Journal of the Statistical and Social Inquiry Society of Ireland, Vol. XXIV, Part IV, 1981/82, pp.41-84

THE BEHAVIOURAL CHARACTERISTICS OF THE MODEL-80 MODEL OF THE IRISH ECONOMY*

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(Read before the Society, 11 February 1982)

1. INTRODUCTION

For as long as governments have had the inclination or capability to influence economic events they have based their policies on their beliefs and prejudices as to how the economy works. These beliefs and prejudices constitute, de facto, a model of the economy. Similarly, while they may not admit it, businessmen have, for centuries, carried an incipient economic model around in their heads. Anyone who is interested in forecasting the future either with a view to altering the likely course of economic events, or accommodating their own activities to that likely course, has to form views on how the economy works. However, it is only really in the last thirty years that economists have begun to formalise these prejudices or views into a quantitative framework.

The process of model building offers a number of advantages over the eclectic alternative. The actual process of setting down one's prejudices in algebraic format may require considerable re-thinking of previously held views to arrive at an internally consistent framework. In addition to acting as a stimulus to logical thinking, the construction of a formal model makes possible the testing of the theoretical framework by confronting it with the reality of economic events. While this formal testing may show that models have many defects, the knowledge of the existence of these defects is an advance. The fact that models produce quantified answers to the questions put to them may lend an air of certainty to what is truly an uncertain process. However, this tendency to view models as black boxes which come up with "right" answers is the fault of the viewers and not of the models themselves. In this paper we hope to show how macro-economic models can add to our understanding of how the economy works, though this understanding is still hedged around with a forest of question marks.

When the Central Bank's Research Department presented their paper on their model to this Society just over three years ago, they concentrated on setting out the methodology of model building and indicating the uses to which their model might be put (Central Bank, 1978). Since that date, the model has been applied to many different tasks and, as a result of the experience gained in both the Central Bank and the Department of Finance, has been considerably altered. This new version of the model, MODEL-80, was developed jointly by the Department of Finance and the Central Bank and has been used in both institutions for the past year. It is described in detail in Bradley et al., 1981.

* The views expressed in this paper are the sole responsibility of the authors and do not necessarily represent the views of the Department of Finance, the Central Bank or the ESRI. The authors would like to express their thanks to their colleagues in these three institutions on whose research this paper is based. In particular the authors would like to thank one of the developers of MODEL-80, Dr John Bradley of the ESRI, for his advice and assistance in preparing this paper.

The major changes made in the model since 1978 are:

(i) Earlier versions of the model made no attempt to model the effect of supply constraints on the economy. MODEL-80 attempts to remedy this in an indirect manner by making the balance of trade sensitive to domestic supply conditions (Browne, 1979, 1980; FitzGerald, 1979).

(ii) In line with the attempt to model the supply of real goods, a considerable amount of effort has been put into trying to model the markets for the factors of production in a more sophisticated way than heretofore (Bradley, 1979; Bradley and O'Cassidy, 1980). While attempts to model the joint demand for capital and labour in a completely consistent manner have so far proved unsuccessful, the model, as it now stands, shows the demand for labour and capital as being sensitive to wages and prices.

(iii) The Government sector has been re-modelled to endogenise a greater proportion of revenue and expenditure and to simplify the model from the point of view of users (FitzGerald, 1979).

(iv) The consumption function has been altered, dropping the liquid assets argument incorporated in the 1978 model (Kelleher, 1977).

(v) Finally, two additional sectors, stocks and output, have been fully endogenised.

Unlike the paper delivered to this Society by the Research Department of the Central Bank (1978), this paper is not so much concerned with the actual specification and testing of a model of the Irish economy as with its behavioural characteristics. Our objective is to describe these behavioural characteristics, evaluate how much faith can be put in them and examine how they conform to current thinking concerning the Irish economy. Some economists involved in macro-economic model building elsewhere, especially in the United States, would deprecate such a concentration on the plausibility of the behaviour of the model. For them the major question to be asked is "does the model forecast well?". However, for those who are involved in policy formulation, such as the Department of Finance, the Central Bank, and most other European model builders, the major purpose for which a model will be used will be to simulate the effects of changes in policy. For this purpose it is vital that the model replicate, as closely as possible, the actual behaviour of the economy so that the effects of marginal changes in key variables can be traced. While too much emphasis should not be placed on this dichotomy ("good" models will generally be good for both forecasting and policy simulation), it should be borne in mind when examining MODEL-80 that it is primarily designed to examine the effects of changes in fiscal policy on the economy.

The specification of MODEL-80 is based on the work of many economists in addition to the authors. To an extent, it represents a drawing together of macro-economic research in recent years. Because of limitations on space, detailed references are frequently omited from the text but are given in the bibliography.

The structure of the rest of the paper is as follows: Section 2 gives a brief outline of the current version of the model; Section 3 discusses the testing of the model and the lessons to be learned therefrom; Section 4 describes the behavioural characteristics of the model; Section 5 examines the sensitivity of the model's behaviour to specification changes, and Section 6 suggests some further avenues which might be explored and invites your comments on how the model should develop in the future.

2. STRUCTURE AND SPECIFICATION

2.1: Introduction

This section aims to give an impressionistic view of the structure and specification of

MODEL-80. Because of the model's size and the limited nature of this paper, it is not possible to go into detail on the precise specification chosen for each equation and why that specification was preferred to the other possible alternatives. Full details of each equation are given in Bradley, et al. (1981). The approach taken here concentrates merely on listing the arguments which appear in key equations in order to provide a background for the discussion of the behaviour of the model in Section 4.

The model itself is large by the standards of the models previously used in Ireland. It is based on annual data and contains 266 endogenous variables - 77 stochastic equations and 189 identities. The model is driven by 107 exogenous variables. The estimation period was 1960-77. The data used were drawn largetly from National Income and Expenditure 1977 and are given in FitzGerald and Kirwan (1979).

Ordinary least squares, with adjustment for autocorrelation, where necessary, was used to estimate most of the model. The one exception was the wage price block where the simultaneity was expected to be greatest. This was estimated using two stage least squares. However, the results achieved by the latter method were very similar to those obtained using ordinary least squares. All the estimation and much of the simulation and testing, were carried out using the TROLL econometric package developed by the United States National Bureau of Economic Research and the Massachusetts Institute of Technology (MIT) (MIT, 1979). This package, now available on the CDPS computer in Kilmainham, was essential to the success of this project. Without it we would probably still be floundering in a sea of paper. In actually using the model for day-to-day policy analysis and forecasting, a specially designed computer package (Bradley and FitzGerald, 1981) is used.

For ease of exposition, the structure of the model is considered under the following sectoral headings:

(i) the demand sector
(ii) the labour market
(iii) output
(iv) the foreign trade sector
(v) the government sector
(vi) prices
(vii) the monetary sector

2.2: The Demand Sector

One of the key sets of equations in the model is that determining personal consumer expenditure, disaggregated into durables, non-durables and services. Over the years, a wide range of specifications has been tried for this variable with more or less success (Digby, 1980; Honohan, 1979; and Kelleher, 1977). The version finally adopted for this model is the simplest formulation where consumption in volume terms is a linear function of real disposable income. In this case the aggregate short-run propensity to consume was 0.57. An alternative formulation, based on Honohan (1979), was tried, where the propensity to consume is parametrised in terms of the rates of inflation and unemployment. While this fitted better on a single equation basis, as is explained in Section 3, it proved unsatisfactory when the overall model was solved as a complete system of equations.

Investment in the model has been disaggregated into residential construction (IRB), non-residential construction (IOB) and non-construction investment (INB) with the private components of each category being treated as endogenous. Net investment is assumed to occur as a result of changes in the desired capital stock, while replacement investment is assumed to be proportional to the initial capital stock. Non-building investment is a function of a domestic activity variable (final demand (FD)), a foreign activity variable, world exports (XW) and the price of output (P_q) relative to the price of capital,

which itself is a function of the price of capital goods (P_I) and the interest rate (i).

$$INB = f(FD, XW, P_q, P_I, i)$$
$$(+) \quad (+) \quad (+) \quad (-) \quad (-)$$

(Where the expected signs are shown in brackets under each argument.)

For non-residential construction the desired capital stock is a function of an activity variable (final demand - FD) and the cost of capital relative to wage rates (W). This equation is based on the Coen cost minimisation model (Coen, 1971):

$$IOB = f(FD, P_I, i, W)$$
$$(+) \quad (-) \quad (-) \quad (+)$$

In the case of residential investment rather than constructing a structural model for the housing market, a crude approach was adopted making it a function of real disposable income (YD) and an interest rate variable so that:

$$IRB = f(YD, i)$$
$$(+) \quad (-)$$

Changes in non-agricultural stocks and intervention stocks are treated as exogenous. For non-agricultural stocks, disaggregated into four categories, a standard partial adjustment model was used for each category. The results indicate that the speed of adjustment of actual to desired stocks is extremely rapid. This is not surprising given that the model is an annual one. As a result, stock building does not have a significant impact on the medium- or long-run properties of the model.

Current Government expenditure on goods and services is split into wage and non-wage components; the wage component being determined by the product of average public authorities wage rates (determined in the wage sector) and the level of employment in that sector; the non-wage component is exogenous.

2.3: Labour Market

In MODEL-80 the major features of the supply of labour, the demand for labour (actual employment) and the determination of wage rates are modelled behaviourally. To the extent that the demand for labour is less than the supply, unemployment occurs.

The demand for labour (E) is a function of the level of output (Q) and the prices of labour (W), capital (P_k) and other inputs (P_i) all relative to the price of output (P_q). A rise in output (Q) leads to a rise in employment, while a rise in the relative price of labour (W/P_q) leads to a fall in employment. Increases in the relative prices of non-labour inputs (P_k and P_i) lead to an increase or reduction in employment depending on whether the inputs concerned are complements or substitutes for labour. Hence:

$$E = f(P_q, W, P_k, P_i, Q)$$
$$(+) \quad (-) \quad (?) \quad (?) \quad (+)$$

Of all the employment equations, the most important in determining the medium-term properties of the model is that shown below for employment in transportable goods industries.

$$\log (E) = -1.52182 - .53546 \log (W/P_q) + .09765 \log (P_k/P_q) - .06722 \log (P_E/P_q)$$
$$(1.4)^1 \qquad (4.1) \qquad (1.1) \qquad (3.5)$$
$$-.20351 \log (P_A/P_q) + .49593 \log (Q) + .73697 \log (E_{-1})$$
$$(1.5) \qquad (4.5) \qquad (4.8)$$

P_E is the price of imported energy and P_A is the price of agricultural output, both of which are inputs to transportable goods industries. This equation shows the short-run elasticity of employment with respect to changes in the product wage and output to be approximately -0.5 and + 0.5, respectively. The speed of adjustment is very slow compared to the findings of other work (Smyth and McMahon, 1975). This results in large long-run elasticities with respect to wages and output of -2.0 and + 1.9, respectively. This equation plays a key role in determining the dynamics of adjustment of the model to changes in relative prices. The fact that it has proved unstable when estimated using a different sample is discussed when dealing with tests of the behaviour of the model.

The supply of labour depends on equations determining migration, the participation rate and the natural increase in the population. In its reduced form, the supply of labour (L) is a function of the difference between Irish and UK wage rates (W-WUK), Irish and UK unemployment (U-UUK) and a time trend (t). The higher are wage rates in the UK or the higher is Irish unemployment, the higher will be emigration and the lower the supply of labour. Conversely, when UK unemployment or Irish wage rates rise, emigration falls (or immigration increases). The reduced form for this sector is:

$$L = f(U,UUK, W, WUK, t)$$
$$(-)\ (+)\ (+)\ (-)\ (?)$$

The percentage change in wage rates (W) is a function of the percentage change in consumer prices (P_c), the rate of unemployment in the previous period (U_{-1}), reflecting supply conditions in the labour market, and the rate of increase in productivity (q) reflecting demand factors, i.e.:

$$\dot{W} = f(\dot{P}_c , U_{-1} , \dot{q})$$
$$(+)\ (-)\ (+)$$

While the unemployment effect in any one year is relatively small, the cumulative effects can be substantial. This influence of the rate of unemployment on wages plays an important role in the model. As with the equation for transportable goods industries' employment, the coefficients of the wage rate equation proved unstable when re-estimated with a different data sample. The significance of this for the behaviour of the model is discussed in Section 5. Finally, agricultural income is treated as exogenous.

2.4: Output

Attempts to estimate joint factor demand equations proved unsuccessful (Bradley, 1979), so that it was not possible to build into the model consistency between factor demands and the level of output. As a result, the levels of industrial and services output, which in turn affect employment, are determined as simple functions of the components of final demand. Government output is a function of government employment and agricultural output is exogenous.

2.5: Trade Sector

In the model, agricultural and services exports are entered exogenously while imports and industrial exports are determined endogenously. The approach taken to modelling both imports and industrial exports is similar. The price equations discussed below assume that Ireland is a price-taker on world markets for tradeable goods. As a result, given that prices cannot adjust to bring demand and supply into line, equilibrium in the

real goods market is ensured by allowing the balance of payments deficit to vary. Thus, in modelling the volume of exports and imports, one is, in a sense, modelling the reduced form of the demand and supply of goods on the domestic market.

With this in mind, industrial exports (X_I) are made a function of the capital stock (K), wage costs (WC) and the price of exports (P_X);

$$X_I = f(K, WC, P_X)$$
$$(+)\ (-)\ \ (+)$$

This is in the nature of a short-run supply function. The higher the capital stock or the price obtained for output (P_X) the greater will be supply and, therefore, exports. Conversely, the higher domestic wage costs, the lower will be exports. As Honohan (1981) has pointed out, improved results could have been obtained by including a foreign demand variable in this equation. However, the results from such a revised specification indicate that this change would not seriously alter the behaviour of the model.

The approach eventually adopted for manufactured goods imports was fairly similar. The volume of such imports (M) was made a function of final demand (FD) and the rate of capacity utilisation (represented by the capital/output ratio (K/Q)). The higher final demand the higher will be the volume of imports, whereas an increase in the capital output ratio (implying in the short run, a reduction in capacity utilisation) will result in lower imports.

$$M = f(FD, K/Q)$$
$$(+)\ \ (-)$$

An alternative formulation, which is closer in character to that adopted for industrial exports, is given below and referred to later in Sections 3 and 5 as the "supply constrained version".

$$M = f(FD, K, W, P_m)$$
$$(+)\ (-)\ (+)\ (-)$$

where P_m represents Irish import prices.

In this equation, the higher is final demand the higher will be imports. The higher the level of wages the lower will be domestic supply and the more imports will be sucked in. On the other hand, an increase in the capital stock (K) or in the price level "taken" by import-competing Irish producers (P_m) the higher will be domestic supply and the lower will be imports.

On statistical grounds there was little to choose between these two equations. As outlined in the next section, the choice was eventually made based on their likely implications for the overall performance of the model.

Finally, the volume of non-manufactured imports was modelled in a fairly similar manner to that discussed above for manufactured imports. However, less emphasis was put on domestic supply conditions in these equations, due to the absence of close substitutes for many of the items included.

2.6: The Government Sector

The government sector of the economy has been modelled in great detail. This has been done, not so much to improve the accuracy of the model, as to facilitate its use to estimate the effects of changes in fiscal policy on the economy. The bulk of government expenditure enters exogenously. The exceptions are government wages, payments to those unemployed, subsidies and national debt interest. In the case of payments to those unemployed, expenditure is a function of numbers unemployed, the rates of benefit and, in the case of pay related benefit, of wages in the previous year. Consumer subsidies are

a function of implicit subsidy rates and the relevant consumption base. National debt interest is a function of debt outstanding, new debt and the interest rate.

The manner in which government expenditure affects the economy is determined by the usual national accounting identities. Transfers affect the economy through raising disposable income. Subsidies affect prices and the value of GNP. Current expenditure on goods and services directly affects the expenditure side of GNP and, through raising wages, also raises the incomes side of the account. To the extent that these items affect the expenditure side more than the incomes side, or vice versa, profits, the difference, make up the residual.

Government capital expenditure, with the exception of direct investment,[2] does not have any channel to affect the level of economic activity. Even direct investment only affects the economy through its direct impact on domestic demand, the effects of the increased capital stock on domestic supply being ignored. This is, as is discussed later, clearly only realistic in the short term and must be taken into account when using the model. The above comments on capital expenditure are equally applicable to government capital revenue whose direct economic impact is also not modelled directly.

The bulk of government current revenue is endogenous to the model. Generally, the level of revenue is made a function of a tax rate variable and an appropriate tax base variable. The channels whereby current revenue affects the economy are similar to those for current expenditure. Direct taxes affect the economy by altering the level of disposable income. Indirect taxes affect directly the income side of GNP and, depending on the nature of the tax, affect, to differing degrees, the price deflators on the expenditure side. The level of disaggregation of indirect taxes is high so as to model more precisely the likely impact of each kind of tax on prices.

The government borrowing requirement is, naturally, equal to the difference between total expenditure and total revenue. The manner in which the debt is financed has an impact, not only on the monetary sector, but also, directly, through national debt interest payments on the real economy. The greater the amount of long-term borrowing, the higher will be national debt interest payments. To the extent that such borrowing is done abroad, national debt interest payments reduce the level of GNP and affect the balance of payments.

2.7: Prices Sector

The different price deflators used in the model are determined in percentage change form. Table 2.1 shows in summary form the explanatory variables which appear in each of the major price equations.

The key price deflator, around which much of the action in the model hinges, is the price of gross output of transportable goods industries. Given that Ireland is a small open economy, it is this price, the price of domestically-produced tradeable goods, which is assumed to be primarily externally determined. In the model it is made a function of the price of manufactured goods imports, against which domestic industry is competing, and of agricultural output prices. The latter is included because a substantial part of industry is concerned with food processing. Thus, in the post-1973 environment, where agricultural prices are largely externally determined, transportable goods industries are modelled as price takers on the world market.

When tradeable goods are consumed at home, they are no longer tradeable goods in the sense that they have had added a sizeable direct tax and subsidy component and a very substantial distribution margin. In addition, when it comes to modelling consumer prices, account must be taken of the fact that consumption includes a substantial tradeable services component. Thus the consumption deflator is a function of industrial output prices, domestic wage costs, indirect taxes, subsidies and import prices (to take account

Table 2.1: *Price Determination in MODEL-80*

Endogenous Variable	Explanatory Variable
Price of output of transportable goods industries	Price of gross agricultural output. Price of imports of manufactured goods.
Price of consumption	Change in appropriate weighted VAT rate, rate of excise taxes and subsidies directly affecting consumption. Prices of imports of manufactured goods. Wage costs in the services sector.
Price of public authorities' consumption (excluding direct employment)	Public administration wage rates. Price of consumption.
Price of non-building investment	Price of imports of manufactured goods.
Price of residential building investment	Industrial wage rate. Price of imports of manufactured goods.
Price of other building investment	Industrial wage rate. Price of merchandise imports.
Price of industrial exports	Price of world exports of manufactured goods. Price of imports of raw materials.
Price of Services Exports	Price of consumption. Price of industrial exports.

of consumer goods imported directly).

The deflator for non-building investment is also dependent on import prices because of its high import content. The price deflator for building investment, a non-tradeable good, is a function of wage rates and import prices. In the case of industrial exports, the price deflator is totally externally determined. The price deflators for stocks are modelled using suitable arguments which are discussed in detail in Bradley, et al. (1981).

2.8: Monetary Sector

The monetary sector is a standard one for a small open economy, operating a fixed exchange rate. MODEL-80 has not been altered to take account of post-EMS changes in monetary affairs. The absence of sufficient observations prevents the estimation of appropriate equations using annual data. As a result, when using the model, *ad hoc* adjustments have to be made to take account of changes in this area. This problem affects, in particular, the role of the interest rate in the monetary sector, which is treated as exogenous. Given that the model shows interest rates as having an impact on the real economy it is important that, in using the model, this is taken into account by ensuring consistent values are entered for the interest rate, the exchange rate and other exogenous monetary variables.

3. TESTING THE MODEL

3.1: Introduction

Large macro-economic models frequently fall into the category of a "serious occasion of sin". Having constructed such a model, there is an impelling temptation to put it to use

as soon as it is completed. It is extremely hard to sit back and continue using "outmoded" analytical instruments while a new improved version is apparently readily available. No matter how strong such a temptation seems to be, it is vital that it be resisted and that adequate time should be devoted to testing and understanding the model before it is put to practical use. To a considerable extent, this path of virtue was followed in developing MODEL-80 and this section discusses the tests carried out on the model prior to its use.

These tests are important for a number of reasons:

(i) They ensure that the model has in fact been assembled correctly and they show up major areas of doubt concerning the specification.

(ii) They give a good idea of how reliable the model is in explaining recent history and, by inference, how much faith can be put in its conclusions when applied to the future.

(iii) They are a vital step in understanding how a large macro-model works and in discovering why it produces the results that it does.

Set out below is a very brief description of the range of tests carried out on the model as a model. These tests, together with the tests on individual equations are discussed in more detail in Bradley, et al. (1981). A special set of tests carried out to determine the sensitivity of the behaviour of the model to possible errors in specification is discussed in Section 5.

3.2: Tests of Tracking Performance

Single equation simulation: This test is the standard test applied to equations when the are estimated and involves treating all variables on the right hand side of the equation as exogenous. These tests on individual equations are not discussed here but are treated in some detail, equation by equation, in Bradley, et al. (1981).

Table 3.1: *Simulation Results for the Growth Rate of Real GNP*

MODEL	MINI	MODEL-80		
Type of Simulation	Single Period	Single Period		Dynamic
Sample	1960-75	1961-77	1961-78	1961-77
Root mean square error of percentage change in GNP (volume)	1.81	1.18	1.38	1.35

Single Period Simulation - Within Sample: This test involves solving the model as a whole using the model solution values for the current period endogenous variables on the right hand side of the equations. Historical values are used for lagged endogenous variables. This test was applied firstly to the data for the years 1961-77 used in estimating the model. Table 3.1 shows the results for the growth rate of real GNP. It is clear from this table that for this crucial variable MODEL-80 performed substantially better than did the old MINI model, albeit for different sample periods. The root mean square error of 1.18 percentage points is quite acceptable.

However, it is obviously necessary to consider the performance of a number of other variables to gain a true impression of the model's worth. This is done in Bradley, et al. (1981), and a summary table of the results for other key variables is given in Appendix 1. Overall, the impression given by these results is that the model has been correctly assembled and is superior to the old MINI model. They do not show any very obvious misspecification and the tracking performance of a range of variables in the within sample period is shown to be satisfactory.

Single Period Simulation - Out of Sample: Needless to say, within sample tracking performance is not the only criterion for selecting models. A somewhat more rigorous test is the simulation of the model in the post-sample period. This gives a better indication of how the model is likely to perform under working conditions and is a more rigorous test of the specification. The results shown in Table 3.1 for 1961-78 were obtained from a sample which differed from that used for estimation, 1961-77, not only by the addition of 1978, but also due to substantial revisions for the 1973-77 period.

The results for GNP showed some deterioration but a root mean square error of 1.38 percentage points still seems quite reasonable. This test showed up potential problems with the wage rate and investment equations which suggests a need to re-examine their specification.

Dynamic Simulation: The dynamic simulation involved, using on the right hand side of equations for each endogenous variable, the values for the lagged endogenous variables generated by the model for earlier periods. This is a very rigorous test of certain aspects of the model's specification as errors may well tend to cumulate over time pushing the model results further and further from the historical figures. The results for the growth rate of GNP for a dynamic simulation from 1961-1977 were very satisfactory. The increase in the root mean square error of under a quarter of one percentage point was low. Generally, errors of this magnitude are close to those obtained by many economic forecasters, though, of course, they are not truly comparable.

The results for employment showed a very serious deterioration in the dynamic simulation. However, the cause of this deterioration was felt to lie more with the misspecification of the wages equations than with any inherent problems in the employment equation.

3.3: Error Decomposition

The tests outlined so far are some of the standard methods used in validating macroeconomic models and were applied to previous versions of the model as described in the paper by the Research Department of the Central Bank, 1978. However, while they are useful in detecting problems, they are not necessarily very useful in tracing their cause. As a result, in developing MODEL-80 it was decided to carry out some additional tests which would not only help in tracing the origins of certain problems but might also throw some light on the model's behaviour.

One way of tackling this problem in a large nonlinear model of this kind is to use stochastic simulation, as was done for the MINI model (Bradley and Sexton, 1978). However, this involves a large number of costly simulations and it was felt that a less rigorous, simpler procedure, suited to the limited resources available, could achieve useful results.

The method actually adopted was to exogenise different sectors of the model and examine the difference this made to the results for a single period simulation. It was hoped that this would identify those equations or sectors which were the major contributors to the errors in the model. However, just because the overall fit is improved by exogenising a particular equation does not mean that the errors stem from that equation.

Rather, that equation may only be a vital channel in transmitting errors stemming from another equation, to the model as a whole. Thus, care must be taken in interpreting the results. With this in mind, we show some of the results obtained from exogenising a number of key equations.

The first set of variables to be exogenised were the equations determining wage rates. As can be seen from the results in Table 3.2, the only variable which showed a significantly improved fit as a result of this change was the inflation rate. As indicated above, this does not necessarily indicate that a substantial cause of the errors in the estimate of consumer prices comes from errors in the wage rate equations. However, on other grounds, it is felt that this is, in fact, the case.

The improvement in fit of consumer prices, together with the exogenised wage rates variables does not result in any significant improvement in the fit of other variables in the model. In the case of the growth rate, the fit even shows a marginal disimprovement. However, the results quoted earlier suggest that in a dynamic simulation, exogenising wage rates would result in a substantial improvement in the model's estimate of employment.

The second experiment carried out was to exogenise non-agricultural stock changes. Because of the high import content of stock building there is a substantial improvement in the estimates of both total imports and of the balance of payments deficit. The improvements are not confined to the trade sector. The volume of consumption, employment, the unemployment rate, and the key growth rate variable, all show a slight improvement.

When consumption is exogenised there is a significant improvement in the fit of a number of other major variables. The RMSE on the growth rate is halved. These results suggest that a substantial part of the errors in the single period simulations are arising in this sector of the model.

The results discussed in this section suggest that considerable further research is required, in particular, into the behaviour of consumers. If any significant improvement could be achieved in that sector it would affect all other variables in the model. However, the fact that improved results can be obtained by exogenising certain sectors does not mean that this should be done when actually using the model. Such a course of action will only be useful if the model is used for forecasting. Even then a better approach is generally for the user to alter intercepts to achieve the desired result.

3.4: Alternative Specification

Having identified problem sectors or equations by the tests set out above, the next step is to examine how the model is improved by changing the specification for some of those equations or sectors. This takes one stage further the usual procedure of choosing equations on the basis of the best fit on a single equation basis. Here the error statistics for key variables in the model as a whole are examined for the case when the alternative equations are used. The alternative specifications tried were for the consumption function and the manufactured imports equation. The results are shown below in Table 3.3.

The incorporation of the consumption functions, where the propensity to consume was made a function of the rates of inflation and unemployment, led to a serious deterioration in the overall performance of the model. This deterioration occurred in spite of the fact that two of these consumption equations fitted better on a single equation basis than did those incorporated in the definitive version of the model.

The reason for this deterioration in performance is that when the model's own estimates of the unemployment rate and inflation are substituted for the historical data in determining the propensity to consume, the errors in these estimates are considerably magnified by the non-linear nature of the specification. This highlights the problems of

Table 3.2: Error decomposition of MODEL-80, 1961-1977, single period simulation

	Error statistic	Full model	Exogenous wage rates	Exogenous stocks	Exogenous consumption
Change in wage rates, industry (%)	RMSE	2.28	-	2.28	2.27
Balance of payments (£m)	RMSE	25.72	29.56	16.41	32.00
Consumption, vol. (£m)	RMSPE	1.95	1.97	1.87	-
Non ag. employment (000)	RMSE	5.95	5.38	4.94	5.55
Government borrowing requirement (£m)	RMSE	20.15	16.60	18.65	15.47
Investment non building, vol (£m)	RMSPE	7.96	7.77	7.89	7.93
Imports, vol (£m)	RMSE	2.90	2.90	1.94	2.74
Change in consumer prices (%)	RMSE	0.97	0.66	0.97	0.96
Unemployment rate	RMSE	0.44	0.43	0.41	0.43
Industrial esports, vol (£m)	RMSPE	5.13	5.13	5.08	5.31
Change in GNP (%)	RMSE	1.18	1.19	1.10	0.58

Table 3.3 Results for alternative model specifications

Specification		A Definitive version of model	B A + Alternative (parameterised) consumption equations	C A + Alternative (supply constrained) equation for manufactured imports
Change in industrial wage rates (%)	RMSE	2.28	2.26	2.28
Balance of payments (£m)	RMSE	25.72	51.64	22.94
Consumption, volume (£m)	RMSPE	1.95	2.39	1.86
Non ag. employment (000)	RMSE	5.95	6.69	6.11
Government borrowing requirement (£m)	RMSE	20.15	24.68	21.19
Investment non building, vol. (£m)	RMSPE	7.96	8.61	7.89
Imports volume (£m)	RMSPE	2.90	3.85	2.80
Change in consumer prices (%)	RMSE	0.97	0.95	0.97
Industrial exports, vol. (£m)	RMSPE	5.13	5.09	5.17
Change in GNP, vol. (%)	RMSE	1.18	1.34	1.13

using non-linear equations in models where the variables which are involved are themselves endogenous within the model.

The use of the alternative (supply constrained) manufactured goods import equation in the model led to a limited improvement in the errors for the balance of payments, the major components of expenditure and the growth rate. However, the specification is non-linear with the relation between imports and the capital stock itself being a function of wage rates and prices. As in the case of the consumption equations, the non-linear nature of the relationship would result in any errors in the model's estimates of the right hand side variables, especially wage rates, having a big effect on the behaviour of the dependent variable, manufactured imports. Given that the coefficients on wage rates and prices in the equation were not well determined and that the wage rates equation itself is not very satisfactory, the possibility of this equation resulting in serious errors in the out-of-sample period was felt to be considerable. In view of these doubts, it was felt to be safer not to incorporate this equation into the definitive version of the model.

3.5: Conclusion

The tests described above show that MODEL-80, while having a number of problem

areas, performed reasonably well by a range of different criteria. It clearly outperformed the MINI model, previously used in the Central Bank and the Department of Finance. However, the usefulness of the tests lies not so much in giving the green light to go ahead and use the model, but more in providing vital information on the areas where the model may not prove totally reliable. For example, the tests make clear the fact that there are problems with the wage rate equations and suggest the need for caution in simulations where they are treated as endogenous. Similar warnings are provided concerning the results for employment, investment and consumption. Thus, the battery of tests will help to inform the judgement of those who have to interpret the model's results and they make clear the dangers of treating this model, or any model, as an infallible black box.

4. THE BEHAVIOURAL CHARACTERISTICS OF THE MODEL-80 MODEL

4.1: Introduction

The justification for constructing a complex formalised econometric model of the economy, rather than relying on informal methods of analysis, is that such a model can stimulate more efficiently the behaviour of the economy and can thus provide insights into the likely impact of different economic policies. This section of the paper describes MODEL-80's behavioural characteristics, discusses the extent to which they conform to theoretical expectations and touches on their implications for economic policy.

4.2: Methodology

The extent to which the behavioural implications of a macro-model can be derived by cursory examination of the individual equations is, among other things, a function of the size and degree of non-linearity of the model. In the case of a linear model it is a relatively straightforward matter to derive analytically the effects of changes in exogenous variables on the different sectors of the economy. However, even with a linear model, if it is sufficiently large, the results may not be readily apparent from a quick examination of the equations. Certainly, in the case of a large non-linear macro-model, such as MODEL-80, an understanding of its behavioural characteristics requires the assistance of extensive simulations. The method usually adopted is to examine the pattern and magnitude of the effects on the endogenous variables in the model, resulting from a specific change in one or more exogenous variables (see Bradley, et al., 1981 for a description of the different kinds of multipliers). The changes frequently take the form of a unit change or a one per cent change in a given exogenous variable. The effects of these changes on the endogenous variables (i.e., the model's multipliers) give a good idea of how the model behaves.

When the results from calculating the multipliers are combined with a knowledge of the precise specification of the model, it is possible to build a comprehensive picture of the behavioural characteristics of that model. It is this procedure which is adopted below and the conclusions concerning the behaviour of the model, derived from the above process, are illustrated by means of the multiplier results for changes in the following variables calculated for the year 1977:

(i) An exogenous rise in wage rates in 1977 of one per cent above the level "they would otherwise have been". Wage rates are then held one per cent above the level "they would otherwise have been" in all subsequent years (i.e., wage rates are made exogenous, their imposed values in each year being one per cent above the level in the "benchmark" simulation).

(ii) A one per cent rise in the price of imports of manufactured goods in 1977. (The higher level of prices is assumed to persist indefinitely.)

(iii) A rise in interest rates of one percentage point in 1977. (The higher level of interest rates is assumed to persist indefinitely.)

(iv) An increase in public administration employment costing £10 million at current (1977) prices, financed by borrowing. (This higher level of expenditure is assumed to persist indefinitely.)

(v) A reduction in the rate of tax on alcohol sufficient to reduce revenue by £10 million at current (1977) prices, financed by borrowing. (The lower level of taxation is assumed to be maintained indefinitely.)

In each of these cases the appropriate changes are made to the historical values of the exogenous variables for 1977. The model is then simulated with the changed exogenous variable, each taken separately, and the results for the key endogenous variables are compared to the results obtained from simulating the model with the original or "benchmark" values of the exogenous variables. Thus, for example, in Table 4.1, when the model was simulated with interest rates one per cent higher in 1977 than their actual outturn for that year, the model showed wage rates as being 0.127 percentage points below their benchmark estimate for that year.

Results are shown for all the major endogenous variables for the year in which the change was made - year 1, the following year - year 2 and years 5 and 10. The figures are derived by comparing the results obtained by running the model from 1977 onwards with and without the changes detailed above. However, the timing of these results in the medium and long term should not be taken literally as the dynamic behaviour of the model is not sufficiently reliable to permit of such precision. They are presented merely to illustrate the medium-term behaviour of the model and are not intended in any way as precise forecasts.

It should be stressed that the illustrative numbers given in the tables are only valid for 1977 and for the size of the changes quoted. Due to the non-linear nature of the model, the size of the multipliers may show considerable variation both over time and for different magnitudes of changes than those shown.

The rest of this section examines the behaviour of the model sector by sector, using the changes in the five exogenous variables, discussed above, as "probes". The compartmentalised approach adopted is preferred for ease of exposition. However, it is obvious that, for the purpose of policy formulation, the effects on all sectors of the economy of a change in these variables must be considered together.

4.3: Wage and Price Determination

As indicated in section 2, MODEL-80 modifies somewhat the crude theory of the external determination of prices which underlay the earlier version of the model. In the present version of the model the most important channel whereby world prices affect the domestic price level is through their effects on the price of output of domestic industry. This in turn affects the price of tradeable goods consumed. However, consumer prices are also affected by domestic wage rates in the services sector because of the substantial non-tradeable component in consumption.

Within the model, wage rates are generally treated as endogenous. In practice, in any one year the process of wage formation can be quite different from that assumed by the model. In fact, it is necessary, in actual simulations for current and future time periods, that the model be adjusted to take account of existing institutional arrangements or the current stance of incomes policy. When wages are treated as endogenous, their major determinant, in the short term, is the rise in prices. As a result, even though some of the rise in consumer prices may be directly attributable to changes in wage rates, these changes themselves are simultaneously determined by prices. To unravel the effect of the different exogenous variables on prices, in particular that of external prices, it is necessary to take

account, not only of their direct effects, but also of the indirect effects through changes in wage rates.

The other factors directly affecting wage rates are the unemployment rate in the previous year and the rate of change of productivity. This presence of a Phillips curve effect has important behavioural implications for the model as a whole. Its presence means that the behaviour of the labour market - in particular the interaction of wage costs and employment - can affect wages and, therefore, prices. This implies that the adjustment of the Irish economy to any exogenous change in prices may involve changes throughout the economy and not just a realignment of domestic prices.

Table 4.1 shows how the changes in the different exogenous variables affect wage rates and prices. It shows that an exogenous increase in wage rates of one per cent, however achieved, would add 0.18 per cent to consumer prices in the first year. The cumulative effects after five or ten years are very close to the initial (or impact) effect.

TABLE 4.1: *Effects of changes in exogenous variables on prices and the labour market*

Cumulative Change	Units	Years	Change in wage rates +1%	Change in manufactured import prices +1%	Change in interest rates +1%	Change in Public Admin. employment +£10m.	Change in excise taxes on alcohol -£10m.
Wage rate	%	1	+1.0	+0.266	-0.127	+0.117	-0.236
		2	+1.0	+0.283	-0.181	+0.204	-0.237
		5	+1.0	+0.287	-0.485	+0.372	-0 120
		10	+1.0	+0.355	-0.493	+0.284	-0.072
Consumer prices	%	1	+0.178	+0.411	+0.004	-0.001	-0.498
		2	+0.173	+0.453	-0.005	+0.008	-0.487
		5	+0.171	+0.454	-0.025	+0.018	-0.468
		10	+0.171	+0.456	-0.026	+0.011	-0.449
Unemployment	000	1	+0.845	+0.087	+1.131	-1.342	-0.578
		2	+1.333	+0.053	+1.590	-1.025	-0.781
		5	+1.780	-0.235	+0.225	+0.250	-0.312
		10	+1.443	-0.116	-0.926	+0 600	+0.541
Emigration	000	1	+0.004	+0.136	+0.729	-0.841	-0.488
		2	+0.279	+0.192	+1.337	-1.077	-0.812
		5	+0.870	+0 020	+1.127	-0.481	-0.863
		10	+0.777	-0.014	+0.048	+0.121	-0.178
Productivity in industry	%	1	+0.428	-0.202	-0.152	+0 030	-0.071
		2	+0.737	-0.254	-0 059	+0.060	-0 270
		5	+1.206	-0.389	-0.516	+0.392	-0.367
		10	+1.446	-0.366	-1.126	+0.519	-0.180
Non-agricultural non-public admin. employment	000	1	-1.451	-0.180	-2.108	+0.320	+1.105
		2	-2 352	-0.199	-3.375	+0.219	+1.754
		5	-3 992	+0.132	-2.981	-0.802	+2.221
		10	-5.423	+0.016	-1.888	-1.293	+1.882
Public admin. employment	000	1	0.0	0.0	0.0	+2.177	0.0
		2	0.0	0.0	0.0	+2.177	0.0
		5	0.0	0.0	0.0	+2.177	0.0
		10	0.0	0.0	0.0	+2.177	0.0

An increase in the price of manufactured goods imports of one per cent results in an instantaneous rise in consumer prices of 0.41 per cent. This includes both the direct effects, through the rise in tradeable goods prices, and the indirect effects through higher wage rates induced by the higher prices. The cumulative impact on prices after five or ten years is close to the impact effect. The fact that the rise in prices is not closer to one per cent does not necessarily invalidate the small open economy hypothesis that the bulk of inflation is externally determined. External factors affect domestic prices through other channels in addition to import prices of manufactured goods - the only exogenous variable which is altered in this case. (If all prices in the model which are directly determined abroad were simultaneously raised by one per cent, consumer prices would rise by between 0.5 and 1.0 percentage points.)

Changes in interest rates have only a slight impact on consumer prices in both the short and the long term. However, because higher interest rates result in higher unemployment and lower productivity, they exert a significant negative effect on wage rates in the longer term.

The results of an increase in public administration employment are based on the assumption that the change is financed by borrowing of a kind that has no effect on domestic interest rates. The effects of such an increase on consumer prices are negligible. However, because there is, naturally, a fall in unemployment consequent on the increase in public sector employment, there is a tendency for wage rates to increase in the medium term.

The effects of a change in excise taxes on prices are estimated on the assumption that wage rates are endogenous to the model. The results indicate that a reduction in excise taxes will impart a substantial downward impetus to prices in the year the change is made. The reduction in prices is transmitted to wage rates on the assumption that they are determined within the model.

In sum these results seem plausible in both direction and magnitude. While they are in line with accepted thinking on price determination in small open economies, they indicate that, certainly in the short term, domestic factors do affect inflation and wage rates.

From the point of view of policy formulation, these results cannot be viewed in isolation from the results for other major economic aggregates, such as the balance of payments and the borrowing requirement, which may impose constraints on policy decisions. While they suggest that an appreciation of the Irish pound vis-à-vis other exchange rates, by altering the external prices faced by the Irish economy, would bring about a substantial reduction in the inflation rate, the desirability and sustainability of such a change obviously depends on many other factors (e.g., the effects on unemployment and the balance of payments).

4.4: The Labour Market

In this model the workings of the labour market have, as outlined above, important implications for other sectors of the model. Employment in the different sectors of the economy is seen as being a function of, among many other things, the price of labour. Thus, an exogenous rise in prices will tend to raise domestic wages and, generally, raise unemployment. This in turn will have a negative effect on wages tending to mitigate, to a limited extent, the de-stabilising effect of the price change.

Because the actual level of employment reacts with a considerable lag to factors affecting the equilibrium level, it will be some time before the level of employment adjusts downwards to a level consistent with the new level of wages. As a result, since output adjusts immediately to its new equilibrium, while employment is higher than its equilibrium level, productivity (output per person) is below its long-term equilibrium. This exerts a negative effect on wage rates even in the short term.

As well as the above effects, the rise in unemployment will itself directly affect labour supply through its effects on migration. Migration is a function of the difference between the UK and Irish rates of unemployment and wages. Thus, the disequilibrium engendered in the labour market through a rise in unemployment will continue until it is offset either by migration or by the change in relative wage rates. To the extent that there is emigration, it allows the economy to return more rapidly to equilibrium at higher levels of prices and wages, and lower levels of employment, than would otherwise have been the case.

This specification of the labour market also has important implications for the effects of factors tending to increase employment. Such factors will tend initially to reduce unemployment. This in turn will lead to immigration (or lower emigration) which will continue until the economy is back in equilibrium. In addition, a rise in employment will raise wage rates through its effect in reducing unemployment. This will reduce the equilibrium level of employment and will set in train an offsetting adjustment to the exogenously engendered rise in employment. In the end, the increase in employment arising from such factors, while still significant, will be less than their initial impact suggested.

As can be seen from Table 4.1, an exogenous rise in wage rates of one per cent leads to a significant initial loss of employment. In addition, because of the slow adjustment of the labour sector, job losses continue to mount up to year ten. As no downward adjustment in wage rates in later years was permitted in this simulation, all the adjustment is constrained to take place by emigration. This outflow ensures that unemployment does not rise in line with the loss of employment but peaks around year five at +1,800.

Changes in import prices of manufactured goods have little effect on employment as domestic prices and wages adjust rapidly to the changed circumstances. Higher interest rates, on the other hand, have a big impact on employment due to the slowdown in investment.

Increases in public administration employment, financed by borrowing, have a big immediate impact on total employment. (If financed by taxation, the positive effects on employment from the increased expenditure would be substantially negatived.) However, the resulting fall in unemployment results in higher wage rates in the longer term. This results in a fall in employment outside public administration in later years. The effects of a cut in indirect taxation are slower to impinge on employment than a change in public expenditure, though their eventual impact is similar in character.

From the policy point of view, differences in the character of the various exogenous changes discussed make it difficult to rank policy instruments in terms of their efficiency for maximising employment. However, these results indicate that, while direct employment by the State has a big immediate impact (if financed by borrowing), its longer term impact is somewhat lower. In addition, account must be taken of the sustainability of such borrowing in the longer term. Changes in wage rates, on the other hand, have a big long-term impact on employment. As will be discussed later, the model does not satisfactorily take account of the effects on employment, of government policy designed to affect supply, for example, the work of the IDA. The quantification of the stimulatory effects of such expenditure must, as a result, be handled outside the context of the model.

4.5: The Determination of the Capital Stock

The desired capital stock is a function of the level of output and of relative prices. Ideally, the desired capital stock, the desired level of employment, and the desired level of output should be determined simultaneously by means of a common underlying production function for each sector interacting with the level of prices. This did not prove possible (Bradley, 1979), although earlier work by Fanning (1979) was promising. This

results in certain inconsistencies in the adjustment of the actual capital and employment levels to the desired level. However, if this is borne in mind it need not seriously affect the usefulness of the model.

In the case of investment in other building, wage costs, by raising the price of building investment, tend to reduce the level of the equilibrium capital stock. However, as can be seen in Table 4.2, this is, somewhat implausibly, more than offset by a substitution effect away from labour to capital resulting in increased investment. Labour costs do not directly affect the equilibrium non-building capital stock. A major determinant of this variable is the volume of world trade, so that it is relatively insensitive to domestic conditions. However, it is also affected to some extent by changes in domestic activity, an accelerator type of effect. Thus, increases in public expenditure and a reduction in taxation result in a small initial increase in investment.

TABLE 4.2: *Effects of changes in exogenous variables on business investment, output and consumption*

Cumulative Change	Units	Years	Change in wage rates +1%	Change in manufactured import prices +1%	Change in interest rates +1%	Change in Public Admin. employment +£10m	Change in excise taxes on alcohol -£10m
Investment, non building, volume	£m	1	+0.175	-0.398	-10.861	+0.718	+0.981
		2	+0.185	-1.502	-7.378	+0.463	+0.563
		5	+0.069	-0.752	-3.868	+0.277	+0.305
		10	+0.026	-0.496	-2.597	+0.145	+0.204
Investment, other building, volume	£m	1	+0.835	-1.581	-11.705	+0.822	+0.929
		2	+0.778	-1.477	-9.545	+0.727	+0.583
		5	+0.411	-1.005	-6.182	+0.651	+0.457
		10	+0.191	-0.679	-4.122	+0.187	+0.311
Employment	000	1	-1.451	-0.180	-2.108	+2.497	+1.105
		2	-2.352	-0.199	-3.375	+2.396	+1.754
		5	-3.992	+0.132	-2.981	+1.375	+2.221
		10	-5.423	+0.016	-1.888	+0.884	+1.882
Consumption,	£m	1	+2.530	-7.774	-4.913	+2.722	+14.240
		2	+3.320	-8.505	-6.198	+3.187	+14.444
		5	+3.130	-7.931	-10.516	+4.296	+14.986
		10	+2.714	-7.377	-12.537	+3.992	+15.193
Change in non-agricultural stocks	£m	1	+0.110	-3.065	-11.622	+1.627	+4.039
		2	+0.615	-1.833	-4.976	+0.564	+1.027
		5	+0.384	-0.326	-1.463	+0.285	+0.021
		10	+0.136	-0.026	-0.583	+0.071	+0.059
GNP, volume	%	1	+0.030	-0.138	-0.347	+0.245	+0.226
		2	+0.051	-0.154	-0.514	+0.248	+0.223
		5	+0.060	-0.162	-0.681	+0.267	+0.229
		10	+0.060	-0.158	-0.734	+0.267	+0.226

The one domestic variable which does have a significant effect on both forms of business investment is the interest rate. This works through altering the cost of capital, and, therefore, the desired capital stock. Both non-residential building and non-building investment are sensitive to changes in this variable. It takes a considerable length of time, at least ten years, before the actual capital stock is close to the desired capital stock and the level of investment returns to close to what it would have been if interest rates had not changed.

4.6: Final Demand

In the model consumption is a linear function of real disposable income. The short-run propensity to consume is fairly low at 0.57, implying a significant leakage into personal savings whatever the state of the business cycle. There is little difference between the short-run and long-run propensities to consume. As a result, as can be seen from Table 4.2, there is little difference between the short-run and long-run effects of policy variables which affect the economy primarily through their effects on real disposable income (such as direct taxes).

The endogenisation of stock changes has a significant effect on the short-run behaviour of the model. As stocks adjust rapidly to their desired level and as their desired level is a function of the level of activity (and an interest rate variable), the effect of this variable is to accentuate any changes which are already taking place. In the case of changes in interest rates, public expenditure and taxation, the effect on stock changes is more than halved by year two. In the case of the five exogenous variables shown in Table 4.2, the effect on stock changes is very small by year five. As stock changes have a high import content, the effect on real GNP is even smaller than the figures for the absolute changes would imply. Conversely, it has a significant short-term effect on the balance of payments.

4.7: Output and the Balance of Payments

The discussion above covers the key elements in the determination of demand in the real goods sector of the economy. What remains to be determined is the supply. Given that prices are largely externally determined, equilibrium in the real goods market, at least in the short-term, is brought about by changes in the balance of payments deficit. Ideally, the supply of goods should be determined through the operation of prices on the same production function which underlies the demand for capital and labour. However, as outlined above, a more *ad hoc* approach had to be adopted.

The volume of imports and exports have been made functions of, among other things, factors affecting the supply of goods and services. As outlined in section 2, the volume of industrial exports is a function of the capital stock, the price received for exports and the price of labour. As a result, labour costs have a negative effect on supply for export, whereas increases in the capital stock have a positive effect. In the case of imports, the capital stock has a negative effect on the propensity to import. However, as at present specified, the effect of supply side factors on the propensity to import is weak. The major effect of the increase in supply, due to an increased capital stock, is higher industrial exports.

Thus, the balance of payments deficit is modelled as the reduced form of the demand for and supply of goods. For the purpose of the factor demand, equations output is required on a sectoral basis. This is determined as a function of final demand. However, given that final demand is, in turn, a function of exports and, indirectly, of imports, sectoral output can be seen to be affected by supply considerations.

Table 4.3 shows the effects of the changes in different exogenous variables on GNP and the balance of payments. In the case of changes in wage rates, the effect on exports is perverse in the medium term. Higher wage rates, as one might expect, lead to a fall in ex-

TABLE 4.3: *Effects of changes in exogenous variables on the balance of payments and output*

Cumulative Change	Units	Year	Change in wage rates +1%	Change in manufactured import prices +1%	Change in interest rates +1%	Change in Public Admin. employment £10m	Change in excise taxes on alcohol -£10m
Industrial exports, volume	£m	1	-2.696	-3.764	-8.852	+0.682	+1.914
		2	-0.543	-4.916	-13.344	+0.345	+1.141
		5	+3.066	-6.882	-21.527	+1.230	-0.266
		10	+5.375	-8.343	-29.601	+3.661	+0.484
Imports, volume	£m	1	-0.192	-11.928	-37.232	+6.321	+13.894
		2	+2.640	-13.952	-35.540	+5.192	+10.746
		5	+5.251	-12.955	-37.912	+6.190	+8.867
		10	+6.517	-12.929	-42.526	+7.497	+9.498
Balance of payments deficit	£m	1	+3.174	+8.073	-38.060	+7.722	+17.954
		2	+3.957	+6.996	-28.555	+6.634	+14.713
		5	+2.092	+10.923	-19.698	+6.661	+14.233
		10	+0.423	+12.260	-14.376	+4.863	+13.933
GNP, volume	%	1	+0.030	-0.138	-0.347	+0.245	+0.226
		2	+0.051	-0.154	-0.514	+0.248	+0.223
		5	+0.060	-0.162	-0.681	+0.267	+0.229
		10	+0.060	-0.158	-0.734	+0.267	+0.236
Wage rates	%	1	+1.0	+0.266	-0.127	+0.117	-0.236
		2	+1.0	+0.283	-0.181	+0.204	-0.237
		5	+1.0	+0.287	-0.485	+0.372	-0.120
		10	+1.0	+0.355	-0.493	+0.284	-0.072

ports in the short term due to a fall in domestic supply. However, there is a rise in exports in later years which occurs primarily because of the inconsistencies between the modelling of the demand for labour and capital, and the determination of output, which were adverted to earlier. When wage rates rise, firms shed labour over a period of years. When they have completed this process, their productivity rises to such an extent that wage costs fall and exports rise. Either the fall in employment is too great or the fall in output is not great enough.

Increases in manufactured goods' import prices result in an increase in the balance of payments deficit. While there is some decline in the volume of imports, this is not sufficient to offset the rise in prices. The fact that the volume of exports falls, highlights the partial nature of such a multiplier: while manufactured goods' import prices rise by one per cent, world export prices, which determine Irish export prices in the model, are left unchanged. As a result, the wage increases, which follow on higher import prices, lead to a fall in supply for export. Thus, the results shown for this multiplier assume a deterioration in the terms of trade for Irish manufactured goods vis-à-vis manufactured goods. (If this assumption were not warranted, a much more complex treatment would be required.)

The big fall in the balance of payments deficit due to a rise in interest rates owes much to the decline in investment which has a high import content. The reduction in the balance of payments deficit is much less by the fifth year than in year one because of the fall off in exports due to the lower capital stock. While this fall in exports would continue in later years and the balance of payments deficit would eventually show an increase, it is still implausible that it does not show an increase for the full period.

The increase in interest rates has a big impact on the growth rate in both the short and the long term. This is because of the effect which this variable has on investment and the capital stock. The impact effect may be too large, suggesting, as it does, an instantaneous reaction of investment to changes in relative prices. However, the long-run effects are not surprising.

Both increases in public expenditure and cuts in taxation will result in significant increases in the balance of payments deficit. The fact that the balance of payments effects of the cut in indirect taxation are greater than for increased expenditure is due to the manner in which they first affect the economy. Expenditure on salaries, which are part of GNP, obviously has a low direct import content, whereas cuts in indirect taxes affect the economy by raising personal consumption which has a higher import content. This lower balance of payments impact helps explain why expenditure on public administration employment has a bigger effect on the growth rate in both the short and the long run.

4.8: The Monetary Sector

Finally, the model has a very simple monetary and financial sector which plays a minor role in the dynamic behaviour of the economy. The demand for money is a function of domestic activity and the supply, through capital flows, is assumed to adjust to meet demand. Interest rates are exogenous and play only a minor role in determining the demand for money and are not directly related to the supply. While this may conform reasonably well to the circumstances prevailing prior to 1979, it certainly no longer holds true. The rate of interest is now, to some extent, related to market conditions. As interest rates play a significant role in determining investment, the absence of a link between the demand and the supply of money and the interest rate must be taken into account in using the model. It is to be hoped that in later versions it will be possible to give a fuller treatment of the role of the monetary and financial sectors in the economy.

5. SENSITIVITY OF THE MODEL'S BEHAVIOUR TO CHANGES IN SPECIFICATION

5.1: Introduction

As we outlined in earlier sections, there remains doubt concerning the precise specification adopted for this model. A number of individual equations showed parameter instability when re-estimated using the latest data sample. In other cases it was impossible to distinguish between alternative specifications for the same dependent variable due to their very similar statistical results. This uncertainty is not unusual when dealing with large macro-models. In fact, we believe that it is present to a greater or lesser degree in all the major macro-models used in other countries. However, we have gone somewhat further in examining and highlighting this problem than has been done for any previous model in Ireland and, armed with this experience, we are in a stronger position in using the model to interpret its results.

5.2: Identification of Potential Problem Areas

The first step in examining the model's sensitivity to misspecification is to identify those equations or coefficients which play a key role in determining the model's behaviour. There are a number of ways of doing this:

(i) Kuh and Neese (1980) describe a method where, by using the matrix of the partial derivatives of all endogenous variables with respect to changes in all exogenous variables (i.e., the model's Jacobean matrix) it is possible to identify those coefficients which play a key role in the model. This process involves calculating, for a particular year, the multiplier effects on every endogenous variable of changes in every exogenous variable - an expensive and time-consuming process.

(ii) An even more expensive and time consuming process is to use stochastic simulation to examine the model's properties. This involves generating a large number of random errors for each equation which are normally distributed with mean zero and standard error equivalent to that estimated for each equation. By adding these random errors into each stochastic equation and carrying out an appropriately large number of "replication" simulations, it is possible to work out the impact of that portion of uncertainty which is related to the stochastic structure of individual equations, on each endogenous variable in the model. This process was carried out for an early version of the MINI model by Bradley and Sexton (1978). However, it is very expensive and, especially, if it is desired to examine the role of errors in individual coefficients in the model, on the model's behaviour, would be extremely time consuming.

(iii) The third method is, not surprisingly, to use previous experience with the model to identify possible problem areas. While this less formal procedure is a lot less intellectually attractive than those others outlined above, the savings in time and expense which it provides have led to its adoption here. It is felt that that limited number of coefficients which play major roles in determining the behaviour of the model can be readily identified from the wide range of simulations already tried using the model. Thus, the more elaborate and expensive methods outlined above are probably superfluous for identifying potential problem areas, even in the case of quite large models.

A further, and very important form of potential misspecification, which will not be detected by the methods outlined above, is that where the model fails to include important channels whereby individual exogenous variables affect endogenous or even other exogenous variables in the model. This form of misspecification, because it cannot be detected from the statistical results for individual equations, can easily be totally missed. However, it can be of very great importance in affecting the model's behaviour. Among the areas where this problem is known to be severe in MODEL-80 are the modelling of exchange rate changes, the agricultural sector, the monetary sector and the effects of the Public Capital Programme on the economy. This problem is dealt with in detail in the conclusion.

5.3: Testing the Sensitivity of the Behaviour of the Model

From our experience using the model, a number of key equations and coefficients were identified as playing important roles in determining the model's behaviour. Among the most important were the equation for manufactured imports, which is concerned with major leakages from the multiplier process and the equation determining employment in transportable goods industries.

Having identified the equations or sectors of the model which play a major role in determining its behaviour, the next step is to test the model to see how sensitive it is to possible problems with these sectors. Once again there are a number of different ways of carrying out such tests. As with the identification of problem areas, their testing is probably best done using some form of stochastic simulation which would allow one to establish standard errors for individual multipliers arising from potential errors in co-

efficients. However, such a course of action would be prohibitively expensive. Instead, two different *ad hoc* methods have been applied. In the first experiment, multipliers were calculated using the alternative "supply constrained" import equation estimated from the same sample and the results compared to those derived from the "definitive" version of the model. In the second set the multipliers are compared from versions of the model incorporating the wage rate and employment equations estimated using different sample periods.

5.4: Alternative Equation for Manufactured Imports

Section two of this paper indicates that there is very little to choose on a single equation basis between the "definitive" version of the equation for manufactured imports and the alternative "supply constrained" version. Section three showed that even when the model was simulated for the within sample period the equations produced similar results. However, the multiplier results in Table 5.1 for both versions of the model make it clear

Table 5.1

Effects of a £10 million increase in expenditure on public administration employment using differing equations for manufactured imports

Cumulative effects on	Units	Year	Import Equation Definitive Version	Import Equation Supply Constrained Version
Total Imports	£m	1	+6.321	+5.818
		2	+5.192	+5.418
		5	+6.190	+8.894
		7	+7.183	+9.880
		10	+7.497	+8.905
GNP, Volume	%	1	+0.245	+0.273
		2	+0.248	+0.218
		5	+0.267	+0.151
		7	+0.272	+0.163
		10	+0.267	+0.209
Wage Rates	%	1	+0.117	+0.119
		2	+0.204	+0.202
		5	+0.372	+0.364
		7	+0.373	+0.359
		10	+0.284	+0.269
Employment	000	1	+2.497	+2.519
		2	+2.396	+2.385
		5	+1.375	+1.250
		7	+0.857	+0.745
		10	+0.884	+0.869
Unemployment	000	1	-1.342	-1.354
		2	-1.025	-1.016
		5	+0.250	+0.300
		7	+0.684	+0.701
		10	+0.600	+0.548

that the two equations have different behavioural implications. (In this case the multipliers are shown for an increase of £10 million in expenditure on public administration employment.)

As can be seen from Table 5.1, the initial impact of the change under either version of the model is very similar. However, from the second year onwards the effects of GNP, using the different versions of the model, begin to diverge, reaching a maximum divergence somewhere between the fifth and seventh years and then coming together by the tenth year. The reason for the divergence is that, using the supply constrained version, the propensity to import is much more sensitive to increases in wage rates induced by the reduction in unemployment. Thus, imports rise from the second year through the fifth year up to the seventh year, when they are substantially greater than shown for the definitive version of the model. This is reflected in big differences in the estimated effects on GNP.

This set of tests on the imports equation shows a considerable range of possible effects of fiscal policy on the economy in the medium term and underlines the caveat that considerable caution must be used when interpreting the model's results. This is particularly true of simulations involving policy changes affecting, directly or indirectly, the rate of increase of wages. As there are other grounds for feeling that the effects of the constraints on supply in the medium term are underestimated, the "best" model for use for medium term simulation probably lies closer to the supply constrained version. For use in simulating policy changes in the short term, the differences are not as great and the "definitive" version may be preferred. In any event, in the absence of clearcut statistical criteria for making a choice, heavy reliance must be placed on the judgement of model users and the model certainly should not be expected to provide a clearcut "correct" answer.

5.5: Re-estimated Equation for Employment in Transportable Goods Industries.

It is clear from the discussion so far in the paper that the equation for employment in transportable goods industries plays a key role in determining the behaviour of the model, in particular in the medium term. It is, therefore, a cause of concern that when this equation was re-estimated using data for 1961-1978, drawn from National Income and Expenditure 1978, there was a considerable change in the magnitude of the estimated coefficients. The estimated equation based on the different data samples are as follows:

Estimation Period 1961-1977

$$\begin{aligned}\text{Log (E)} = {} & -1.52182 - \underset{(4.1)}{0.53546}\ \text{Log}(W/P_q) + \underset{(1.1)}{0.09765}\ \text{Log}(P_k/P_q) - \underset{(3.5)}{0.06722}\ \text{Log}(PE/P_q) \\ & \underset{(1,5)}{-0.203511}\ \text{Log}(PA/P_q) + \underset{(4.5)}{0.49593}\ \text{Log (Q)} + \underset{(4.8)}{0.73697}\ \text{Log}(E_{-1})\end{aligned}$$

Estimation Period 1961-1978

$$\begin{aligned}\text{Log (E)} = {} & 1.77076 - \underset{(1.5)}{0.2115}\ \text{Log}(W/P_q) + \underset{(2.4)}{0.17309}\ \text{Log}(P_k/P_q) - \underset{(1.2)}{0.5221}\ \text{Log}(P_E/P_q) \\ & \underset{(0.27)}{-0.04608}\ \text{Log}(PA/P_q) + \underset{(2.3)}{0.23393}\ \text{Log (Q)} + \underset{(2.5)}{0.51382}\ \text{Log}(E_{-1})\end{aligned}$$

The short-run elasticity of employment with respect to real wages fell from -0.5 to -0.2 and the long-run elasticity fell from -2.0 to -0.4. A more rapid adjustment of the actual level of employment to the equilibrium level is implied by the coefficients of the re-estimated equation.

Table 5.2

Effects of alternative sets of coefficients for the equation determining employment in transportable goods industries.

Cumulative change	Units	Year	Change in wage rates +1%		Change in Public Admin. employment + £10m	
			Standard Coefficients	Alternative Coefficients	Standard Coefficients	Alternative Coefficients
Non agricultural employment	000	1	-1.451	-0.759	+2.497	+2.413
		2	-2.352	-1.045	+2.396	+2.374
		5	-3.992	-1.362	+1.375	+2.071
		10	-5.423	-1.497	+0.884	+1.938
Unemployment	000	1	+0.845	+0.473	-1.342	-1.296
		2	+1.333	+0.696	-1.025	-1.019
		5	+1.780	+0.945	+0.250	-0.082
		10	+1.443	+0.930	+0.600	+0.524
Emigration	000	1	+0.004	-0.224	-0.841	-0.816
		2	+0.279	-0.197	-1.077	-1.065
		5	+0.870	+0.020	-0.481	-0.724
		10	+0.777	+0.085	+0.121	-0.161
Wage rates	%	1	+1.0	+1.0	+0.117	+0.121
		2	+1.0	+1.0	+0.204	+0.201
		5	+1.0	+1.0	+0.372	+0.351
		10	+1.0	+1.0	+0.284	+0.357
Industrial exports, volume	£m	1	-2.696	-4.231	+0.682	+0.800
		2	-0.543	-3.287	+0.345	+0.414
		5	+3.066	-2.235	+1.230	+0.136
		10	+5.375	-1.930	+3.661	+0.893
Imports, volume	£m	1	-0.192	-2.129	+6.321	+6.498
		2	+2.640	-0.343	+5.192	+5.231
		5	+5.251	+0.371	+6.190	+4.930
		10	+6.517	+0.331	+7.497	+5.464
Balance of payments deficit	£m	1	+3.174	+2.742	+7.722	+7.793
		2	+3.957	+4.011	+6.634	+6.583
		5	+2.092	+3.382	+6.661	+6.578
		10	+0.423	+2.835	+4.863	+6.182
GNP, volume	%	1	+0.030	+0.017	+0.245	+0.246
		2	+0.051	+0.031	+0.248	+0.247
		5	+0.060	+0.035	+0.267	+0.258
		10	+0.060	+0.031	+0.267	+0.259

These results indicate the need for caution when considering the behaviour of the model, in particular when the employment effects of changes in wages are being estimated. To provide an assessment of their significance for the overall behaviour of the model, multipliers were calculated using the alternative set of coefficients for this equation. In a very crude sense, the difference between the resulting set of multipliers and the multipliers obtained using the "standard" set of coefficients gives an indication of the degree of uncertainty which surrounds particular aspects of the model's behaviour. This method of using coefficients estimated from different samples to test the sensitivity of the model's behaviour contrasts with the more abstract perturbations used by Kuh and Neese (1980), for the same purpose.

Table 5.2 shows the results of a one per cent rise in wage rates (calculated as described in Section 4.2) and of a £10 million increase in expenditure on public administration employment using both the "standard" set of coefficients for the transportable goods industries equation and the version using the alternative set of coefficients estimated from the more recent sample. The results show that, using the alternative set of coefficients, the fall in employment arising from an increase in wage rates is much lower than with the definitive version and the rise in unemployment is, consequently, reduced. Because of the more rapid adjustment to the desired labour stock implied by the revised coefficients, the fall in employment is already two-thirds of its peak value by year two. In contrast, in the standard version, the adjustment, while larger, is proportionately slower.

As a result of the smaller increase in unemployment using the alternative coefficients, the increase in wage rates actually results in immigration in the first two years. In later years emigration is much lower than in the standard version of the model.

There is also a small increase in the balance of payments deficit in the medium term. This is due to somewhat more plausible behaviour for industrial exports which show a fall resulting from increased wage rates, throughout the period. However, the effects on the growth rate are little changed, still, implausibly, showing a small increase for the whole ten-year period.

In the case of increased public sector employment, the impact effects are almost identical for the two sets of employment coefficients. In the medium to long term, the effect of the alternative employment equation is to reduce the fall-off in employment from its peak in year one. As a result, the level of unemployment is lower in periods 5 and 10 than when the standard coefficients are used and, as a result, emigration is lower or immigration higher. With the exception of these differences, the changes in the other major economic aggregates are little altered by using the alternative employment equation.

The conclusion which can be drawn from these tests is that uncertainty about the magnitude of the coefficients in the employment equation raises doubts about the behaviour of employment, unemployment and migration in the model without affecting the behaviour of the other major economic aggregates. Thus, uncertainty about the behavioural implications of the instability of the coefficients of the employment equation is concentrated on one particular area of the model.

6. CONCLUSION

The fact that approximately half this paper has been concerned with testing MODEL-80 and highlighting the doubts and problems which still remain should not be misinterpreted. These tests have established three essential features which make the model an invaluable tool for policy formulation:

(i) The model is better, in terms of goodness of fit, than previous models used for fiscal policy simulation in Ireland.

(ii) Its behavioural characteristics are reasonably consistent with current theories concerning the workings of the Irish economy. MODEL-80 shows considerable improvement compared to previous models in its ability to simulate changes in incomes policy. The inclusion of a supply constraint, through the balance of payments, makes the model more suitable for medium-term forecasting and policy simulation. It also results in somewhat more realistic multipliers for the effects of changes in fiscal policy.

(iii) The identification of those aspects of the model's behaviour which are least certain helps focus the user's expertise and judgement where it is most required.

There clearly remain a number of aspects of the model where further work is required. In the previous section we mentioned that an important form of potential misspecification, which could not be detected by the tests applied there, was the failure to include some important channels of economic causation. The elimination of this problem, by broadening the model and incorporating new channels or sectors into it, is of considerable importance.

There are four major areas where we feel the scope of the model could be extended: the modelling of the effects of government policy, especially of the Public Capital Programme, on the supply side of the economy; the incorporation of an agricultural sector; revision of the monetary sector; the explicit modelling of the role of exchange rate changes.

In the current version of the model, the effects of expenditure by the IDA, or other government capital expenditure, on private investment, have not been explicitly incorporated. As a result, when using the model, *ad hoc* adjustments have to be made to take this factor into account. Such *ad hoc* adjustments cannot readily be made to the multipliers, such as those shown elsewhere in this paper, so that they will tend to underestimate the effects of government policy on the supply side of the economy. To eliminate this potential source of error will require detailed modelling of the manner in which government policy affects the nation's productive potential.

The agricultural sector, which was suggested in the 1978 paper to this Society as a possible area where the model's scope should be broadened, remains a priority in any further development of the model. The omission of such a sector means that a large number of *ad hoc* changes must be made in order to simulate changes in agricultural policy or the external environment for agricultural produce.

The model, as it stands, is not very suitable for simulating the effects of exchange rate changes. While some limited improvement could be achieved in this area, it is questionable how worthwhile this would be. Because the crucial effects of exchange rate changes on the Irish economy depend on the manner and timing of the adjustment of that economy to such changes, a quarterly model is really essential for such a purpose.

As well as broadening the scope of the model, the tests described in this paper illustrate the need for major improvements in certain existing sectors of the model. These are the consumption function, the determination of the demand for labour and capital and the determination of wages and prices.

The tests described in section three indicate clearly that an improvement in the consumption function would do more than any other factor to improve the model's performance. However, given the very large amount of work which has already gone into this function (reviewed in Digby, 1980), it seems unlikely that a miracle awaits researchers around the next corner!

In the case of modelling the demand for labour and capital, it is to be hoped that an integrated approach will prove more fruitful in the future than it has done in the past. The instability of these equations in the existing version of the model indicates that there is considerable scope for improvement.

The wage rates equations in MODEL-80 have proved particularly unsatisfactory in the out-of-sample period. The Phillips curve relationship does not appear to be well defined and there is obviously need for further research in this area.

Having set out our views as to the changes which need to be made in the model and the future course which we feel research in this area might take, we look forward to hearing your comments, suggestions, and criticisms.

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FOOTNOTES

1. t statistics are shown in brackets.

2. The other categories of capital expenditure are capital transfers (e.g., IDA grants) and loans and purchases of share capital.

APPENDIX 1 Tests of Tracking Performance

Table A.1: Summary simulation results for MINI and MODEL-80 - single period simulation

		MINI	MODEL-80
PERIOD		1960-75	1961-77
SOURCE		NIE76	NIE77
	ERROR STATISTIC*		
Average annual earnings	RMSPE	2.35	2.32
Balance of payments (£m)	RMSE	35.67	25.72
Consumption (Volume)	RMSPE	2.10	1.95
Non agricultural employment (000)	RMSE	4.97	5.95
Government borrowing requirement (£m)	RMSE	10.61	20.15
Investment, non building (Volume)	RMSPE	na	7.96
Imports (Volume)	RMSPE	3.64	2.90
Percentage change in consumer prices	RMSE	0.81	0.97
Profits (£m)	RMSE	30.97	23.14
Unemployment rate	RMSE	0.36	0.44
Industrial exports (Volume)	RMSPE	12.56	5.13
Percentage change in GNP (Volume)	RMSE	1.81	1.18

* RMSPE = root mean square percentage error

RMSE = root mean square error

Table A.2 Simulation Results for the Out of Sample Period

Years		1961-77	1961-78
Source		National Income and Expenditure 1977	National Income and Expenditure 1978
Variable	Error Statistic		
Industrial wage rates (%)	RMSE	2.28	3.52
Balance of payments (£m)	RMSE	25.72	62.20
Consumption, volume (£m)	RMSPE	1.95	2.12
Non ag Employment (000)	RMSE	5.95	7.28
Government borrowing requirement (£m)	RMSE	20.15	29.17
Non building investment (£m)	RMSPE	7.96	10.23
Imports, volume (£m)	RMSPE	2.90	4.05
Change in consumer prices (%)	RMSE	0.97	1.26
Profits (£m)	RMSE	23.14	35.87
Unemployment rate	RMSE	0.44	0.45
Industrial exports, vol (£m)	RMSPE	5.13	5.17
Change in GNP, vol (£m)	RMSE	1.18	1.38

Table A.3 Multiple period simulation of MODEL-80, 1961-77

VARIABLE	STATISTIC	Single Period	Multiple Period
Change in industrial wage (%)	RMSE	2.28	3.18
Balance of payments (£m)	RMSE	25.72	33.40
Consumption, Vol (£m)	RMSPE	1.95	2.60
Non ag. employment (000)	RMSE	5.95	13.18
Government borrowing requirement (£m)	RMSE	20.15	17.60
Investment non building, volume (£m)	RMSPE	7.96	7.63
Imports, volume (£m)	RMSPE	2.90	3.32
Change in consumer prices (%)	RMSE	0.97	1.07
Profits (£m)	RMSE	23.14	44.35
Unemployment rate (%)	RMSE	0.44	0.83
Industrial exports vol. (£m)	RMSPE	5.13	7.12
Change in GNP, vol. (%)	RMSE	1.18	1.35

DISCUSSION

P. T. Geary: It is a pleasure to propose the vote of thanks to John FitzGerald and Owen Keegan for the paper they have presented to the Society. It is obviously the product of much hard work and ingenuity. The authors are generous in their acknowledgement of the contributions of their colleagues in the Department of Finance and the Central Bank to the development of MODEL-80 and we are indebted to all of them for their efforts. To comment on a paper sixty-one pages in length is hard enough; when it is based on another (Bradley, et al., 1981) which is more than two-hundred pages long, it will be appreciated that I find it necessary to be very selective. I propose, therefore, to deal mainly, if not exclusively, with the general issues raised by the FitzGerald-Keegan paper, a task made easier by the forthrightness of its introduction and conclusion.

In the introduction to their paper, John FitzGerald and Owen Keegan present the following rationale for the construction of a macroeconometric model: it requires the development of an internally consistent framework and makes possible the testing of that framework by "confronting it with the reality of economic events". They go on to say that the paper "is not so much concerned with the actual specification and testing of a model of the Irish economy as with its behavioural characteristics" because "MODEL-80 . . . is primarily designed to examine the effects of change in fiscal policy on the economy". The authors' emphasis on the use of the model for purposes of policy evaluation motivates many of my comments.

I think it is accurate to say that the status of large-scale macroeconometric modelling in the economics profession is lower than it was ten years ago. Widespread dissatisfaction with the performance of macroeconometric models in the U.S. during the 1970s led to some highly critical appraisals. It was argued that the theoretical basis of the models, the "Keynesian orthodoxy" of the 1960s, had been shown to be inadequate, especially by the unemployment/inflation experience of the 1970s. But it was further argued that macroeconometric models were not fully based on coherent economic theorising, on the following grounds. First, the estimation of the models required the exclusion of variables from behaviour equations despite the absence of credible theoretical grounds for doing so, what Sims (1980) called "incredible identification". Second, in practice, estimated macro models use so many *ad hoc* specifications to obtain good statistical fits that there is no presumption of internal theoretical consistency. Third, macro models are extremely cavalier on the issue of stochastic specification: the nature of the assumed random disturbances has no theoretical basis (see Sargent, 1977). Fourth, the treatment of expectations, if the topic is treated at all, is inadequate: firms making optimal investment plans, for example, are not assumed to generate optimal or "rational" expectations (see Lucas, 1981).

It should be emphasised that some of these issues are the subject of still heated controversy; one need only cite Malinvaud's (1981) use of the term "rational expectations fanatics" to illustrate. But Ray Fair (1979), perhaps the most highly regarded econometric model builder in the U.S. today, recently wrote in the *Journal of Political Economy*:

> There is currently in macroeconomics a considerable difference of opinion as to what the true structure of the economy is like. One way in which this difference manifests itself is in the wide variety of macroeconometric models that are in existence. One might have thought at the beginning of large-scale model construction in the early 1950s that by the late 1970s the debate would be over fairly minor specification issues. This is, of course, not the case, as any casual glance at a number of models will reveal. There is also little sign that the range of differences is narrowing.

Against this background, I found that the paper by John FitzGerald and Owen Keegan possessed a curious serenity, as though untouched by the battles which raged around its subject. I can't help feeling that the authors would have written somewhat differently had they chosen to place their contribution more firmly in the context of current controversies. In this connection, I was struck by the small number of international publications and large number of unpublished discussion papers referred to by the authors, which had the effect of burying some of their intellectual debts.

Before dealing with the fundamental question of policy, I shall comment briefly on a few issues of detail, as a way of illustrating some of the points made earlier. It should be emphasised that some of them were highlighted by the authors themselves. First, MODEL-80 contains a number of *ad hoc* specifications, as an examination of Bradley, et al. (1981) shows. Among the behaviour equations of which this may be said are the consumption function, investment function and employment function. As the authors comment, satisfactory estimation of the consumption function has proved to be particularly difficult, necessitating the use of an implausible specification; the investment and employment functions are unabashedly hybrid, the former incorporating a 10 per cent depreciation rate which seems very high and the latter including both the price and quantity of output as explanatory variables on the basis of an argument about the existence of monopoly in some sectors of the economy. What this does to the internal theoretical consistency of the model is hard to gauge.

Second, a large part of the paper consists of the presentation of model simulations which reveal how a change in a variable such as the wage rate influences all sectors of the model. As the authors say, these exercises serve to reveal the workings of the model in a way no other procedure can match, and they are of considerable interest. While some of the results are plausible, one in particular was puzzling. This was the, to this writer, extraordinary sensitivity of many variables in the model to a change in interest rates. For example, a one percentage point change in interest rates has a bigger two-year effect on unemployment than a one percentage point change in wages. Third, as the authors stress, some parameter estimates proved highly sensitive to the addition of an extra observation, and data revisions. This is not an uncommon experience in econometric estimation but is obviously worrying.

I shall now deal directly with the question of the usefulness of a model like MODEL-80 for the purpose of policy evaluation. As will be recalled, John FitzGerald and Owen Keegan emphasised the policy relevance of their work and concluded that despite "the doubts and problems which still remain . . . the model (is) an invaluable tool for policy formulation". I do not accept this conclusion, for the following reasons. The first is that the combination of model specification problems, unstable coefficient estimates and some simulation results suggests to me that the model cannot yet be regarded as a satisfactory representation of the Irish economy. Next, even if the model didn't have these drawbacks, the fact that an alternative model with quite different theoretical perspectives might produce as good a within-sample performance but different multipliers, raises obvious questions as to exactly what the multipliers (or simulation results) mean. A "strong" view would be that they are meaningless; it might be more reasonable to say that since within-sample performance is an inadequate way of discriminating between models, the simulations of a model not adequately tested against alternatives should be interpreted with caution. In addition, even though it may be computationally burdensome, one would like to see the simulations presented with confidence intervals, even of an informal kind.

Finally, the model is open to the now widely accepted Lucas-critique of econometric policy evaluation. The gist of Lucas' (1976) argument is that while econometric models may be useful for forecasting, "simulations using these models can, in principle, provide

no useful information as to the actual consequences of alternative economic policies". This is because simulations are based on *a single set of fixed parameters* estimated from the sample period, whereas the true parameters may not remain fixed but may vary with each alternative policy. Lucas himself discussed the circumstances under which econometric policy evaluation could proceed; essentially policy changes which are seen as changes in regime can be dealt with. There has been much additional work in this area, e.g., Wallis (1980). The FitzGerald-Keegan paper does not deal with expectations at all, a deficiency not justified by the fact that the model is annual; whether this helps to account for some of the parameter instability seems to me to be a question worth pursuing.

To conclude, I have concentrated on problems, many of which were pointed out by John and Owen, precisely because of their emphasis on the usefulness of MODEL-80 for policy formulation. My argument is more with their application than with their method. They have produced a large amount of evidence on the workings of the Irish economy and for this we are all in their debt. As far as suggestions for further work are concerned, they indicate that they would like to extend the model. One of my reactions to that is that the model is already large and that it might be worthwhile to incorporate different features in a smaller model. For example, the treatment of expectations might be considered in such a model; perhaps a more aggressively experimental approach - either in the direction of extensive parameterisation using information from tightly specified sectoral models or in the direction of a less structured time-series approach with quarterly data - would be worth contemplating. I wish them success in their continuing efforts and am very happy to propose this vote of thanks.

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J. W. O'Hagan: I would like to second the vote of thanks to John FitzGerald and Owen Keegan for their well researched paper. It is a continuation of a large volume of work that has gone into the construction of an econometric model for Ireland over the last few years. The comments I would like to make refer in large part to this work *in toto*. As such, they are not intended as criticisms of tonight's paper *per se*, but merely as a questioning of the whole exercise of econometric model building in Ireland to date.

It has been suggested, perhaps somewhat cynically, that if an economist is someone who guesses wrong about the economy, an econometrician is someone who uses a com-

puter to guess wrongly about the economy. Much more serious, however, are the criticisms of econometric model building from respected people within the profession. In this regard, Leontief's much quoted statement - that "in no other field of empirical enquiry has so massive and sophisticated a statistical machinery been used with such indifferent results"[1] - has to be examined carefully in an Irish context.

Econometric model building, needless to say, costs money. More important, there is evidence to suggest that it costs more than any other quantitative forecasting method.[2] This applies in particular to the development costs, which include the costs of developing an appropriate model for the given situation. The human resource cost here can be very substantial indeed, amounting to many man-years. In this regard, I would like to have some knowledge of the costs to date of developing and applying the econometric models that exist in Ireland. I do know that economists in the Central Bank, the Department of Finance and The Economic and Social Research Institute have spent varying amounts of time on econometric model building - but how long, and at what costs in terms of human resources (including computer and secretarial staff time) and other resources? Only then can we attempt to assess the wisdom or otherwise of proceeding with MODEL-80.

My concern with costs, partly reflects my scepticism regarding the benefits of a model, such as MODEL-80, in an Irish context. The authors of to-night's paper stress that the present model is an invaluable tool for policy formulation for three reasons: (i) It is better in terms of goodness of fit than previous models; (ii) its behavioural characteristics are reasonably consistent with current theories concerning the workings of the Irish economy; and (iii) the identification of those aspects of the model's behaviour which are least certain helps focus the user's expertise and judgement where it is most required.

The statement that a model is an invaluable tool for policy formulation because it is better than other models is, of course, a *non-sequitur.* To a lesser extent, the same reservation applies to the other statements above. I would, in fact, like to draw attention to two aspects of the model which raise serious doubts, in my mind at least, about its value to policy makers. Both of these deficiencies the authors explicitly acknowledge in their paper and, as such, the differences between us appear to arise more over the seriousness of the deficiencies rather than over their existence.

The first aspect of econometric models, when used for the purposes intended in this paper, that seriously undermines their usefulness is the instability of parameter estimates. This problem is inherent in almost all econometric models, and MODEL-80 provides a classic illustration of this. The authors state that it is "a cause of concern" that when the equation for employment in transportable goods industries was re-estimated, there was a considerable change in the magnitude of the estimated coefficients.

Let us look more closely at this. The re-estimation involved the addition of only *one* extra year to the sample and yet there were quite dramatic shifts in parameter estimates, particularly, and unfortunately, with respect to one of the most crucial estimates of the model - the elasticity of employment with respect to the real wage. This, of course, is no reflection on the authors, but merely a reflection of the almost insuperable problems of using economic time-series data in multiple regressions. The point is that with the addition of another one or two observations, this problem could occur in any estimated equation of the model.

The second major reservation I have about MODEL-80 is that the effects of expenditure by the IDA, or other government capital expenditure, on private investment are only incorporated into the model in an *ad hoc* and unspecified way. I think the authors seriously underestimate the importance of this defect on the usefulness of the model for any sort of medium-term forecasting. The reasons for this view have already been well documented elsewhere by Sean Nolan and myself.[3] and I will only deal briefly with them here.

Any model concerned with medium-term economic trends in Ireland must have as its primary focus, the firm: the kernel of such a model will be its theory of the firm. Particular regard must be had to the determinants of investment, with a central role for the flow of new foreign investment into Ireland. This, in turn, requires the careful treatment of the role of such factors as profitability and various government policies. A second relationship which would have to be central to the model is that between investment and employment. Such a relationship will clearly be influenced by a number of factors, particularly IDA policies and the evolution of technology. Now, both of these key relationships are not at all adequately dealt with in MODEL-80. Indeed, the "eclectic alternative", which the authors appear to initially reject, has to be resorted to by them in incorporating these crucial behavioural relationships into their analysis.

It is, perhaps, somewhat unfair to raise the above points here tonight. No doubt, the authors started from the assumption that modelling on the lines of MODEL-80 was legitimate and useful and that their brief was to improve its performance - taking its broad framework as given - and to explore its behavioural characteristics in some detail. This they have done in a rigorous and interesting fashion. I therefore warmly thank them for presenting their paper to the Society here tonight.

FOOTNOTES

1. See S. Makridakis and S. Wheelwright, 1978. *Forecasting Methods and Applications,* Wiley, New York.
2. Quoted in P. Kennedy, 1979. *A Guide to Econometrics,* Martin Robertson, Oxford.
3. Nolan, S. P. and J. W. O'Hagan, 1980. "The Central Bank MAXI Econometric Model: Supply Factors - Phase I, Preliminary Comments", Department of Finance.

R. C. Geary: MODEL-80 is as important for what it promises as for what it is. It is ironical, but singularly apt, that this paper should appear during a General Election, not that it will have an effect on the result of the present occasion, but in the future - on the highly optimistic assumption that information, knowledge, reason and logic, wisdom in fact, will govern political action and attitude in future. To repeat, a highly optimistic assumption.

For years after the war, the Planbureau of the Netherlands, under its Director, Jan Tinbergen, who invented the system of equations approach, were accustomed each year to present to the government the effects on key endos, e.g., GNP, employment, unemployment, prices, etc., of changes in policy of various types, these changes expressed as vectors of policy variables, i.e., variables like taxation, public expenditure, etc., which government could influence in greater or lesser degree. I do not know to what extent these findings affected government decisions at any time. I have the strong impression that the influence lessened as time went on, for the reason, no doubt, that in the Netherlands, as everywhere else, power groups are far less interested in the public good than in their own good. The parliamentary party democracy we practise has great merit, but in it power groups have disproportionate power. Even if this continues, the public are entitled to know the effects of policies proposed to them in the short and long run, whether the parties or powers like it or not. An elaboration of Table 4.1 of the paper and other tables in Section 4 could be admirably adapted to this end. Its columns would be headed Policy I, II, III, etc., each policy being defined as vectors of changes in policy variables, including, of course, no change. Other options than those proposed by the political parties would be examined. Optimal choice or choices would be sought. It is a sobering thought that policies designed to optimise employment or real GNP would be different. One might even have recourse to linear of non-linear programming using the present equations in

equality or non-equality forms as reasonable constraints and an objective function to be optimised, enshrining the non-material as well as the material ideals for the people.

Through the good offices of John Bradley, I have been privileged to study the very large volume mentioned third in the References of which our lecturers and John Bradley were co-authors. This, naturally, contains many more detailed results than in tonight's paper, but extending to showing effects of various changes up to five years, where tonight's paper in tables in sections 4 and 5 commendably extends these to ten years. From the larger paper I extracted a few results when I was studying it. The most devastating of these was that an increase of £1m in public expenditure (except on public employees) would increase the balance of payments by nearly £1m simultaneously and £0.6m after five years. It would have no appreciable effect on unemployment. Expenditure of £1m on public employment would increase the balance of payments by £0.9m simultaneously and £0.7m after five years, all values at 1975 prices. It would increase non-agricultural employment by 271 (falling to 118 after five years). This employment effect would mean a cost of £3,700 per person employed at 1975 prices. There is no point in discussing these findings here and now. But at least it can be said that they are crucially relevant and the possibilities of extension on the lines indicated of incalculable value.

Table 4.1 and others in Section 4, as they stand, are worthy of close study. To repeat, I hope that my suggestion of extension to effects of whole policy sets of changes on major endos will be adopted for study.

I was puzzled at first that an increase of 1 per cent in wage rate occasioned a progressive increase in productivity in industry until I noticed that this would be due to a much larger decline in non-agricultural non-public administration.

This suggested approach of showing the effect of a whole policy (i.e., a set of changes) instead of change in a single policy variable, finds further justification in the fact of colinearity of exos: a change in a single exo will be likely to be accompanied by changes in other exos and the latter changes should accompany the presumed change in the prime exo.

It is satisfactory that the large MODEL-80's goodness of fit during the estimation period is better than that of the Mini. At the same time, this is no guarantee of superiority outside the estimation period, i.e., for forecasting. Maurice Kendall told me that the experience of his commercial company, CEIR, found no superiority in forecasting in the more elaborate over the simple models. In this uncertain region everything should be tried.

In this context, might I make an appeal for a resumption of the input-output approach to model making, dealt with in my 1965 Society paper. Since then there has been a vast extension of I-O tables at the hands of Eamon Henry. A great number of policy decisions can be derived from this model by changing a very few parameters. This approach might help to cope with the familiar objection to models like MODEL-80 that they are based on past experience and the future is certain to be different.

I would like to have the lecturers' reaction to that other objection that the answers it yields depend on the form of the model, which is a series of cause-effect relationships, which, however well grounded in economic theory, require statistical proof. A large R^{-2} and a DW near 2 are reassuring, it is true, and mention of DW prompts mention of tau, which is simpler, is nearly as efficient, has no region of imprecision and, as Irish, use of it is more patriotic! Mention of your getting out of your model what you put into it is another argument for using many approaches, as independent as possible, to model-making for planning and forecasting.

I would like to recommend to the Irish Model group the notion of the anti-forecast, i.e., results designed to show what *not* to do. I think that this function of the model would be at least as important as its positive function, i.e., the determination of best

policy. Furthermore, equations could be used singly for such determination, as distinct from the whole set always. Anti-policy results would be effective in their appeal to politicians and public. For example, I read last week in a popular USA periodical that 1 per cent addition to the unemployment rate adds $25 billion to government excess spending.

By the way, I have no objection to the single equation solved by OLS (as distinct from 2 SLS, FIML, etc.) adopted generally for the solution of MODEL-80, even though this results in coefficient-bias. Controvertially, I hold that individual coefficient values are of no importance. It is the whole set of values used for forecasting and planning that matters.

I am uncertain about the test used by the authors, i.e., that displayed in Table 3.1, in which the equations determine their forward values themselves. The favourable results revealed by standard errors are partly due to the test covering nearly all the estimation period. I would prefer a test bearing on 1978 alone; in fact, a comparison of the results from MODEL-80 with naive extrapolations for all 266 endos. Might I ask the authors if the model would have signalled the present recession, with particular regard to the unemployment rate?

Economics is the study of cause and effect. Trouble is, we don't know how much of each phenomenon is cause or effect. May I appeal to the authors and their colleagues to include the study of associative relationship in their programme. This eliminates any hypothesis of cause-effect. Also strive to eliminate most of the still large number of exos. Larry Klein, the US pioneer in this field, wanted to eliminate all exos but this perhaps was over-ambitions, for there remain time and the weather. At this time I would add expenditure by USA and major powers on armaments which passes reason and qualifies for the epithet exogenous, to use no worse language about it.

Might I near end by suggesting the inclusion of dummy variables to express effects of non-statistical causes.

The conflict between the two equations for log (E) in section 5.5 is incredible, namely, that increasing the estimation period by one year (from 1961-1977 to 1961-1978) completely changes the coefficient set. I looked up the results for the 1961-1977 in the Bradley, et al., paper to find that this is statistically excellent with an $\bar{R}^2 = .98$ and a DW = 1.92, even if helped by inclusion of the lagged log (E_{-1}) on the r.h.s. And the devastating contrast of Table 5.2! This experience requires closer examination. How has the inclusion of 1978 affected other equations? Nineteen-seventy-eight is not regarded as an exceptional year. If the general effect of its inclusion in the estimation period yields contrasts like those of Table 5.2, doubt is cast on the value of MODEL-80 as a whole.

I conclude by congratulating the authors and their colleagues on their work so far and wish them every success with its continuation, as I hope in many directions.

Mr S. Cromien: I do not wish to comment on the specific details of this excellent paper. I am speaking rather to pay tribute to the work which the authors have carried out in the Department of Finance, the fruits of which are to be seen in the paper. John FitzGerald has made this particular area of work his own in the Department and, in collaboration with Owen Keegan and other colleagues there and in the Central Bank, has made great advances in it through his fresh and creative approach.

It is unusual for a Government department to be engaged in original research. The work of a department is public administration and it is difficult in normal circumstances to justify, or indeed find the resources for research. However, we have made an exception in this case, both because we are keenly interested in the results of their practical application to our economic and fiscal work and because we feel we have special expertise in relation to Government expenditure and taxation.

Our investment has paid very considerable dividends in the improved sophistication of our methods, notably in the study of policy options. I see Brendan Menton in the audience. When he and I represented the whole economic forecasting apparatus of the Department, if not of the State, our methods were rather less sophisticated. I may say, jokingly, I am not sure that our figures now are always all that much more accurate but they are at least intellectually more satisfying! Thanks to work carried out by John FitzGerald and his colleagues, we can do things now which are of immense benefit, especially at budget time.

Paddy Geary and John O'Hagan quite legitimately raise questions about the effectiveness of model building and infer that it is not useful for policy formulation. I think we are conscious of the dangers of relying too heavily on models or indeed on any mechanical means of forecasting. It seems unnecessarily critical, however, to suggest that models have not some part to play in the preparation of policy. In fact, the practical reality nowadays is that they cannot be done without. If, for example, advice on the effects of alternative tax measures is required, it seems better to be able to produce a series of answers which are based consistently on a detailed, even if faulty, analysis of the economy rather than rely on mere guesswork. What is important, of course, is how the model's results are used. They have to be used with discretion. A large share of intuitive judgement has to be added to the mix of figures.

Mr C. M. Fanning: The paper under discussion is an excellent example, indeed almost a guide, as to how to go about dissecting a large-scale macroeconometric model. It is done with a thoroughness that is quite rare, even by international standards, and from now on must be taken as the baseline evaluation of a model. However, Patrick Geary, in his response, has picked on the claims made for the model as a tool for policy analysis. In a brief space he has succinctly brought together the main points which go to the core of this issue and it is on this I shall concentrate. Broadly, I am in agreement with the scepticism expressed but believe it is worth pursuing a little further, and from a slightly different perspective, in order to suggest sources of the problem and possible responses to the critique. To do this it is necessary to first look at the place of macroeconometric models in economic research and, thereby perhaps, identify the correct attitude to such models. Economics, probably not alone among the humanities, is a discipline where policy debates wax and wane but all too often there is no final resolution. The parameters of conflict may change and the mathematical and statistical techniques become more sophisticated but *deja vu*, if not close encounters for the third time, is a common state of awareness. The area being examined here is no exception. An interesting exchange of letters between Keynes and Harrod (Keynes, 1973) concerning the empirical work of Tinbergen and Schultz in the 1930s contains some of the main issues relevant and I shall avail of their interchange as a context for my comments.

Keynes, as always, emphasised that he saw economics as a branch of logic and, as he said, it "is a science of thinking in terms of models joined to the art of choosing models which are relevant to the contemporary world". This was necessary, as he pointed out, because the material is not homogeneous through time; thus, the object of a model is to identify the semi-permanent from the transitory factors "so as to develop a logical way of thinking about the latter, and of understanding the time sequences to which they give rise in particular cases". He raised a matter which is crucial for empirical models in theoretical research:

> ... it is the essence of a model that one does *not* fill in real values for the variable functions. To do so would make it useless as a model. For as soon as this is done the model loses its generality and its value as a mode of thought.

Harrod, in response, argued that if "equations of static theory are of importance, surely they should be given provisional quantitative significance, even if this has to be done from time to time. Just as, surely, one wants to know the value of the multiplier, even if one also knows that it is subject to both cyclical and secular change". The empirical importance of one variable relative to another, he suggested, might affect judgement with regard to various matters without impugning the validity of the model. This view was essentially accepted by Keynes and he clarified his position as follows:

> Tinbergen endeavours to work out the variable quantities in a particular case, or perhaps in the averages of several particular cases, and he then suggests that the quantitative formula so obtained has general validity. Yet, in fact, by filling in figures, which one can be quite sure will not apply next time, so far from increasing the value of his instrument, he has destroyed it. All the statisticians tend that way.

Whatever about the accuracy of Keynes' views about Tinbergen or statisticians, his correspondence raises issues that are central to contemporary debate and, in particular, suggests the place of macroeconometric models as being under the umbrella of general macroeconomic theory. Its contribution is to facilitate judgement about the applicability of the theory and indicate orders of magnitude of the relative factors for a particular time and place. A major limitation of this technique follows from the latter point: economic institutions and relations are subject to change. But economic theory, except in a very few areas, and then only to a limited extent, does not provide a theory of parameter change to guide empirical work. In my view, Patrick Geary has rightly singled out the unsatisfactory nature of economic theory and the lack of internal theoretical consistency as the major sources of difficulties for macroeconometric models such as MODEL-80. As Kalecki once said, "economics consists of theoretical laws which no one has verified and empirical laws that nobody can explain". A good example of the latter is the so-called Verdoorn relationship between the rates of productivity growth and output growth. Estimates of this correlation for Irish industry show plausibly good fits but parameter shifts as between sub-periods (Kennedy and Foley, 1978: 90-93). This relatively robust empirical relationship lacks an acceptable and verified theory inclusive of parameter instability.[1]

There is no doubt that the structural changes following the rapid increase in real oil prices and heightened awareness about supply bottlenecks which occurred from the mid-1970s resulted in a major undermining of macroeconometric models in use at the time. Helliwell and McRae (1981), who have been in the forefront of reconstructing the macroeconometric approach, concisely state the task and the research problem in modelling:

> In designing macroeconomic models, the crucial trick is to choose a structure of aggregation and functional forms that exposes the key channels of influence, makes efficient use of a priori information, and thus allows the available observations to be used to estimate key parameters about which little is known. Any model structure that was chosen under these criteria a decade ago is sure to be the wrong structure now that energy price changes and other events have posed new and largely unforeseen problems of adjustment.

The question which then arises concerns the appropriate role for macroeconometric models in policy research and the national policy determination process. This was not the immediate subject of the FitzGerald and Keegan but the impression they give is that their role is self-evident. If the intention is merely to guess future values for variables, then criterion for use are obvious. However, for economic forecasting proper (which, at the

one time, is less than foretelling the future and much more in terms of information content) and policy analysis, both of which are based on explanation and interpretation, Geary is correct to question the authors' claim that the "model (is) an invaluable tool for policy formulation". In order to identify the role for macroeconometric models, it is necessary to consider the nature of (i) the technique itself and (ii) policy research and the policy decision process. The first aspect shall be considered here.[2]

The methodological aspect requires coming to grips with the macroeconomic, econometric, and model aspects of the technique. First, the models are held to be macroeconomic. Yet there is no consideration of the grounds on which it can be postulated that an entire economy, or even a sector or industry, can be regarded as an integrated and unified decision-making unit and modelled on the basis of individualistic behaviour. The economy is a system of units and the relations between them. Too little attention, indeed usually none, is paid to these and the level at which analysis is conducted and explanation sought. Specifically, theoretical analysis is often conducted in terms of conceptual entities such that it is not always made clear how to translate the analysis into real world categories. This seriously affects the policy implications that can be derived. If macromodels are to be useful tools for policy analysis (as against projecting details of national or government accounts), it is necessary that they be truly macro models.

Second, the econometric basis of the models means that they are historical by the very nature of the data. This in turn raises questions about the estimation and evaluation approaches which are generally based on the statistics of frequency probability. But as Solow (1980) pointed out, "all we have to go on is the one experimental run that history performs for us, and history never bothers to repeat itself holding constant all but one factor at a time". FitzGerald and Keegan state that the construction of a macroeconometric model allows a theoretically consistent framework to be confronted "with the reality of economic events". As Geary mentions and the authors recognise, the statistical techniques and data may be inadequate for selecting between theoretical formulations and functional specifications; but it is more than that - they may even be inappropriate for each other. It is not a minor matter in the exercise that we say the models are validated. This procedure contrasts sharply with the refutation tests which are applied to scientific hypotheses. To substantiate the claims for usefulness in policy analysis, it is necessary to consider to what extent the prediction or historical replication tests conducted are sufficient tests of the explanatory power of the model.

The historical nature of the data also has implications for the theoretical underpinnings of empirical models: the *ex ante* position may be quite different in regard to behaviour than it looks *ex post*. For instance, *ex ante* each firm must make plans on the basis of price and quantity expectations. In terms of recorded data, outcomes may be better than, worse than, or as expected. Across all firms a profit margin, i.e., the markup, is observed between revenues and historical costs. Thus, testing (fitting) a markup theory of pricing may result in the theory being 'validated'. Furthermore, price or recorded revenue per unit is quite a different matter from purchaser's cost which effectively varies as, for example, the period of trade credit or discounts for quantity varies. Finally, postulating profit maximisation in a world of uncertainty is meaningless (Alchian, 1977). It may be fine in a world of "as ifs" and prediction but that is not a sufficient basis for explanation or policy prescription. I believe aspects such as these make macroeconometric models more a tool of description than is usually admitted and once again puts the emphasis on their macro theoretic framework.

Third, the model aspect is simply a recognition of the partialness of the results and is due to the abstraction involved in any such analysis. These issues, in particular the macro theoretical aspects, are major sources of the ad hocery, coefficient instability, and theoretical inconsistency stressed by Geary as affecting the usefulness of models at present.

The exploration and resolution of these matters are essential for the appropriate use of macroeconometric models in the policy process.

FOOTNOTES

1. This relationship, of course, can be provided with a neoclassical theoretical underpinning but that itself is accompanied by a substantial baggage of untested/maintained hypotheses.
2. This second issue is a very broad one and raises matters concerning the policy process in general and the role of economic, just like any scholarly, research in it. This topic has been considered briefly at another meeting of the Society (Fanning and Bradley, 1982: Part IV).

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Reply by John D. FitzGerald and Owen Keegan: We would like to thank all those who commented on our paper. Their comments and criticisms were extremely valuable and will help direct the future course of our researches.

Dr R. C. Geary's suggestion that the model multipliers should be used to help inform the Government's deliberations on economic policy was, we would feel, over-ambitious. The large number of caveats entered in this paper and the complexity of interpreting and criticising the model's results mean that it can only be used as one of a number of technical inputs into the policy-making process. As such, its place is probably still in the "backroom".

In his comments on the paper, Patrick Geary questions the validity of using the model as a tool for policy analysis on a number of different grounds. He begins by referring to the undeniably diminishing status of economic modelling in the economics' profession over the last ten years, a factor he ascribes to the poor performance of large macromodels in the US in the 1970s. It is not surprising that economic modelling, which was closely identified with the success of macroeconomic policy in the 1960s, should have been tainted by the perceived failure of these policies over the 1970s. Since this has resulted in economic models being treated with more scepticism than previously, particularly in the 1960s, it is probably a necessary antidote to previous euphoria.

Patrick Geary refers to the problem of the inadequate theoretical basis of econometric models and the frequent lack of a consistent theoretical underpinning. He cites four manifestations of this malaise.

There is no doubt that MODEL-80 scores on all four counts: in some cases by default, as the issues were not considered when the model was being developed; in other cases, despite a search for theoretically consistent specifications, recourse had to be made, perforce, to *ad hoc* alternatives to make the model work. We can be grateful to Mr Geary for pointing the way to further research and to the need for further development work on the econometric model in Ireland to be carried out in the light of general developments in macroeconomic and modelling theory. Whether these criticisms of the imperfect state of economic modelling invalidate the use of models such as MODEL-80 for policy analysis, or simply serve to emphasise the need for caution and expertise in their use, is a moot point on which we are bound to disagree with Mr Geary.

Finally, as regards the "widely accepted Lucas critique of econometric policy evaluation", there is no theoretical reason why shifts in parameters in response to policy changes could not be deduced or estimated and imposed on the model when the effects of certain policies are being simulated.

The rational expectations critique has not invalidated the use of macroeconomic models as tools for policy analysis. It has merely served to increase the reliance on the judgement of the model user and to confirm yet again the futility of using any econometric model as a mechanical tool.