hand consists in predicting a large number of variables, this in itself does not necessarily create difficulties; by keeping to a few equations, not all difficulties are eliminated.

An important distinction is that between recursive and interdependent systems. The advantages which the recursive system and causal chain offer have been outlined by Wold [8, 9] , who also initiated a wide range of practical applications, particularly in demand and supply analysis for various commodities. In this field, it is generally possible to arrive at a logical specification of the causal connection which exists between the variables, and thus to build up a causal chain model.

The position is different where national accounts totals are concerned. Here, the causal direction of any relationship which exists is often uncertain. For example, the specification of a causal direction from income to total expenditure, which is correct for individual households and thus in a cross section study of household budgets, may cease to be valid for the economy as a whole, since an autonomous decision to save or dissave and thus to reduce or increase consumer spending may influence gross national product.

Most macro-economic models encountered in practice thus constitute interrelated rather than recursive systems, without any cause-effect relationship being specified between the endogenous variables. However, most models contain current exogenous variables which are specified as influencing the endogenous variables without being influenced by them and thus as causal in the relationships.

The usual procedure in the construction of models and their application to forecasting is based on two underlying assumptions. In the first place, the structural equations and the parameter estimates contained therein are taken as lending themselves to theoretical interpretation and as giving an insight into the working of the economy. Secondly, the use of these structural equations or prediction equations derived from them, together with estimates of the current exogenous variables from outside information, is believed to help with forecasting future values of the variables in the system.

In the present study, these two assumptions are successively examined. Arising out of these considerations, a new approach to model formulation for short-term forecasting is advocated; and an illustration in the form of a simple prediction model is given.

2. True and apparent structural relationships.

An estimated quantitative relationship between economic variables is clearly useful if it represents a true structural relationship. By this is meant a mathematical relationship between the levels of the variables concerned which holds good over the whole observation period to which the data refer, as well as in the near future which is to be studied.

In practice, the existence of such a relationship is open to doubt in many instances. The problem of the stability or instability of structural parameters and of tests to measure their behaviour has been systematically investigated and discussed by Menges and Diehl [5]. Instability may arise through a jump or a gradual shift in one of the parameters. Certainly, the possibility of a jump has in some cases been recognised by model builders, who have broken up the observation period and estimated separate equations for two or more sub-periods.

A parameter shift over time is even more commonly assumed explicitly by the introduction of a linear time trend or implicitly by the use of first differences in an equation estimated in the ordinary way, in which a constant term is thus permitted to appear. It is maintained here that this procedure already violates the assumption of a true structural relationship. If considerations of error specification lead to the formulation of relationships in terms of first differences, then a true relationship would require the fitting of a regression through the origin. Also, if the constant term in the relationship between the original variables is subject to change over time, the same may well apply to the coefficient of any of the variables. Furthermore, a more complex situation may easily be envisaged.

Take x_1 and x_2 as two variables, transformed into first differences. Each of these may be considered as consisting of an autonomous part ξ_1, ξ_2 and an induced part η_1, η_2 such that

$$x_1 = \xi_1 + \eta_1$$

$$x_2 = \xi_2 + \eta_2$$

It is now assumed that the induced part of either variable depends on the autonomous part of the other. In the simplest case

$$\eta_1 = \beta_{12}\xi_2$$

$$\eta_2 = \beta_{21}\xi_1$$

This assumes not only proportionality between autonomous change in one and induced change in the other variable, but also the absence of further variables influencing the relationships and of errors in the usual sense. The parameters β_{12} and β_{21} may be regarded as the true structural coefficients in the system. We have

$$x_1 = \xi_1 + \beta_{12}\xi_2$$

$$x_2 = \xi_2 + \beta_{21}\xi_1$$

Only the variables x_1 and x_2 are observable, but it is clear that β_{12} and β_{21} are not identified and that no estimates may be derived from observations for x_1 and x_2. For example, take the autonomous changes as independently distributed random variables

$$\xi_1 = \overline{\xi_1} + \epsilon_1$$

$$\xi_2 = \overline{\xi_2} + \epsilon_2$$

with variances σ_1^2, σ_2^2. Then

$$E(x_1) = \overline{\xi_1} + \beta_{12}\overline{\xi_2}$$

$$E(x_2) = \beta_{21}\overline{\xi_1} + \overline{\xi_2}$$

$$E\{(x_1 - \overline{x_1})^2\} = \sigma_1^2 + \beta_{12}^2\sigma_2^2$$

$$E\{(x_2 - \overline{x_2})^2\} = \beta_{21}^2\sigma_1^2 + \sigma_2^2$$

$$E\{(x_1 - \overline{x_1})(x_2 - \overline{x_2})\} = \beta_{21}\sigma_1^2 + \beta_{12}\sigma_2^2$$

The regression coefficient b_{21} of x_2 on x_1 will thus generally be a weighted mean of β_{21} and $1/\beta_{12}$. Alternatively, if the regression is computed on the cumulative variables of which x_1 and x_2 are the first differences, this virtually uses the ratio $\overline{x_2}/\overline{x_1}$, which is also generally a weighted mean of β_{21} and $1/\beta_{12}$ though with different weights. Without making assumptions about $\overline{\xi_1}$, $\overline{\xi_2}$, σ_1^2 and σ_2^2 which would probably be unwarranted, it is not possible to estimate β_{21} or β_{12} from $\overline{x_1}$, $\overline{x_2}$, $\Sigma(x_1 - \overline{x_1})^2$, $\Sigma(x_2 - \overline{x_2})^2$ and $\Sigma(x_1 - \overline{x_1})(x_2 - \overline{x_2})$.

If we have three variables in first difference form such that

$$x_3 = x_1 + x_2$$

as in the Haavelmo model of the consumption function, then there may exist three autonomous changes and six structural parameters connecting the induced with the autonomous components, subject to three identities so that

$$x_1 = \xi_1 + \beta_{12}\,\xi_2 + \beta_{13}\,\xi_3$$

$$x_2 = \xi_2 + \beta_{21}\,\xi_1 + \beta_{23}\,\xi_3$$

$$x_3 = \xi_3 + \beta_{31}\,\xi_1 + \beta_{32}\,\xi_2$$

with $\beta_{31} - \beta_{21} = \beta_{32} - \beta_{12} = \beta_{13} + \beta_{23} = 1$.
To estimate any of the coefficients from the sums computed from observations is even less practicable in this case than in the previous one.

The addition of a further explanatory variable which is observable does not help to make the system identified. If

$$x_1 = \xi_1 + \beta_{12}\,\xi_2 + \gamma z$$

$$x_2 = \xi_2 + \beta_{21}\,\xi_1$$

where z is observable, then γ may be estimated by simple regression of x_1 on z or by partial regression of x_1 on z and x_2; but β_{12} and β_{21} elude estimation as before.

The true relationship or relationships could, of course, be more complex still; but even the simple system

$$x_1 = \xi_1 + \beta_{12}\,\xi_2, \quad x_2 = \xi_2 + \beta_{21}\,\xi_1$$

may be imagined as generating a wide variety of time series. Since for the theoretical correlation coefficient ρ between x_1 and x_2 we have

$$1 - \rho^2 = \frac{(1 - \beta_{12}\,\beta_{21})^2\,\sigma_1^{\,2}\,\sigma_2^{\,2}}{(\sigma_1^{\,2} + \beta_{12}^{\,2}\,\sigma_2^{\,2})(\beta_{21}^{\,2}\sigma_1^{\,2} + \sigma_2^{\,2})}$$

correlation between the series may be high or low according to the values of β_{12} and β_{21}.

Although it is not possible to prove this, it is suggested here that this is a realistic way of looking at short-term relationships between economic macro-variables. If this is accepted, then it follows that true structural relationships cannot be established between the observed variables but only apparent structural relationships. It may still be useful to formulate and estimate such relationships, but they should then be looked upon as predictive relationships which permit the prediction of one variable from another; and they should be judged by the degree of their predictive usefulness rather than by their contribution to economic insight.

3. Classification of variables.

Traditional econometric model building involves a distinction between endogenous and exogenous variables. This procedure is legitimate in as far as the variables in the second category are truly exogenous, exerting an influence upon the endogenous variables but not in turn being influenced by them. In practice, it is not always easy to find an adequate number of such variables in a macro-economic system. The true relationships which exist between the endogenous variables and those classified as exogenous for practical reasons may well be in the nature of two-way relationships such as were discussed in the preceding section; and in this case, numerical relationships which may be established have only a limited theoretical value. For example, exports are often treated as exogenous, but on the other hand, exports and gross national product may well both have autonomous components mutually influencing each other.

Seen from the practical point of view in connection with forecasting, the main considerations governing the choice of variables to be treated as exogenous are, firstly, the extent to which it is possible to obtain a reasonably good estimate for the series from outside information; and secondly, the extent to which it helps in predicting the variables treated as endogenous. The importance of the former point is obvious, as some series tend to be notorious in eluding prediction. The latter point may be illustrated here by an example.

In the Haavelmo model of the consumption function

$$C = \alpha + \beta Y + \epsilon$$

$$Y = C + Z$$

let C represent personal expenditure and Y gross national product, both at current prices, so that Z is domestic investment plus government expenditure plus net exports. Z is treated as exogenous; consequently the regression of C on Z is to be estimated.

Data published by the O.E.C.D. [6] for the twelve years from 1950 to 1961 (with adjustments to ensure continuity for France and Germany) have been used to estimate regressions for 14 different countries. The resulting estimates b/(1-b) vary between 1.035 and 2.448, and thus the indirect least square estimates b between .509 and .710. The values of r^2 in the regression of C on Z vary between .845 and .992, and indeed are above .9 for 13 of the countries.

Substituting the actual values of Z for each of the 12 years into each regression, the predicted values C_p have been computed and converted into 11 first differences ΔC_p; similarly 11 first differences ΔC in actual consumption expenditure have been computed for each country. The measure of the prediction error $\Sigma(\Delta C - \Delta C_p)^2$ has then been obtained for comparison with the measure of dispersion $\Sigma(\Delta C - \overline{\Delta C})^2$, and their ratios are as follows:

Country	$\dfrac{\Sigma(\Delta C - \Delta C_p)^2}{\Sigma(\Delta C - \overline{\Delta C})^2}$
Austria	1.37
Canada	22.35
Denmark	1.64
France	.65
Germany (Fed. Rep.)	1.78
Greece	1.97
Iceland	1.06
Ireland	10.76
Italy	2.03
Netherlands	1.42
Norway	13.33
Sweden	4.52
United Kingdom	15.86
United States	10.28

In all countries except France, the ratio is greater than 1. Even if the regression equation of C on Z and the exact value of Z each year had been given, the resulting prediction for ΔC would thus in most countries have been worse than if only the correct value of $\overline{\Delta C}$ was given and this average had been used each year as the forecast increase in personal expenditure.

Although this illustrative example may be considered as an extreme case, it highlights the difficulties which arise in connection with the use of current exogenous variables for forecasting purposes. The position may be improved by estimating prediction equations from first differences, but on the other hand if the values of the exogenous variables are themselves uncertain, another element of error is introduced.

One may escape some of these difficulties if the model is formulated in such a way as to contain no current exogenous variables, so that the only predetermined variables which occur are lagged terms. A model of this kind, which attempts to explain quarterly changes in personal consumption, in gross private domestic investment, and in government expenditure plus net foreign investment in current prices for the United States, was constructed by Gallaway and Smith [4]. The explanatory variables refer to changes in the two previous quarters, except for an indicator of liquid assets at the beginning of the current quarter which may also be considered as a lagged term.

Whilst a model of this kind, once it is given, makes forecasting one period ahead a simple matter of arithmetic, it is clear that a price has to be paid for this simplification of the forecaster's task. This is shown up by relatively low coefficients of determination in the Gallaway-Smith model, amounting to .23, .40 and .42 respectively in the three equations. If the fit of the equations to past data is not a good one, they clearly cannot be expected to yield accurate forecasts in the future. Indeed, it would be surprising if it were otherwise, as the implication would be a very high degree of determinacy for the movements of major economic variables.

The accuracy of prediction may be improved by introducing explanatory variables which are essentially leading indicators, such as the number of houses started in an equation for residential building, and anticipations for plant and equipment expenditure in an equation for actual plant and equipment expenditure; these are features, for example, of the Friend-Jones model [2]. Such variables, however, do not make any contribution towards an explanation in terms of the economic system but merely provide forecasting devices; and unless they are themselves explained by structural relationships, their use means that features of non-econometric forecasting methods have been introduced into the econometric model equations.

The approach which is suggested here follows a different principle. It is recognised that there is a need for using variables which are estimated on the basis of outside information, and thus a need for making a distinction between these variables and others which are to be estimated by means of an econometric model. But this distinction does not have to follow a classification into exogenous and endogenous variables made on theoretical grounds; and the two kinds of variables in the model may be more aptly described as predictor variables and predicted variables. Lagged variables may of course be used side by side with the predictor variables.

The problem which arises then consists in finding suitable predictor variables, for which one may reasonably hope to be able to make some kind of prediction by extrapolation or other simple assumptions, and which at the same time can make a substantial contribution towards explaining the changes in those variables which are to be predicted by the model. As there is usually some information available about almost all the variables in the system but none of them necessarily very accurate, the choice of predictor variables may not be an easy one and may permit a number of alternatives.

In general, it would seem reasonable to estimate from outside information changes in larger aggregates and to deduce changes in their components by model equations. This is a standard technique in forecasting consumer expenditure patterns, which does not seem to come amiss here even though there may be no causal connection between aggregate and components. This is in contrast to the non-econometric procedure of estimating each component from outside information and thus building up the totals.

4. A model for Ireland.

The general considerations outlined here will now be applied to an experimental forecasting model for

Ireland. The problem faced here concerns the forecast for one year ahead - that is to say, for the current year as soon as the figures for the past year are given, in provisional form at any rate, - of the following national accounts totals at current prices:

C personal expenditure
G government current expenditure
I gross fixed investment
X exports of goods and services
M imports of goods and services
Y gross national product

The following variables at current prices may also be introduced.

B stockbuilding
D final demand

which is defined here as excluding stockbuilding so that

$$D = C + G + I + X$$
$$= M + Y - B$$

In the first instance, it may be noted that in the long run the ratios between various aggregates are very stable. Indicating for example the current price totals for 1948 by C_o, G_o ..., the following ratios are obtained for 1963:

$$C/C_o = 2.047$$
$$G/G_o = 2.324$$
$$I/I_o = 3.570$$
$$X/X_o = 2.363$$
$$M/M_o = 2.206$$
$$Y/Y_o = 2.264$$

Thus government current expenditure, exports, imports and gross national product increased at practically the same rate; since the increase for investment was higher, that for personal consumption had obviously to be lower. Admittedly there is a fortuitous element in this, since the foreign trade variables contained a smaller price component and a larger volume component than government expenditure and national product. Even so, one might feel inclined to formulate the following long-term relationships:

$$G/Y = \text{const.}$$
$$X/M = \text{const.}$$

Of course, these relationships would have little value for short-term analysis; but they have some bearing on the formulation of short-run relationships, since they suggest that these should be expressed in terms of percentage differences (or logarithmic differences). The year-to-year percentage changes for all variables except B may be denoted by c, g, i, x, m, y and d respectively; thus e.g.

$$c = 100\ (C - C_{-1})/C_{-1}$$

Also the changes p_m and p_y in the implied price indices for imports and gross national product are introduced. If m' and y' are percentage changes at constant prices

$$p_m = 100\ (m - m')/(100 + m')$$
$$p_y = 100\ (y - y')/(100 + y')$$

In the light of the general propositions developed in the previous section, the change in final demand d has been chosen as the main predictor variable for c, g, i, x, m and y. The justification for the choice lies in the fact that some general indication of the way final demand is moving is usually available at the beginning of the year, even though there is no strong evidence for the numerical value of the increase in any one of its components. Alternative indicators could, of course, have been chosen, as for example the change in total market supplies which includes stock-building.

The difference between p_y and p_m is also introduced into the equations for m and y, as import prices and the national product price may diverge considerably, with consequent effects upon the two value totals. Price changes are generally easier to forecast than quantum changes with the help of extrapolation and assessment of the effects which forthcoming wage rises may have, so that $p_y - p_m$ seems suitable as a predictor variable.

Furthermore, a lagged expression is introduced into each equation; except for the investment equation, the term consists in a difference between lagged percentage changes. These expressions are in the nature of adjustment variables, indicating an adjustment in the opposite direction after a divergence between variables which display a considerable degree of long-term stability in their relation to each other. For example, an abnormally large increase in consumption as compared with the increase in gross national product in one year may be expected to be followed by a relatively small increase in the following year and vice versa. In the equation for i, the term i_{-1} does not represent an adjustment but reflects the cyclical nature of investment in the face of long-term decisions, thus predicting a large increase for the current year from a large increase in the past year.

From statistics officially published by the Central Statistics Office [1], year-to-year changes from 1948/49 to 1962/63 inclusive were computed and used as a basis for estimating six prediction equations, which after some experimentation were obtained as follows:

$$c_p = 1.12 + \underset{(.152)}{.640}\, d - \underset{(.125)}{.157}\, (c_{-1} - y_{-1}) + K \quad (R^2 = .635)$$

$$g_p = -.61 + \underset{(.367)}{1.150}\, d - \underset{(.191)}{.076}\, (g_{-1} - y_{-1}) + K \quad (R^2 = .450)$$

$$i_p = -2.41 + \underset{(.768)}{1.041}\, d + \underset{(.184)}{.563}\, i_{-1} + K \quad (R^2 = .615)$$

$$x_p = -.39 + \underset{(.400)}{1.139}\, d - \underset{(.107)}{.043}\, (x_{-1} - m_{-1}) + K \quad (R^2 = .410)$$

$$m_p = -3.45 + \underset{(.562)}{1.808}\, d - \underset{(.256)}{.895}\, (p_y - p_m) - \underset{(.180)}{.410}\, (m_{-1} - d_{-1}) + K \quad (R^2 = .759)$$

$$y_p = 1.33 + \underset{(.173)}{.700}\, d + \underset{(.073)}{.374}\, (p_y - p_m) - \underset{(.154)}{.356}\, (y_{-1} - d_{-1}) + K \quad (R^2 = .774)$$

Effectively, the equations are used only to estimate five differences between the rates of increase in value, since c_p, g_p, i_p and x_p must be consistent with the inserted value for d. Consistency is ensured by the additive correction term K which is the same for all equations but varies from year to year. For the 15 years of the observation period, K varies between -1.3 and +1.0.

The coefficients of determination are unadjusted for degrees of freedom and indicate the goodness of fit before the adjustment K has been made. In general, the effect of this correction is to bring about a slight improvement in fit. Since the individual variables are components of the explanatory variable d, it is of course not surprising to find reasonably high correlations in spite of the simple nature of the equations.

The coefficients of the price variable and of the lagged terms all have the expected sign, though the coefficients of the adjustment variables for consumption, government expenditure and exports are not statistically significant. Similarly, the differences from 1 obtained for the coefficients of d are not significant, but their sign is in accordance with common sense.

Since the construction of the model, provisional data for 1963/64 have become available. The values of the predictor variables are

$$d = 12.7$$

$$p_y - p_m = 9.0 - 3.2 = 5.8$$

Substituting these and the lagged variables into the equations, crude prediction values are obtained. From the condition

$$C_{-1}\ c_p + G_{-1}\ g_p + I_{-1}\ i_p + X_{-1}\ x_p = 12.7$$

it follows that $K = .6$

and the model yields the following results, compared with the official estimates:

$c_p = 9.8$	$c = 10.6$
$g_p = 14.4$	$g = 17.2$
$i_p = 18.8$	$i = 19.9$
$x_p = 14.8$	$x = 12.1$
$m_p = 13.6$	$m = 14.0$
$y_p = 13.7$	$y = 13.6$

The agreement is reasonably good, particularly so for imports and gross national product.

The problem of forecasting the changes 1964/65 is of greater current interest at the time of writing this paper. In ordinary circumstances, this task would involve an estimate to be made of d and $p_y - p_m$, or perhaps different estimates based upon alternative assumptions. In this instance, however, official 1965 projections have already been published for the major national accounts data in the framework of the Second Programme [7]. The model may thus be applied to ascertain whether the official projections are consistent with each other in the light of the experience embodied in the equations. In so far as substantial discrepancies are observed, it becomes then a matter of judgment whether these may be ascribed to special factors operating in the current situation, to errors in the model or to errors in the official predictions.

The published data imply that

$$d = 7.9$$

$$p_y - p_m = 4.1 - 2.3 = 1.8$$

These figures need not turn out to be correct but may be taken as acceptable. The model predictions and corresponding official projections then are as follows:

$c_p = 5.8$	$c = 7.7$
$g_p = 7.4$	$g = 6.0$
$i_p = 16.2$	$i = 14.3$
$x_p = 7.9$	$x = 5.8$
$m_p = 7.9$	$m = 5.1$
$y_p = 6.4$	$y = 8.3$

Thus, the model suggests a smaller increase in personal expenditure and a larger increase in other final demand components, particularly exports, than the official projections; it also suggests a larger increase in imports and a smaller increase in gross national product.

The differences for government expenditure and investment are inconsiderable, particularly in view of the fact that the total amounts involved themselves are relatively small. The differences for exports and personal expenditure are more substantial. Since special factors such as the British import surcharge are in operation, one may well be inclined to accept the official projections for these variables as more realistic than the pure model predictions. It will be noted that the model also overestimated the rise in exports and underestimated the rise in consumption between 1963 and 1964; if this tendency persists, the model may have to be revised.

One may feel less inclined to believe that special factors are at work to reduce imports below and raise gross national product above the level predicted by the model, or in any event that they would do so to the extent suggested by the official projections. A larger differential between import price and national product price might help to bring this about; but this would affect the projections at constant prices.

One may thus conclude that the officially projected 4% increase in real gross national product between 1964 and 1965 is unlikely to be realised. The anticipation of a balance of payments deficit for 1965 to the tune of £30 mill. which is no higher than that observed for 1964 also seems mildly optimistic.

5. General Conclusions.

The model described here is not claimed to be perfect in any way. Improvements may be attempted in various directions, by modifying the specification for the equations already estimated and by adding on further equations for other variables. It may, however, serve here to exemplify the type of model which, on the basis of the argument developed, appears suitable for short-term forecasting.

The main feature of the equations in the model is that they do not contain any implication of cause-effect relationship between the predictor variables formally treated as exogenous and the predicted variables formally treated as endogenous. The distinction is made on the basis of practical rather than theoretical considerations. The equations then indicate patterns in rates of change which are likely to be realised in present conditions.

Some of the predictor variables used may in fact be truly exogenous, as for example import prices in a small country like Ireland. If, however, variables which are theoretically exogenous but difficult to predict are introduced as predictor variables, then the character of the model is changed; it will then be chiefly suitable for making conditional forecasts based on alternative assumptions. The main field of practical application for such conditional forecasts lies in the realm of long-term and medium-term rather than short-term forecasting. Similarly, policy instruments such as taxation rates may be used in a model, provided enough experience has been gained to assess their effect. The model then becomes a policy decision model rather than a forecasting model.

Perhaps the most important point which emerges is the general lesson that in model building, special regard should be had to the purpose for which the model is built. We have moved away from the idea of constructing a single index describing the general price level, or a single total describing national income and product; instead, a variety of such index numbers and national accounts totals are now being given. In the same way, there may be a case for building models of different kinds for different ends, rather than attempting the formulation of all-purpose models.

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