THE ECONOMIC AND SOCIAL RESEARCH INSTITUTE ISBN 0-7070-0110-2

HERMES-IRELAND
A Model of the Irish Economy: Structure and Performance

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Price IR£40.00

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OCTOBER 1989

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ACKNOWLEDGEMENT

The HERMES-IRELAND model was developed under contract for the EC, Directorate General for Science, Research and Development (DG XII) over the period 1982 to the present date.

The authors owe much to the stimulating collaboration with the participants in the complete HERMES project. In particular, Dr. Gonzales d'Alcantara was the intellectual father of this wayward Irish child! The other members of the central group (Dr. Alexander Italianer, Professor Paul Zagamé, M. Eric Donni and M. Francois Libeau also provided invaluable assistance over the years. M. E Römberg and M. Pierre Valette kept a watchful eye over the administration of the project and were more patient and understanding than we ever deserved.

The authors would also like to thank their colleagues in the Economic and Social Research Institute and the Department of Finance for valuable advice and comments. The authors, of course, remain solely responsible for the content of this publication.

CHAPTER 1 : INTRODUCTION

[1.1] : Introductory Remarks

If a macroeconometric model is used for forecasting and policy analysis it is essential that a complete description of the model be available for consultation by users of the model's output. Besides fulfilling this practical purpose, a detailed description of the model and its simulation properties also provides a useful repository of current applied econometric research. The purpose of this document is to address the above practical and theoretical objectives. It aims to provide a distillation of the research work that went into the construction of the Irish national sub-model of the EC HERMES project. This represents a substantial revision and extension of the earlier ESRI Medium-Term Model (Bradley, *et al*,1985). It also provides the modelling background to the *Medium-Term Review: 1987-1992* (Bradley, Fitz Gerald and Storey, 1987)[1]. For this reason, we confine ourselves to coverage of purely descriptive material relating to the model system, its simulation and its multiplier properties.

[1.2] : Linked Economic Model Systems

One of the important by-products of the development of national accounting statistics and the Keynesian economic revolution was the construction of macroeconometric models of individual economies for use in policy analysis and forecasting. During the 1950s and 1960s such models were implemented for most of the developed economies of the western world[2]. A logical development of these individual country models was to extend the modelling process to groups of economies and attempt to model linkages between countries as well as the internal economic mechanisms within each country.

If the construction of individual country models is a difficult task requiring much time and resources then, *a fortiori*, the construction and operation of internationally linked models represents a massive commitment of resources. Such linked model systems have been approached in two different ways. In the first, existing models of individual countries have simply been gathered together and additional mechanisms grafted on to supply the missing inter-economy linkages. Important examples of this approach are Project LINK, set up by Nobel laureate Lawrence Klein and operated by the Wharton School in Pennsylvania (Waelbroeck,1976), and the OECD INTERLINK model (Richardson,1988).

The second approach arose out of a realisation that the assembly of a heterogeneous collection of individual country models, each constructed according to different empirical requirements and theoretical assumptions, made the resulting linked model simulations very difficult to interpret and rationalise. Such systems function as a "black box" and are impenetrable even to an expert outside eye. An alternative approach is one where models of all component countries are constructed *de novo* according to a fairly uniform empirical and theoretical schema. An example of this approach was the COMET model of the EC, constructed as a model of the nine member states (the six original members plus the UK, Denmark and Ireland - Barten *et al*,1976) and later extended to incorporate detailed models of the USA and Japan together with a schematic treatment of other countries (Greece, Spain, Portugal) and blocks of countries (other OECD, OPEC, socialist and developing countries - Barten *et al,1980*).

However, during the 1970s the world economy was hit by a series of massive supply-side shocks (oil price rises, energy shortages, other commodity price rises) which opened up fundamental weaknesses in the demand-side theoretical underpinnings of many operational macroeconometric models (Blinder,1979). For a time the modelling approach was in a state of eclipse, further exacerbated by the vigorous critique of the rational expectations school (Lucas and Sargent,1981)[3].

During this period of re-examination, the empirical and theoretical emphasis of models also shifted in another direction. In the 1970s there had been an explosive growth in research on the economics of production. Early production studies usually tried to explain an added-value measure of output in terms of capital and labour inputs alone, and used fairly simple production functions to do so, e.g., the Cobb-Douglas or the Constant Elasticity of Substitution (CES) function. New developments in production and cost functions generalised the earlier "two-factor" added-value functions to multiple-factor models. Hence, a measure of gross output was explained in terms of inputs such as capital, different types of labour, energy and other material inputs. The fact that the energy price shocks of the 1970s

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1 A revised version of this model was used in preparing the *Medium-Term Review: 1989-1994*, Bradley and Fitz Gerald, 1989.

2 Jean Waelbroeck,1975 provides a survey of model research outside the USA.

3 The rational expectations assumption is that the public behaves optimally, given its own objectives and the information available to it, and that the public understands precisely what contingency plans have been chosen for future policy. A conclusion that follows from this assumption is that the use of macromodels to project the likely effects of different policy choices, then choosing the best from among the projected outcomes, is unjustifiable. However, Sims,1982 gives a defense of the careful use of macro policy models.

had rendered obsolete a sizeable fraction of the existing industrial capital stock, and that new investment needed to be highly energy efficient, gave rise to interest in "vintage" models of the capital stock. These vintage models attempted to capture the often limited extent to which old plant and machinery could be "re-tooled" to work efficiently in an era of radically changed relative factor prices. Previous approaches had usually assumed that the capital stock was "putty", i.e., could be remodelled continuously and completely as relative factor prices varied.

[1.3] : The Origins of the HERMES Model

It was during this period of change that a proposal was made within the European Commission in DG XII to replace the ageing COMET model with a model which incorporated some of the new developments in supply side issues alluded to above. After preliminary discussions with the EC member country experts, a detailed technical blueprint of the proposed (as yet unnamed) model was prepared for DG XII by Gonzales d'Alcantara (d'Alcantara,1980) and circulated to guide subsequent work on the new modelling project. In this introductory section we confine ourselves to the non-technical aspects of the project, in particular its evolution since 1981 and return to consideration of the technical aspects in Chapter 2 below.

The COMET model had been constructed by a team of researchers based at the Katholieke Universiteit Leuven and led by Anton Barten. While this resulted in efficiency of construction it also had some undesirable consequences traceable to the imposition of *total* uniformity on the individual country model structures. This is a rigid requirement which must be applied with great care in the case of smaller more open economies. For example, in the case of the Irish COMET-submodel,

(a) the capacity output measure (involving the concept of the full employment labour force) was unrealistic

(b) the sectoral aggregation was excessive (i.e., output was produced by a single sector which aggregated industry, agriculture and services)

(c) price determination over-emphasised domestic factors

(d) the government sector was too rudimentary for use by domestic policy analysts

In addition, since extensive "hands-on" experience is necessary in order to build confidence in the use of any economic model, national groups were unlikely to take policy analysis from COMET as seriously as they would results emanating from a "home-grown" model[4].

In the light of the above facts, three key elements came to dominate the planning of the new model:

(a) national team involvement for the actual construction stage, under the close expert guidance of a Central Group based in DG-XII in Brussels

(b) considerable sectoral disaggregation of the model, particularly in the production branches

(c) an emphasis on energy aspects and the integration of energy into the model framework

Besides addressing the problems that arose with national use of COMET, the new project also provided the opportunity to encourage national modelling groups to use the greater amount of harmonised data available from EUROSTAT sources. Where such data were missing (indeed, they were almost entirely missing in the case of Ireland), at least a start would be made in deriving unofficial estimates of such data, and hopefully initiate a process whereby, with the assistance of the Luxembourg Statistical Office, official estimates might eventually be produced by the national Statistics Offices.

The decision to construct a disaggregated model was not taken lightly. The *rationale* for going down the route of disaggregation was that this can lead to much deeper insights into economic processes. On the other hand, the data problems can multiply rapidly and the size and complexity of the resulting model system can become unmanageable. As detailed in Section 2 below, the attempt to produce Irish data to the initially specified level of disagggregation failed (particularly in the production sector) and delayed the operationalisation of the new Irish model by about three years.

Finally, the need to incorporate energy into the new model in a fundamental way arose from the pressures brought to bear on the world economy by the OPEC-related energy crisis. In the new model, energy was to be treated both as a factor input in all production sectors (in fact, the complete list of factor inputs were to comprise capital (K), labour (L), energy (E) and other materials (M), i.e, a KLEM system), and as a production sector in itself (where eight different types of energy were to be distinguished). In this respect the new model was unique and differed from previous and other contemporary models.

The first outline of the new model proposed, in November 1980, a three-stage project lasting three years, involving

(a) construction of a complete model data bank

(b) estimation of individual equations

(c) assembly and simulation of all national models, both in isolation and as an integrated system

Members of the Central Group, led by Gonzales d'Alcantara, visited each country and held discussions with the national teams. In the light of these meetings, some revisions were made to the original model specification and a definitive specification was issued (d'Alcantara and Italianer,1982). In addition, the new model was given a name, HERMES[5].

4 Versions of COMET were made available to each member country. However, due to the technical complexity of implementation, COMET was never successfully run in Ireland by Irish analysts.

5 (H)armonised (E)conomic (R)esearch (M)odel and (E)nergy (S)ystem. Hermes, it will be recalled, was the son of Zeus; a messenger of the gods and a god of science. In the light of all the subsequent unforeseen difficulties in bringing the HERMES project to completion, SISYPHUS might have been a more appropriate name!

The EC initiative in the modelling area was timely since the Irish national model being used in the early 1980s, MODEL-80 (Bradley *et al*,1981; Fitz Gerald and Keegan,1982), was overdue for revision. Models of the Irish economy had been first constructed in the mid-1960s[6] and displayed their Keynesian origins in their focus on the determination of the different categories of demand in the economy. However, the only model which had been used extensively for policy analysis and forecasting was MODEL-80, which was in operational use within the Department of Finance, the ESRI and the Central Bank of Ireland.

Rather than develop an independent national model, the very limited resources available within the country pointed towards the use of the new HERMES model as the national model for use within Ireland as well as for linked simulations within the EC. Many of the problems with MODEL-80 were similar to those which had led to the development of the HERMES specification. In addition, by working within the HERMES project rather than in isolation, it would be possible to make use of and benefit from research findings from the other member countries.

Our purpose in this document is to provide a permanent record of the development of the HERMES-IRELAND submodel. In Chapter 2 we describe the specification of the HERMES model and how the Irish team was forced, mainly by data difficulties, to modify and simplify this specification while, at the same time, keeping to the spirit of the original. In Chapters 3 - 7 we describe successively the production sector, the household sector, external trade, the government sector and the energy sector. In Chapter 8 we describe the within-sample tracking performance of the model when simulated and compare it to the previous Irish model, MODEL-80. In Chapter 9 we present and discuss an economic overview of the entire HERMES-IRELAND submodel while in Chapter 10 we describe the performance of the model when key variables and parameters are perturbed, i.e., the model multipliers. Finally, in Chapter 11 we discuss future work on HERMES-IRELAND in the light of our experience to date.

6 The earliest complete macroeconometric model of Ireland was constructed by Brendan Walsh as part of a Ph.D. dissertation (Walsh,1966). A complete survey of modelling in Ireland prior to HERMES-IRELAND is available in Bradley and Fanning, 1982

CHAPTER 2 : THE HERMES MODEL SPECIFICATION: AN EXPOSITION

The HERMES specification (d'Alcantara and Italianer,1982) had as its main focus an attempt to come to grips with the modelling of the supply processes which characterised the post-OPEC world. This focus had both theoretical and empirical implications. Empirically it was necessary to work at a level of sectoral disaggregation considerably greater than in most previous models and theoretically the models required were complex and sophisticated.

In the production block a nine-branch level of disaggregation was settled on, comprising

[A] : Agriculture, Forestry and Fishery products
[E] : Fuel and Power products
[Q] : Manufacturing Products - Intermediate Goods
[K] : Manufacturing Products - Capital Equipment
[C] : Manufacturing Products - Consumer Goods
[B] : Building and Construction
[Z] : Market Services - Transport and Communication
[L] : Market Services - Other
[N] : Non-Market Services

Eight of these branches are completely or partially in the market sector of the economy where the objective of the HERMES system was to model the determination of output and factor inputs (capital, labour, energy and other materials) in an integrated behavioural schema. Given its importance, energy usage was disaggregated into eight separate energy products:

[E1] : Coal and Lignite
[E2] : Coke
[E3] : Crude Oil
[E4] : Petroleum Products
[E5] : Natural Gas
[E6] : Derived Gas
[E7] : Electricity
[E8] : Other (including Nuclear)

Given the need to use the complete HERMES system for policy analysis and forecasting within the entire EC, another key feature of the specification was the inter-model linkage mechanisms via bilateral trade flows. To start with, the individual national models were designed to handle the determination of imports and exports on a "stand-alone" basis. However, if all the HERMES component models were run in this way, inconsistent trade flow data would be generated since there would be nothing to ensure that, for example, Ireland's exports to Germany equalled Germany's imports from Ireland (adjusting for c.i.f./f.o.b. differences). Clearly a trade flow linkage system represents only a start towards a fully linked system of models by means of trade flows, capital flows, other factor flows and exchange rates. Briefly, the HERMES trade linkage model specification stipulates that bilateral import volumes are determined by reference to individual market supply and demand functions, while prices are determined by aggregate product import and cost prices.

A feature which distinguished HERMES from previous approaches, in addition to branch disaggregation, detailed treatment of energy and bilateral trade flow modelling, was the design of its uniform structure (or common specification). The notion of a common specification can be approached in various ways. For example one could require that the theoretical underpinnings of each country model were similar but perhaps treat each country at different levels of branch disaggregation[1]. A more stringent requirement would be to force both the theoretical underpinnings and the level of empirical branch disaggregation to be identical. The most stringent requirement would be to force every country model to be *identical* in every way other than the numerical values of the behavioural coefficients. This final approach was initially advocated in HERMES. There are many advantages in settling on a uniform structure such as the ability to compare the size and robustness of parameter estimates across different countries and the overall "intellectual" control of the model. However, the difficulties in obtaining comparable data for all EC member countries in order to implement the desired common specification were seriously underestimated and departures from the ideal were forced on national teams as they grappled with the problems of missing data.

[2.1] : The Proposed HERMES Production Block

The major modelling innovations in HERMES are concentrated in the production block. Here the focus is on modelling the five industrial branches, with particular concentration on the three manufacturing industry branches. A four factor model is proposed where gross output is produced by a range of factor inputs, including energy. Although energy is subsequently disaggregated into eight types, in this block it is treated as a single aggregate. The purpose of the block is to obtain models of capacity output and long-run factor inputs which, when combined with essentially *ad hoc* adjustment mechanisms, lead to actual output and factor inputs.

1 By *theoretical underpinnings* we mean the general theoretical principles that underly the model specification. For example, all Keynesian models could be said to have the same theoretical underpinnings.

In order to implement this approach within a modelling framework, certain "technical" choices must be made. First, a choice must be made as to the number and type of factor inputs. The original HERMES specification called for a four-factor KLEM approach (i.e., capital, labour, energy and other materials). Next, a choice must be made on whether to use a vintage capital model (where each year's investment is considered as a separate factor input) or a non-vintage model (where the capital stock is completely homogeneous over time). A closely related question concerns the exact nature of the vintage model to be used i.e., whether factor substitution possibilities are to exist *ex ante* and *ex post* (the putty-putty case), *ex ante* but not *ex post* (the putty-clay case), or neither *ex ante* nor *ex post* (the clay-clay case). The original HERMES blueprint called for the putty-clay approach. Next, a choice must be made between the many possible candidates for the production function used to characterise the technological possibilities of firms. Here the HERMES specification was fairly eclectic, but with a leaning towards generalisations of the simple two-factor CES function[2]. Finally, constant returns to scale were assumed, and this permitted the separate determination of capacity output and factor inputs in a two-stage process[3].

In summary, the HERMES blueprint proposed a four factor KLEM model, using a vintage putty-clay capital input, and a generalisation of the CES production function upon which was imposed constant returns to scale. In this approach it is assumed that with each vintage of investment or production capacity there are associated marginal technical coefficients which are variable *ex ante* but fixed *ex post*. In other words, the factor inputs are substitutable *ex ante*, when a choice exists between a range of possible technologies. However, having selected a particular technology and carried out the necessary investment, the producer is constrained by fixed technical coefficients for the lifetime of that capacity vintage. In this framework factor proportions at the margin can be derived as the result of a process of minimization of the expected costs of production while the rigid factor proportions associated with past investment vintages can be used to generate profitability conditions which determine the scrapping age of old capacities. Total production capacity varies at the margin with current gross investments and with the scrapping of unprofitable old vintages.

Consider the following definitions:

Q_t^c = New production capacity installed in year t (i.e., new capacity vintage or generation)

L_t^n = Normal level of labour input required to operate the capacity vintage introduced in year t

E_t^n = Normal level of energy input required to operate the capacity vintage introduced in year t

M_t^n = Normal level of materials input required to operate the capacity vintage introduced in year t

I_t = Gross fixed capital formation in year t

The marginal production function can be written in the following general terms, where we have dropped the time subscript for simplicity:

$$Q^c = f(L^n, E^n, M^n, I)$$

The process of determing output capacity and the normal factor input levels is considered in two stages:

STAGE I : Determination of normal factor input levels

Assume that capacity output is given and that the firm minimizes costs. Hence, one must solve the following optimization problem, where the factor prices (denoted by "p" accompanied by the appropriate subscript) are exogenous:

$$\text{Minimize} \quad C = C(L^n, E^n, M^m, I, p_L, p_E, p_M, p_I)$$

where

$$Q^c = f(L^n, E^n, M^n, I)$$

The general solution expresses each factor input as a function of the vintage capacity output and all the factor prices, i.e.

$$L^n = g_1(Q^c, p_L, p_E, p_M, p_I)$$
$$E^n = g_2(Q^c, p_L, p_E, p_M, p_I)$$
$$M^n = g_3(Q^c, p_L, p_E, p_M, p_I)$$
$$I = g_4(Q^c, p_L, p_E, p_M, p_I)$$

Examples of these factor demand equations for particular choices of the production function f(.) are given in d'Alcantara and Italianer,1982.

STAGE II : Determination of Vintage capacity Output Level

Using the above factor demand equations, the firm's profit can be expressed as a function of capacity ouput and all prices, including the output price.

$$\Pi = \Pi(Q^c, p_Q, p_L, p_E, p_M, p_I)$$

Hence, maximizing profit with respect to capacity output yields

$$Q^c = g_4(p_Q, p_L, p_E, p_M, p_I)$$

A basic problem facing all who attempt to estimate vintage models is the lack of vintage data at the macrosectoral level. In practice, only the levels of total effective output, total factor inputs and gross investment are available from published sources[4]. Three possible estimation strategies suggest themselves:

(a) only estimate the single investment equation, where the investment factor input is observable:

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2 For example, the Mukerji isoquant function (Mukerji,1963: Hanoch, 1971) as used by d'Alcantara,1983, and the Sato two-level CES function (Sato,1967), which has been extensively used by the OECD macromodelling group (Artus and Peyroux,1981) and by John Helliwell (Helliwell, Booth and McRae,1982). A wide range of flexible functional forms could also have been used (Fuss, McFadden and Mundlak,1978).

3 Refer to Bradley and Fitz Gerald,1988 for details of how the two-stage decomposition is derived and implemented.

4 Indeed, as we shall see below, in Ireland these is considerable difficulty even with the energy and material inputs data so there is a temptation to work in the simpler added-value framework.

(b) try to construct vintage capacity and factor input data from *observed* differences in total output and factor inputs:

(c) specify the vintage model in such a way as to largely avoid the use of artificial data[5].

The second method was used in preliminary work on the three manufacturing branches of the Irish HERMES submodel and is reported in Bradley and Wynne,1983(a) and 1983(b). The results did not inspire confidence since the data construction methodology, as described in Italianer,1983, was difficult to implement in the complete absence of information on depreciation rates and scrapping ages. Furthermore, the three-way disaggregation into industries producing capital, consumption and intermediate goods was very difficult to operationalise given the limited availability of published national accounting output data for Ireland (e.g., no data on real sectoral output is given in the OECD National Accounts for Ireland). In addition, even if such a model could be constructed, its use out of sample would be nearly impossible. Everything pointed towards the requirement for a simplification of the HERMES original blueprint for use in Ireland, and this is taken up in Chapter 3 below.

[2.2] : The Proposed HERMES Energy Submodel

Energy is treated as an integral part of the HERMES blueprint and it is handled both as a factor input (the aggregate "E" factor input used above) and in disaggregated form as eight energy subcomponents. The main purpose of the energy submodel is to allocate the aggregate intermediate energy demand over its different products. In the submodel, inter-energy substitution is allowed and the optimal energy product mix is a function of relative energy prices. Briefly, the modelling process is treated as follows.

The aggregate production function for each branch is assumed to have all the necessary properties to permit a two-stage optimization process (Fuss,1977), i.e.,

(a) the producer first chooses the optimal energy input mix within the aggregate energy input, and

(b) the producer then optimizes the energy aggregate "E" itself, a stage already covered above.

The necessary regularity conditions assumed ensure that there exists a homothetic function that aggregates the eight energy types $\{E_1,\ldots,E_8\}$ into the energy aggregate, i.e.,

$$E = E(E_1, E_2, \ldots, E_8)$$

Dual to the energy input function E(.) is an energy cost function

$$C = C(p_1, p_2, \ldots, p_8)$$

where the p's represent the different energy prices. This may be written in the form

$$C = E.c(p_1, \ldots, p_8)$$

where c(.) is the unit cost function. Given the assumption of homotheticity (i.e., the optimal budget shares are independent of the level of aggregate energy), a translog unit cost function may be written in the form

$$\log(c) = \alpha_0 + \sum_{i=1}^{8} \alpha_i \log(p_i) + 0.5 \sum_{i=1}^{8}\sum_{j=1}^{8} \gamma_{ij} \log(p_i)\log(p_j)$$

Cost minimization yields the following energy share equation:

$$\frac{p_i E_i}{\sum_{j=1}^{8} p_j E_j} = S_i = \alpha_i + \sum_{j=1}^{8} \gamma_{ij} \log(p_j)$$

where the theoretical requirements of adding-up, linear homogeneity and symmetry place various restrictions on the parameters α_i, γ_{ij}.

The parameters which serve to characterise the possibilities of inter-energy substitution are the Allen elasticities:

$$\sigma_{ij} = \frac{\gamma_{ij} + S_i S_j}{S_i S_j}$$

$$\sigma_{ii} = \frac{\gamma_{ii} + S_i(S_i - 1)}{S_i^2}$$

where the own price and cross price elasticities are given by

$$\eta_{ij} = \sigma_{ij}.S_j$$

The initial attempts at deriving data for the Irish energy submodel are described in Bradley and Reilly,1983. The only source of energy use by branch available in time-series form is the Energy Balance Sheets published by the International Energy Agency. These permitted the isolation of energy volume use for the following fuel types:

Coal, Coke and Lignite	$E_1 + E_2$
Crude Oil	E_3
Petroleum Products	E_4
Gas (Natural and Manufactured)	$E_5 + E_6$
Electricity (Hydro and Thermal	E_7

and for the following aggregated branches:

Agriculture	A
Manufacturing Industry plus Building	Q + K + C + B
Transport Services	Z
Other Services (Marketed and Non-Marketed)	L + N

5 The first approach has been used by Artus and Peyroux,1981. It essentially requires *all* the production function parameters to be recovered from the *single* investment equation. The second approach is proposed by d'Alcantara and Italianer,1982, and Bossier *et al*,1983 implement it for the Belgian HERMES submodel. The third approach is used by d'Alcantara,1983 in the SERENA model of the Belgian economy.

Preliminary examination of the energy data indicated that it was generally unreliable and included inexplicable random shifts in energy use between and within sectors. In addition, no published price data by branch were available and the assumption had to be made that the energy prices for any given energy type were the same across all branches. The estimations reported in Bradley and Reilly,1983 were unsatisfactory and the shifts in the use of different fuels within branches were relatively insensitive to prices but were characterised by slowly changing trends due to technological changes (e.g., the shift from coal to oil within shipping).

[2.3] : The Proposed HERMES Consumer Demand System

Total private household consumption accounts for over 60 per cent of GNP in most western economies and is an important economic mechanism within any macro model. In the HERMES blueprint it was felt desirable to disaggregate private consumption into a large number (fifteen) of commodity groups since the composition of demand is important in explaining structural change in the medium term. In addition, the availability of disaggregated consumption could permit a more accurate modelling of the indirect taxes which bear on consumption bases, a benefit which, given its rudimentary taxation system, was not however exploited in the original HERMES specification. Rather than estimate a series of independent disaggregated consumption functions, a consumer demand system was proposed for incorporation within HERMES.

The implicit assumption was made that one may separate the consumer's decision on what proportion of income to consume from the decision on how he allocates total consumption expenditure over the whole range of consumer goods. The former decision was to be modelled by the aggregate consumption function while the latter was to be handled by an appropriate consumer demand system. The separability assumptions resulting in a two-stage decision process used here are very similar to those used in the energy submodel treated above.

The theory of consumer demand is well developed and suggests constraints on consumer behaviour which allow one reduce the difficulties of the subsequent estimation process. A detailed report on Irish work in this area is provided in Prendergast,1984. There was relatively little difficulty in assembling the necessary disaggregated consumption data (Prendergast *et al*,1983). However the number of years data available (about twenty-five years, starting in 1960) was insufficient to permit robust estimation with the full fifteen consumption categories. Estimation with fewer categories yielded better results.

Given the very large size of the resulting consumption submodel (with all its ancillary equations determining disaggregated volumes, values, prices, etc) and the lack of input-output matrices to provide the necessary links within HERMES-IRELAND between consumption, production and prices, it was decided to postpone the incorporation of the consumer demand system to a later version of the model.

[2.4] : Trade-Flow Linkages in HERMES

Individual national models, when they are constructed on a stand-alone basis, contain both import and export equations. The import equations constitute a key leakage mechanism out of the national economy which serves to reduce the scope and autonomy of domestic policy actions. However, the imports of one country are the exports of another. Hence, when studying groups of countries (such as the EC members), any attempt at a systematic EC-wide analysis requires a model in which linkages between the different member states are taken into account, if only in a simple fashion.

The economies of the EC members are linked in many different ways: most obviously through trade in commodities and services; through factor flows of labour and mobile fixed investment; and through financial mechanisms involving capital flows, exchange rates and interest rates. The original HERMES blueprint proposed a linkage mechanism based solely on trade in goods produced by the five industrial branches of the HERMES production block. The trade data, derived from OECD sources, was extensively processed to make it suitable for use in HERMES and is documented in Italianer,1982a.

The details of the proposed bilateral trade flow model for HERMES are available in a series of papers by Italianer and others[6]. Briefly, a basic assumption is made that the utility function which aggregates bilateral imports is weakly separable into at least total imports of each of the following five products: agricultural goods, energy, and manufactured goods (further disaggregated into the intermediate, equipment and consumption categories). Hence, the marginal rate of substitution between any two bilateral import flows for a given product is independent of any bilateral import flow for any other product. Each national model has equations determining total imports of these five products.

The next key assumption concerns the nature of each bilateral market for any product. It is assumed that in each such market *ex ante* demand and supply equilibrate through adjustment of the bilateral demand and supply prices. By this means, the total actual imports of each product, determined in a first stage, are allocated over all trading partners in a second stage.

As an illustration of this process, consider a static version where time and product subscripts are dropped for simplicity. The bilateral import demand equations take the form

$$\log(M_{ij}^d) = \gamma_{ij} + \alpha_{ij}\log(M_j) + \varepsilon_{ij}\log\left(\frac{PM_{ij}}{PM_j}\right)$$

where

M_{ij}^d = *ex ante* volume demand by importer j supplied by exporter i

PM_{ij} = price index for above

M_j = total imports of product by importer j

6 Barten and d'Alcantara,1977; Italianer,1982a; Italianer,1982b; Italianer and d'Alcantara,1983;

PM_j = price index for above
α_{ij} = allocation elasticity
ε_{ij} = relative price elasticity

The bilateral export supply function may be written as

$$\log(X_{ij}^s) = \eta_{ij} + \beta_{ij}\log(XP_i) + \pi_{ij}\log\left(\frac{PX_{ij}}{PD_i}\right)$$

where

X_{ij}^s = *ex ante* volume supply by exporter i on import market j
PX_{ij} = price index for above
XP_i = export capacity for product by exporter i
PD_i = price index of domestic costs for producing in country i
β_{ij} = allocation elasticity of total export supply capacity
π_{ij} = relative price elasticity

Assuming market clearing,

$$M_{ij}^d = X_{ij}^s = M_{ij}$$

and if the c.i.f./f.o.b factor is constant over the sample period then

$$PM_{ij} = PX_{ij}$$

then one can solve for bilateral import volumes and price:

$$\log(M_{ij}) = \psi_{ij} + \frac{\pi_{ij}}{\pi_{ij}-\varepsilon_{ij}}\alpha_{ij}\log(M_j) - \frac{\varepsilon_{ij}}{\pi_{ij}-\varepsilon_{ij}}\beta_{ij}\log(XP_i) - \frac{\pi_{ij}\varepsilon_{ij}}{\pi_{ij}-\varepsilon_{ij}}\log\left(\frac{PM_j}{PD_i}\right)$$

$$\log(PM_{ij}) = \chi_{ij} + \frac{\pi_{ij}}{\pi_{ij}-\varepsilon_{ij}}\log(PD_i) - \frac{\varepsilon_{ij}}{\pi_{ij}-\varepsilon_{ij}}\log(PM_j) + \frac{1}{\pi_{ij}-\varepsilon_{ij}}(\alpha_{ij}\log(M_j) - \beta_{ij}\log(XP_i))$$

Hence, bilateral imports are a weighted average of the volume components of the demand and supply functions while the bilateral import prices are a weighted average of the aggregate product import price and cost price.

A dynamic generalisation of the above system has been estimated for the EC member countries, the USA and Japan and is reported in Italianer and d'Alcantara,1983. In this document we are reporting on the national model HERMES-IRELAND and we postpone further analysis of the trade-flow linkage equations to a later date when the Irish submodel is fully incorporated into the overall HERMES system. HERMES-IRELAND does, of course, contain import and export equations, to be described in Chapter 5 below.

[2.5] : A Reduced Version of HERMES-IRELAND

In summary, the original specification of the HERMES model can be characterised by four important numbers:

(a) the number of production branches (9)
(b) the number of private consumption categories (15)
(c) the number of different energy types (8)
(d) the number of different factor inputs (4)

Before any empirical implementation of the original specification of HERMES can start, very detailed sectoral production data and highly disaggregated consumption and energy data are needed. Early reports of the Irish HERMES national team concentrated on attempts to rectify major data deficiencies in the Irish national accounts. These attempts largely failed for the following reasons:

(a) Only one Input/Output matrix on a NACE/CLIO basis exists for Ireland (for the year 1975);

(b) There is a major break in the key source of disaggregated industrial data (the annual Census of Industrial Production) in the year 1973 when a change was made from the ISIC United Nations classification to the NACE classification. No provisions for backwards consistency calculations were made;

(c) There are large gaps in the Eurostat and OECD sectoral national accounts for Ireland. In particular, the sectoral volume output tables are missing;

(d) A major revision of the domestically published national accounts in 1982/83 (affecting the period 1972-1982) was not applied systematically to the Eurostat and OECD versions;

Faced with these difficulties, the Irish national HERMES team had to take practical decisions on the nature of the national sub-model. The choice lay between the level of disaggregation in the Irish sub-model of COMET[7] and the unattainable ideal of the original HERMES specification. After much research and data analysis, the following was adopted as a first approach to operationalising HERMES-IRELAND:

(a) Four rather than nine production branches were treated: aggregate industry, agriculture, marketed services and non-marketed services;

(b) The aggregate industry branch (manufacturing plus construction and utilities) was analysed with a three-factor (KLE) rather than a four-factor (KLEM) bundled CES-CES vintage production function using a modification of the approach recommended in Moncomble,1985). Full details are given in Section 3.1.2 below;

(c) A simpler *ad-hoc* three factor (KLM) approach was used in agriculture and a two factor (KL) approach in marketed services;

(d) Only aggregate consumption was included since the missing input-output matrices rendered it impossible to link a disaggregated multi-commodity expenditure system into the production side of the model;

(e) The inter-fuel substitution model, although estimated, was not included in the first version of the operational model;

7 One production block, aggregate treatment of consumption and no treatment of energy (Barten *et al*,1980).

(f) A more detailed government sector than that specified for the original HERMES model was included, at the request of the Irish Department of Finance, to permit HERMES-IRELAND to be used in realistic policy simulations[8].

Consequently, although HERMES-IRELAND differs from the original HERMES specification or blueprint, the philosophy of that specification motivated and guided the construction of the Irish sub-model. This model has been tested and used extensively both in the ESRI and in the Department of Finance, and formed the basis for the preparation of the last two *Medium-Term Reviews* of the Irish economy published by the ESRI, which examined the prospects for the Irish economy over the periods 1987-92 (Bradley, FitzGerald and Storey,1987) and 1989-94 (Bradley and FitzGerald,1989).

Constructing HERMES-Ireland in this fashion had the following advantages:

(a) It provided a basis for testing and implementing the exciting new ideas proposed by the HERMES Central Group but taking account of the limitations on available reliable data in Ireland;

(b) It permitted the replacement of the previous Irish income-expenditure policy model, MODEL-80, which had been used operationally over the period 1979-1986 (Bradley *et al*,1981; FitzGerald and Keegan,1982);

(c) It provided a significant improvement on the sectoral disaggregation and methodology of the Irish sub-model in COMET-III, the only extant international model which contains a behavioural model of Ireland[9];

(d) The present operational version of HERMES-IRELAND is being used for policy analysis within Ireland and will provide opportunities for progressive improvement and further disaggregation as new data sources become available;

(e) Our approach in constructing HERMESW-IRELAND may be of interest to any other national teams who have experienced major difficulties with sectoral data. An operational form of HERMES which has most national models built to the full original specification, but some built to a simplified or "stripped- down" specification, may be useful while data difficulties are being progressively overcome.

8 This was particularly necessary since HERMES-IRELAND is the *only* operational macroeconometric model maintained and used in Ireland.

9 Ireland and other small OECD countries are represented in the OECD INTERLINK model system largely by a series of identities.

CHAPTER 3 : THE PRODUCTION SECTORS

Previous Irish macromodels provided little or no sectoral disaggregation of the production or supply side. Disaggregation, where implemented, tended to involve the expenditure and income aspects of the model[1]. Although the aim of the original HERMES specification was to provide a nine-branch disaggregation of the supply side of the model, as explained above this proved impossible due to limitations of available Irish data. A compromise had to be reached, attempting to relate the HERMES ideal to the Irish data realities.

In the light of these data inadequacies and the policy uses to which the model would be exposed, the following basic level of disaggregation was settled on:

(a) **Industry**, consisting of mining, manufacturing, utilities and building

(b) **Agriculture, forestry and fishing**

(c) **Marketed services**, consisting of that part of total services not included in the non-marketed sector

(d) **Non-marketed services**, consisting of the public administration and defence category plus health, education and other predominantly non-marketed services

In sections [3.1] - [3.4] we examine each of these sectors in turn, presenting the methodology used to model their properties and behaviour

[3.1] : Industry

As discussed in Chapter 2, a major data constraint forced the Irish HERMES team to model the industrial sector as a single branch. This means that the HERMES-IRELAND industrial sector aggregates the following original HERMES branches into a single branch, which we denote by "I":

Q : Manufacturing Products, Intermediate K : Manufacturing Products, Equipment C : Manufacturing Products, Consumption E : Fuel and Power Products B : Building and Construction	===> I : Industry

Some aspects of these separate branches can be studied with available data. However, efforts to incorporate the full level of disaggregation into the Irish model were abandoned and the above simple aggregate approach adopted.

The industrial sector of HERMES-IRELAND is characterised by an aggregate production function. First efforts at estimating this production function followed the original HERMES specification (Bradley and Wynne,1983a and 1983b). We then switched to the simpler methodology proposed by Moncomble,1985. However, early estimation results and complete model simulations indicated that the CES-CD bundled production function used by Moncomble (which imposes a unitary elasticity of substitution between the capital-energy (KE) bundle and labour (L)) gave rise to excessive sensitivity of employment to wage costs. Furthermore, work in the OECD indicated that this elasticity of substitution was likely to be considerably smaller than unity when provision for "retro-fitting" is allowed (i.e., partial adjustment *after* installation of the capital stock to optimal capital-energy proportions)[2]. In the light of these research findings we decided to adopt the OECD methodology for the aggregate industry block of HERMES-IRELAND rather than the Moncombie approach.

Hence, our industrial production function can be characterised as a bundled CES-CES type with capital, labour and energy being used to produce output, measured as added-value plus energy. The system of bundles used has capital and energy combined in an inner vintage bundle, but one which permits some degree of retro-fitting. This capital-energy bundle is then combined with labour in another, outer, CES function. Labour-embodied (or Harrod neutral) technical progress is assumed rather than the Hicks neutral type used in Moncomble,1985[3]. A process of long-run cost minimisation is used to determine the long-run factor demands. Adjustment mechanisms are then used to relate the long-run to the actual factor inputs. Full details are given below in Sections [3.1.1] to [3.1.3].

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1 Bradley and Fanning,1982 gives a comprehensive survey of Irish models prior to the 1980s.

2 Helliwell *et al*,1986, show elasticity of substitution values for the OECD "big-seven", using aggregate private sector data, ranging from 0.8 for Japan down to 0.3 for the United Kingdom.

3 Previous research (Bradley and Fanning,1984) indicated that technical progress was biased and tended to be both labour saving and capital using. However, the inclusion of two technical progress parameters rendered the estimation very difficult so the simplifying assumption of Harrod neutrality was adopted.

[3.1.1] : Determination of Capacity Output in Industry

In a medium-term model a key issue concerns the manner of determining output *capacity* in the industrial sector. The existence of multinational corporations (MNCs), and the consequential close integration of the supply sides of SOEs like Ireland into the wider OECD economy, suggests a direct supply-side linkage where Irish industrial capacity is determined as a share of "world" capacity and is influenced by Irish industrial competitiveness (Bradley and Fitz Gerald,1988). Actual output, or equivalently the rate of capacity utilisation, will result from explicit short-run supply decisions made by producers, which are of course also influenced by demand conditions (Helliwell and Chung,1985 gives details). This is the approach that has been implemented in the model[4].

The firms making up the aggregate industrial sector consist in part of Irish based subsidiaries of foreign multinationals but also of indigenous firms either based entirely in Ireland or with both Irish and foreign based plants. With the progressive dismantling of trade barriers in recent decades, the obstacles to supplying the world market from plants located in many different countries have largely vanished. The relatively free movement of capital, advanced communications techniques and the free mobility of entrepreneurial talent have meant that the geographical location of firms, and individual plants within firms, is quite flexible. When multinational firms wish to increase production or launch new products, they deal with a market covering many nations. For any given product line they face essentially three interrelated choices.

(a) *how much* to produce;

(b) *where* to produce among a wide range of alternative countries or regions;

(c) *how* to produce it, i.e., having chosen a specific location, what technology is to be used in production.

In constructing HERMES-IRELAND as a stand-alone model we are looking at the above process from the point of view of Ireland. Hence, we may be permitted to abstract from analysis of the first choice - how much to plan to produce for the global market - by invoking the concept of a given world capacity demand over which Ireland has no influence[5]. The second choice of where to produce involves a decision on where to locate a plant or, if the plant is already in place, what portion of world demand is to be serviced from it. Given easily transferable technology and capital between regions, the decision to locate productive capacity in one region rather than another will be based mainly on factors such as labour costs, profitability, tax regimes, transport costs, etc. The empirical relationship between location and cost can either determine how Ireland's share of world productive capacity (i.e., output capacity) is related to relative competitiveness measures or, equivalently, how its share of world mobile investment is determined.

There are major problems in arriving at a suitable measure of the "world" against which Ireland competes. For example, increased profitability of US firms tends to encourage them to locate production plants in Ireland to service European markets and to benefit from Ireland's EC access and advantageous corporate tax regime. However, increased industrial profitability in Spain, Portugal, Belgium, regions of the UK, etc., tends to attract multinational investment away from Ireland. Hence, the world consists of source countries, which provide multinational investment if they are doing well in their own economies, and sink countries, which bid away this investment from Ireland if they are more competitive[6].

In considering Irish industrial competitiveness, attention is normally concentrated on comparisons of wage costs and unit labour costs. However, a wide range of other elements affect competitiveness, including the cost of domestic inputs (for example electricity, other services, and interest rates). Also vitally important is the favourable tax treatment accorded to exporting firms. The best indicator of overall competitiveness is profitability. For Ireland, with its low rate of industrial corporation tax, this indicator has the additional advantage (which more traditional cost of capital measures lack) of capturing the effects of the potential for transfer pricing as a factor attracting foreign investment to Ireland[7]. We define a measure of profitability as the share of added-value going to "capital" (or, more accurately, to profits i.e., one minus labour's share). This definition of Ireland's industrial profitability relative to the rest of the world is used to provide an empirical explanation of Ireland's share of world capacity output.

Planned industrial output capacity in Ireland (QSTARI) is determined in HERMES-IRELAND as follows:

$$\frac{QSTARI}{QWSTARI} = f\left(\frac{PRWORS}{PRIRLS}, t\right)$$

where QWSTARI represents "world" output capacity (defined as a three year moving average of a suitably weighted measure of actual output in a range of OECD countries), PRWORS is a measure of world profitability and PRIRLS is Irish profitability. In the model listing in Appendix 2, three versions of this equation are provided:

(i) a version where the world profitability measure treats the USA, Germany and the UK separately (Appendix 2, equation 3)

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4 In most conventional Keynesian macro models output is set equal to demand. In a small open economy (SOE) model this means that "world" influences work purely through the demand side of the model, thus focussing attention on the trade equations and, in particular, exports.

5 Eventually the determination of EC (or world) capacity will be endogenous within the full HERMES linked model system.

6 In empirical work we are forced by lack of data to use the competitiveness of a group of the largest OECD economies as representative of the "world" with which Ireland competes.

7 The prices recorded for tax and customs purposes for trade between subsidiaries of a multinational corporation may not be "arms length" prices but may be chosen deliberately to minimise tax or tariff burdens.

(ii) a version where aggregate world profitability is used (Appendix 2, equation 4)[8]

(iii) a version where no relative profitability measure is used i.e., Ireland's share of world capacity is simply a time trend (Appendix 2, equation 5)

Estimation results are presented in Appendix 2

[3.1.2] : Estimating the Production Function

Gross output is normally measured as the sum of added-value, energy and other material inputs. As discussed in Section 2 above, whereas added value and energy inputs can be approximately identified in published data, it proved impossible to identify the other material inputs. Hence, we are forced to work with a more limited measure of "gross output" consisting of added-value plus energy.

Three different output concepts are needed in our modelling approach and are defined as follows:

QSTARI : This is the future gross output level that producers anticipate will be profitable and permanent enough to justify assembling factors to produce it at normal (i.e., planned) utilisation rates. This is referred to subsequently as "planned output".

QVIN : This is the quantity of gross output that could be produced if the *existing* quantities of employed factors were used at average rates of utilisation. This is referred to subsequently as "normal output". We will see below that it is defined by inserting actual employment and the vintage bundle of capital and energy into the underlying production function.

QHI : The actual level of gross output, whose price index is PQHI. This is related to the above QVIN by means of a capacity utilisation rate, CURH.

Output and factor inputs are related by an underlying production function. In estimating the parameters of this production function for the industrial sector we follow closely the methodology used by John Helliwell in the OECD INTERLINK model and the MACE model of Canada (Helliwell *et al,1986).* The key assumption made when we estimate the parameters of the production function is that, if the sample period is sufficiently long and representative, the sample average utilisation rate can be taken as the normal utilisation rate. Sample averages and long-run cost minimisation conditions can then be used to identify key parameters, and short-run factor demand equations serve to establish the adjustment dynamics of actual to long-run factor inputs. Hence, the general strategy for choosing parameters is to derive them as far as possible from the requirement that the production function should hold on average over the sample period, and that the cost-minimising factor ratios should on average be equal to the actual factor ratios.

The Nested Production Structure:

Capital and energy are bundled together in an inner CES function as follows.

The Inner CES Function:

$$(3.1) \qquad KE = \left(bKI^{\frac{s-1}{s}} + cEI^{\frac{s-1}{s}}\right)^{\frac{s}{s-1}}$$

where

KE = Capital-energy bundle
EI = Energy input
KI = Capital input
b,c = Scale parameters
s = Substitution elasticity

The capital-energy bundle (KE) is then combined with efficiency units of labour in an outer CES function.

The Outer CES Function:

$$(3.2) \qquad QVIN = \left(B\{EFFL.LI\}^{\frac{r-1}{r}} + CKE^{\frac{r-1}{r}}\right)^{\frac{r}{r-1}}$$

where

QVIN = Potential output
EFFL = Labour efficiency index
LI = Total employment
KE = Capital-energy bundle
B,C = Scale parameters
r = Substitution elasticity

The Vintage Structure and the Retrofitting Parameter:

Capital goods often embody fairly fixed energy requirements. However, some degree of retrofitting can normally be carried out within a mainly vintage structure. In order to explore this possibility, consider the CES functional form for combining capital and energy, where the cost-minimising ratio of (vintage) energy (EVIN) to capital (KI) is as follows.

$$(3.3) \qquad \left(\frac{EVIN}{KI}\right)^{*} = \left(\left(\frac{c}{b}\right).\left(\frac{UCCI}{PE}\right)\right)^{s}$$

where

EVIN = vintage energy input
KI = capital input
UCCI = capital cost variable
PE = energy price index

Three different cases now arise, depending on the nature of the capital model and the retro-fitting possibilities allowed.

CASE (i) : Putty-putty model with immediate adjustment:

Here, capital and energy always bear their cost-minimising relationship to each other, and hence,

$$(3.4) \qquad EVIN = \left(\left(\frac{c}{b}\right).\left(\frac{UCCI}{PE}\right)\right)^{s} KI$$

CASE (ii) : Strict putty-clay vintage model with a proportional scrapping rate:

Here, the optimal capital/energy ratio can only be applied to gross investment. Hence, energy demand is given by

$$(3.5) \qquad EVIN = EVIN_{-1}.(1 - RSCRI) + II.\left(\left(\frac{c}{b}\right).\left(\frac{UCCI}{PE}\right)\right)^{s}$$

8 In the first two, the production function technology describing this decision is assumed to be of Generalised Leontief (GL) type.

where,

EVIN = vintage energy requirements
RSCRI = the (proportional) rate of scrapping
II = gross fixed investment

CASE (iii) : Flexible vintage model (putty/semi-putty):

If it is assumed that some fraction, RETRO, of the previous period's capital stock can be retrofitted to embody the latest cost-minimising capital-energy ratio, then the energy requirements to operate the existing capital stock are defined as follows;

$$(3.6) \qquad EVIN = EVIN_{-1}.(1 - RETRO - RSCRI) \; + \; (II + RETRO.KI_{-1}).\left(\left(\frac{c}{b}\right).\left(\frac{UCCI}{PE}\right)\right)^{s}$$

The equivalent definition of the vintage capital-energy bundle is

$$(3.7) \qquad KEVIN = KEVIN_{-1}.(1 - RETRO - RSCRI) \; + \; (II + RETRO.KI_{-1}).\left(b + c.\left\{\left(\frac{c}{b}\right).\left(\frac{UCCI}{PE}\right)\right\}^{s-1}\right)^{\frac{s}{s-1}}$$

The flexible vintage model (3.6)-(3.7) reduces to the putty-putty model (3.4) if the retrofitting parameter equals one minus the scrapping rate (i.e. RETRO = 1-RSCRI). The flexible vintage model reduces to the strict putty-clay model if the retro-fitting parameter is identically zero (i.e., RETRO=0).

Estimating the Parameters of the Inner CES Function:

The flexible putty-clay vintage formulation of the optimal capital-energy bundle has been given in (3.7) above. The putty-putty equivalent of this equation is the optimal ratio

$$(3.8) \qquad \frac{KEVIN}{KI} = \left(b + c.\left\{\left(\frac{c}{b}\right).\left(\frac{UCCI}{PE}\right)\right\}^{s-1}\right)^{\frac{s}{s-1}}$$

In estimation, the following variables and parameters are assumed to be known: the scrapping rate (RSCRI), gross fixed investment (II), gross fixed capital stock (KI), and the user price of energy (PE).

The user cost of capital is defined as follows:

$$(3.9) \qquad UCCI = PII.\left(RSCRI + \frac{RHORI}{100}\right).\frac{1 - RGKTI}{1 - RGTYC}$$

where

PII = the deflator of gross fixed investment
RGKTI = the rate of investment grant
RGTYC = the effective (average) corporate tax rate

RHORI is the real supply price of capital and is defined as a constant, with a value such that on average total factor earnings exhaust total output over the sample period. Hence, since

$$(3.10) \qquad PQHI.QHI = AAEI.LI + PE.E + \left(\frac{RHORI}{100} + RSCRI\right).PII.KI$$

then

$$(3.11) \qquad RHORI = 100. \frac{Mean(PQHI.QHI) - Mean(AAEI.LI + PE.EI + PII.KI.RSCRI)}{Mean(PII.KI)}$$

Assumption 1 : The energy-capital ratio is optimal on average over the sample period, subject to the prevailing relative prices. Hence, from (3.4)

$$(3.12) \qquad \frac{c}{b} = \left(Mean\left(\frac{EI}{KI}\right)/Mean\left(\left\{\frac{UCCI}{PE}\right\}^{s}\right)\right)^{\frac{1}{s}}$$

Hence, given a value of the parameter s, the ratio c/b can be derived from observed variables.

Assumption 2 : KEVIN is normalised such that

$$(3.13) \qquad Mean(KEVIN) = Mean(KI)$$

This permits the calculation of the parameter b as

$$(3.14) \qquad \log(b) = \frac{s-1}{s}\left(Mean\left\{1 + \left(\frac{c}{b}\right)^{s}.\left(\frac{PE}{UCCI}\right)^{1-s}\right\}^{\frac{s}{1-s}}\right)$$

The elasticity of substitution, s, and the retrofitting parameter, RETRO, are determined by estimating the energy demand function

$$(3.15) \qquad \log(EI) = a_1 + a_2\log(EVIN) + u$$

where u is the stochastic error term and EVIN is the vintage energy requirement needed to operate the capital stock, KI, subject to prevailing relative energy prices, and defined in (3.6) above.

Computational Procedure:

We are now able to set up a computational procedure for the estimation of the scrapping rate (RSCRI) and the parameters of the inner CES production function (i.e., s, b and c):

Step 1: Choose initial parameters (s_0 ,$RETRO_0$) in the range .1 <s < .99 and .1 < RETRO < 1-RSCRI.

Step 2: Calculate the parameters b and c using the above formulae (3.12) and (3.14)

Step 3: Calculate the time series for EVIN, using equation (3.6), with the initial value $EVIN_{to} = EI_{to}$

Step 4: Estimate the regression $\log(EI) = a_1+a_2 \log(EVIN) + u$ and record the results

Step 5: Choose the next parameter pair (s, RETRO), using a grid step of 0.1

Step 6: If grid exhausted, select (s,RETRO) pair which maximise the likelihood function.

Estimating the Parameters of the Outer CES Function:

It now remains to determine the parameters of the outer CES function (i.e., r, B, C, and EFFL). The outer function bundles labour and the capital-energy aggregate into gross output,

$$(3.16) \qquad QVIN = \left(B.(EFFL.LI)^{\frac{r-1}{r}} + C.KEVIN^{\frac{r-1}{r}}\right)^{\frac{r}{r-1}}$$

Cost-minimising behaviour by producers implies that

TABLE 3.1 : Estimation of CES Parameters

(a) log(QHI/LI)	= 1.086 + (9.6)	0.494 log(AAEI/PQHI) + (6.1)	0.0212t (10.8)	RSQ = 0.988 DW = 0.79
(b) log(QHI/LI)	= 0.809 + (5.8)	0.643 log(AAEI/PQHI) + (7.0)	0.0219t (8.2)	RSQ = 0.992 DW = 1.84 RHO = 0.7 (7.2)
(c) log(KEVIN/LI)	= 1.593 + (14.2)	0.112 log(AAEI/PCKE) + (2.7)	0.0419t (39.1)	RSQ = 0.991 DW = 0.66
(d) log(KEVIN/LI)	= 1.399 + (9.6)	0.157 log(AAEI/PCKE) + (3.4)	0.0455t (15.7)	RSQ = 0.994 DW = 1.76 RHO = 0.75 (7.3)

$$(3.17) \quad \left(\frac{KEVIN}{LI}\right)^* = \left(\left(\frac{C}{B}\right)\cdot\left(\frac{AAEI}{EFFL.PCKE}\right)\right)^r$$

where AAEI is average annual earnings and PCKE is the cost of the capital-energy bundle computed from the cost function which is dual to the inner CES production function, i.e.,

$$(3.18) \quad PCKE = (b^s.UCCI^{1-s} + c^s.PE^{1-s})^{\frac{1}{1-s}}$$

Alternatively, profit maximisation with the assumption that KEVIN is fixed yields

$$(3.19) \quad \log\left(\frac{QHI}{EFFL.LI}\right) = -r.logB + r\log\left(\frac{AAEI}{EFFL.PQHI}\right)$$

For simplicity, assume that the labour efficiency index, EFFL, is a simple function of time, i.e.,

$$(3.20) \quad EFFL = \exp(gt)$$

where g is a constant parameter. Then the estimated equations become

$$(3.21) \quad \log\left(\frac{QHI}{LI}\right) = -r logB + r\log\left(\frac{AAEI}{PQHI}\right) + g(1-r)t$$

for constrained profit maximisation, and

$$(3.22) \quad \log\left(\frac{KEVIN}{LI}\right) = r\log\left(\frac{C}{B}\right) + r\log\left(\frac{AAEI}{PCKE}\right) + g(1-r)t$$

for cost minimisation.

The determination of the elasticity of substitution between labour and the KE bundle (r) and the rate of labour-embodied technical progress (g) proved very difficult. The relevant regressions are shown in Table 3.1.

These yielded the following estimates of the parameters "r" and "g":

	r	g
(a)	0.4940	0.0420
(b)	0.6439	0.0616
(c)	0.1115	0.0471
(d)	0.1565	0.0539

There are strong statistical reasons for choosing either (b) or (d) above. However, (b) implies a very high rate of labour embodied technical progress (6.2% p.a.) and a moderately high value of r (0.64), while (d) has a high value of g (5.4% p.a.) and a very low value of r (0.16). All four sets of values of r and g were tested, but only option (a) yielded sensible results for the derivation of QVIN. Consequently, (a) was adopted, although clearly the DW statistic is unsatisfactory[9].

Finally, it remains to determine the parameters B and C. The ratio (B/C) is determined in the same way as for the ratio (c/b) above, i.e.,

$$(3.23) \quad \frac{B}{C} = \left(Mean\left(\frac{\exp(gt).LI}{KI}\right)/Mean\left(\frac{PCKE}{AAEI.\exp(gt)}\right)^r\right)^{\frac{1}{r}}$$

Given the ratio (B/C), the individual parameters are determined as follows;

$$(3.24) \quad C = Mean\left(\left(\frac{KI}{QHI}\right)^{\frac{1-r}{r}}\right) \Bigg/ Mean\left(1+\left(\frac{B}{C}\right)^r\cdot\left(\frac{PCKE}{AAEI.\exp(gt)}\right)^{r-1}\right)$$

Estimation Results

Using data for the period 1962 to 1984, the above methodology was applied and the following results obtained:

The optimal regression determining the choice of parameter pair (s,RETRO) was as follows;

log(EI) = 0.514 + 0.908 log(EVIN)
(2.3) (27.7)

RSQ = 0.973 DW = 1.33

s	= 0.525	elasticity of substitution between capital and energy
RETRO	= 0.2	retro-fitting parameter
b	= 0.611	parameter attached to energy in KE bundle
c	= 0.086	parameter attached to capital in KE bundle
r	= 0.494	elasticity of substitution between L and KE bundle
g	= 0.042	rate of labour-embodied technical progress

9 At a later stage, a more sophisticated treatment of technical progress will be used, as described in Helliwell *et al*,1986. In addition, the possibility of bias in technical progress will be examined, although this greatly complicates the estimation process (Bradley *et al*,1985).

B = 0.113 parameter attached to labour in outer CES function

C = 0.506 parameter attached to KE bundle in outer CES function

Long-Term Price Elasticities for 1960, 1970, 1980 and 1984:

The long-term own and cross factor price elasticities, E_{ij}, are presented in matrix form as follows for the aggregate industrial production function:

$$\begin{pmatrix} E_{LL} & E_{LK} & E_{LE} \\ E_{KL} & E_{KK} & E_{KE} \\ E_{EL} & E_{EK} & E_{EE} \end{pmatrix}$$

(a) Year 1960:

$$\begin{vmatrix} -0.284 & 0.132 & 0.077 \\ 0.284 & -0.464 & 0.116 \\ 0.284 & 0.199 & -0.271 \end{vmatrix}$$

(b) Year 1970:

$$\begin{vmatrix} -0.312 & 0.129 & 0.053 \\ 0.312 & -0.502 & 0.099 \\ 0.312 & 0.244 & -0.205 \end{vmatrix}$$

(c) Year 1980:

$$\begin{vmatrix} -0.273 & 0.108 & 0.113 \\ 0.273 & -0.365 & 0.156 \\ 0.273 & 0.149 & -0.381 \end{vmatrix}$$

[3.1.3] : The Adjustment of Factor Demands

The above methodology produces the optimal factor inputs KSTARI, LSTARI and EVIN. It is assumed that all factor inputs are quasi-fixed, i.e., any disequilibria in factor inputs take some time to adjust. Simple error correction (ECM) adjustment mechanisms are assumed and estimated:

(3.25) $\text{dlog(II)} = a_1 + a_2\text{dlog(KSTARI)} + a_3\log(\text{KSTARI}_{-1}/\text{II}_{-1}) + a_4\log(\text{UCOSTI/UCOSTIMA})$

(3.26) $\text{dlog(LI)} = a_1 + a_2\text{dlog(LSTARI)} + a_3\log(\text{LSTARI}_{-1}/\text{LI}_{-1}) + a_4\log(\text{CURH})$

(3.27) $\log(\text{EI}) = a_1 \log(\text{EVIN}) + a_2 \log(\text{CURH})$

Estimation yielded the following:

Var	a_1	a_2	a_3	a_4	RSQ	DW	RHO
II	-0.707 (1.7)	2.26 (3.1)	0.32 (1.6)	-1.88 (2.0)	0.418	2.14	
LI	0.011 (3.5)	1.30 (1.9)	0.32 (5.5)	0.23 (7.9)	0.959	2.19	.20 (0.9)
EI	0.99 (4.0)	0.38 (3.4)			0.990	1.39	

No lags of adjustment were found for energy (EI). In the case of investment, the equilibrium form of the adjustment equation yields

II/KSTARI = 0.11

which implies an 11% rate of depreciation. This is a little higher than the 8% assumed in the generation of the data for KI. In the case of labour, LI overadjusts to LSTARI, and in equilibrium LI equals LSTARI for an equilibrium value of CURH=0.953, i.e. 95% rate of capacity utilization.

[3.1.4] : The Determination of Actual Output

Over time actual output, QHI, adjusts to "normal" output, QVIN, and the rate of adjustment depends on the disequilibrium between domestic sales of industrial goods (GSOID) and capacity output (QVIN), and on disequilibrium demand in the world economy (YWDIS)[10]. Estimation yielded the following:

$$\text{dlog(QHI)} = \underset{(9.2)}{0.915}\ \text{dlog(QVIN)} + \underset{(1.1)}{0.0884}\ \log(\text{QVIN}_{-1}/\text{QHI}_{-1}) + \underset{(1.8)}{0.349}\ \text{dlog(GSOID/QVIN)} + \underset{(2.0)}{0.377}\ \text{dlog(YWDIS)}$$

RSQ = 0.837 DW = 1.45

[3.1.5] : Summary of Industrial Branch

The core of the industry sub-model involves the determination of industrial capacity output and the related long-run factor demands for labour, capital and energy. In the highly stylised treatment used in HERMES-IRELAND, the world is divided into two components - Ireland and the "rest of the world" (henceforth "ROW"). Firms making a choice between locating production activities in Ireland or in the ROW do so on the basis of relative profitability, and Ireland's capacity output share is a function of its competitiveness, thus measured.

Given this capacity output share, and assuming constant returns to scale, the technology used to produce in Ireland. i.e. the optimal factor ratios, is arrived at by a process of cost minimisation. Here, the production function is assumed to be of bundled CES-CES type similar to that used in the production block of the OECD INTERLINK model.

Thus, our interpretation of the technology of the industry sector is along standard neoclassical lines. Capacity output together with measures of expected relative factor prices are used to determine the cost minimising long-run demands for labour, capital and energy. Since we impose a specific technology on the relationship between capacity output and long-run factor inputs (i.e., a bundled CES-CES technology), the labour, capital and energy requirements cannot become inconsistent with the underlying technology of the model, a very desirable property for medium-term analysis. The translation of long-run to actual factor demands is by means of adjustment mechanisms which attempt to capture the processes which prevent instant adjustment. Hence, in the short run the national industrial firm need not be on its long-run production function. Actual output in industry is determined primarily by the capacity

10 Refer Helliwell and Chung, 1985 for background details of the theory.

output measure, but is affected by abnormal changes in domestic sales of industrial goods and by disequilibrium in world demand conditions.

Full specification of equations and estimation results are given in Appendix 2, equations 1 - 46. The equations 23-46 are mainly simple accounting and definitional identities required in the full industrial branch. However, one relationship (equation 29) should be highlighted. This determines that portion of total industrial profits (YCI) which is repatriated by foreign owned multinational industries with production units based in Ireland. This proportion has increased very rapidly in recent years. The large size of profit repatriation is a measure of the magnitude of the foreign-owned part of the industrial sector. Such an outflow of profits represents a major leakage out of the Irish economy, a leakage which may also be of importance in other SOEs. In the full HERMES linked system these profit outflows will have to be associated with the corresponding profit inflows, most of which probably go to the USA.

[3.2] : Agriculture

In the case of agriculture,forestry and fishing (AFF), it is necessary to recognise that employment and investment decisions are unlikely to derive from neoclassical optimising paradigms which are more appropriate to a relatively capital intensive industrial sector exposed to international competitive forces. In Irish agriculture, institutional, government and demographic forces are dominant and any realistic model must take account of this.

Given the importance of the agricultural component of AFF, and the ready availability of data on gross output and material inputs, we model gross agricultural output by means of a simple supply function making output sensitive to capacity (measured as a five-year moving average of actual output), relative prices of output and inputs, and weather conditions. A separate equation explains the demand for material inputs and permits the derivation of added-value in agriculture. Added-value in forestry and fishing, a very small element of total AFF, is left exogenous.

Employment in AFF is modelled as a labour-release or migration-out process in that agents who do not leave are assumed to be employed. The long-term factors permitting and encouraging the release of labour from AFF are the growth of labour productivity, the relative earnings differential vis-a-vis the non-agricultural sector and the availability of work elsewhere in the economy. However, only a simplified form proved robust in estimation.

Since the behaviour of total investment in AFF is particularly difficult to model, due both to the importance of investment in cattle stocks and to the complex system of grants, subsidies and other incentives available to farmers, we consider only a subset of the investment process i.e. machinery and buildings. A simple flexible accelerator model is used which links the capital stock to output and the real cost of capital. Agricultural stock changes are left exogenous.

Gross output (QGA) is allocated between domestic absorption (QDA), exports (XA) and agricultural and intervention stock changes (STADL and STIVDL) in the following simple way. The proportion of gross output absorbed by domestic consumption has been historically very stable and is modelled as a smooth function of time:

$$\frac{QDA}{QGA} = f(t)$$

Given the assumption of exogenous stock changes, agricultural exports are residually determined:

$$XA = QGA - QDA - (STADL + STIVDL)$$

The remaining identities in this sector develop the required income and price measures needed elsewhere in the model. Full specification of equations and estimation results are given in Appendix 2, equations 47 - 70.

[3.3] : Marketed Services

The complex heterogeneity of the service sector makes it difficult to implement a comprehensive decision based factor demand system. For example, the inclusion of large non-commercial and self-employment components is likely to affect the sensitivity of employment and investment to a relative factor price measure. Also, the distinction between capacity output and actual output is less clear since there are shorter production processes involved, a more simplified technology and a less structured labour force.

In this version of the model we have attempted to "purge" the total services sector of the non-marketed element. Public administration and defence are isolated clearly in the national accounts and thus provide little difficulty (ignoring, of course, the underlying measurement problems and the somewhat suspect national accounting conventions involved). The isolation of other non-market services (mainly health & education services) is a more difficult problem and our attempts represent a very crude preliminary effort.

Real output in the marketed services sector (OSM) is determined by a weighted measure of final demand (GSOSM), where GSOSM is determined as a weighted average of consumption (both private and public), investment, stock changes and exports. The weights are derived from the 1975 input/output table and measure the service sector output content of each category of domestic demand. Hence,

$$OSM = f(GSOSM)$$

In preliminary versions of the model the factor demand system for capital and labour was derived by cost minimisation subject to a two-factor added-value CES technology. This imposes a certain consistency of behaviour (which was perhaps unwarranted) on the market services sector. After encountering simulation difficulties with this early version, the factor demand system was replaced and the capital stock (KSM) is presently determined as an ECM adjustment to trend output with the employment-output ratio (LSM/OSTARSM) as a quadratic function of time.

$$\Delta \log KSM = a_1 + a_2 \Delta \log(OSTARSM) +$$

$$a_3 \log\left(\frac{OSTARSM_{-1}}{KSM_{-1}}\right) + a_4 t$$

$$\log\left(\frac{LSM}{OSTARSM}\right) = b_1 + b_2 t + b_3 t^2$$

A crucial relationship in the model is the residual determination of the value of marketed services output (OSMV) from the current price identity of GDP on an output and expenditure basis, i.e.,

$$OSMV = GDPEV - (OIV + OAGV + OSHEV - YAFS + (TE - SUB)) - STATDISV$$

where Appendix I gives definitions of the variables on the right-hand side. We return to the discussion of the implications of this equation later in Section 3.6 when we deal with price determination. Identities 85-90 determine other variables required in the model.

[3.4] : Non-Market Services

The non-market sector is treated in two parts: public administration and defence and other non-market services (mainly health and education). Real output of the health & education services sector is determined by the level of employment (LSHE):

$$\frac{OSHE}{LSHE} = constant$$

In the case of public administration and defence, output (OPA) is similarly determined as a function of employment (LPA). Both LPA and LSHE together with investment decisions are regarded as discretionary policy instruments. Further identities are given in Appendix 2, equations 91-99.

[3.5] : Construction Investment and Stock Changes

Total fixed investment (excluding housing investment) is derived in the individual sectoral branches above, i.e., industry, agriculture, marketed services and non-marketed services. These investment expenditures are a mixture of building and construction, on the one hand, and machinery and equipment on the other. The breakdown between these two categories within sample is on the basis of the historical values. Out of sample, the breakdown is projected at the most recent value available.

Agricultural and intervention inventory changes are left exogenous. Non-agricultural inventory changes (STNADL) are determined in a simple adjustment model to a desired stock level which is a function of industrial output (OI), i.e.,

$$STNADL = a_1 + a_2 OI + a_3 STNA_{-1}$$

All the relevant identities are given in Appendix 2, equations 177-195.

[3.6] : Output and Expenditure Prices

The determination of prices within a full-scale economy model is a complex process. For example, unless output prices are handled in a manner which is consistent with prices on the expenditure side, inconsistencies will arise when the model is closed (for example, by setting the value of output equal to the value of expenditure). In HERMES-IRELAND this latter identity is imposed by making the value of output in the market services sector a residual (see Section [2.3] above). With this constraint, any mismatch between the modelling of prices on the expenditure and output sides of the national accounts will necessarily result in a distortion of the price of marketed services.

Our specification of the price sector is of particular importance in examining the effects of taxation on prices. The direct incidence of any tax on the economy (before taking account of the multiplier effects) is determined by the changes in output and expenditure prices. For example, a rise in VAT on consumer goods will increase consumer prices to the extent that the direct incidence is on *consumers*. However, to the extent that the incidence is on *producers* the output price (i.e., the price of value added including profits) will fall and consumer prices will remain unchanged reflecting the reduction in rate of profit caused by the imposition of the tax. Finally, if it is borne by *distributors* the price of producers and consumer prices remain unchanged and it is the price of other services (the value added of the sector) which falls. In every case the deflator of indirect taxes on the output account must rise by an appropriate amount to reflect the rise in tax rates. While each price on the output and expenditure accounts may be modelled separately, the interaction of the different equations will determine, among other things, the incidence of taxation. Therefore, it is important that these equations, while modelled and tested separately should also be examined as a system.

The basic inspiration for the determination of prices and wages comes from the Scandanavian model (Lindbeck,1979), where we identify the industry sector with the "tradables" sector and the services sector with "non-tradables". The Scandanavian model assumes perfect commodity arbitrage for the homogeneous aggregate tradable commodity (i.e., the domestic price of tradables is a function of the world price and the exchange rate). Successive studies of price determination in the Irish economy have found this to be an appropriate model, though the way the "world price" is defined is a matter for debate (See Flynn and Honohan,1986; Callan and Fitz Gerald,1988).

In HERMES-IRELAND the crucial tradable good is the output of the industrial sector. We are concerned with both the price of the gross output of that sector (the price determined on the world market), and the price of domestic value added. The price of the gross output affects, in turn, the prices of a number of items of expenditure, in particular export prices and the price deflator of consumption. Previous studies have shown that the consumption deflator should not be modelled as if consumption were a pure tradable good (See Bradley et al.,1981). Even in the case of goods produced in the domestic industrial sector or imported directly from outside, there is a substantial distribution margin which means that their prices are affected by domestic factors. As a result, in modelling expenditure prices allowance must be made for the possibility that domestic costs will also affect prices.

Output Prices:

To facilitate the modelling of the effect of changes in world energy prices, the price of world output of manufactured goods is itself endogenised as a function of energy prices (PM3, the price of Irish energy imports), and the price of Irish nonenergy imports (PMGNE). As discussed later in Chapter 10, we must take account of this channel of causation when examining the effects of a change in world energy prices on the Irish industrial sector and the economy as a whole. Hence,

$$PWORLD = f_1 (PM3,PMGNE.)$$

The price of gross output of transportable goods industries (PQTI) is then a function of world prices of manufactured goods (PWORLD) and of gross agricultural output prices (PQGA)[11]. The price of gross agricultural output is itself externally determined by EC policy. The weight on agricultural prices implied by the estimated equation is 0.29, very close to what is implied by the weight of food output in total gross output.

$$PQTI = f_2 (PWORLD,PQGA)$$

The relationship between the gross output price of transportable goods industries and the price deflator of value added in the total industrial sector (including building and utilities) is determined in a two stage process:

(a) Firstly the price deflator for value added plus energy inputs (PQHI) is determined as a function of the price of gross output in transportable goods industries and the price of merchandise imports (PMG):

$$PQHI = f_3 (PQTI,PMG)$$

As shown in Appendix 2, this equation is actually estimated with PQTI as the left hand side variable. The gross output price and the price of materials used in the industrial sector (predominantly imports) are determined by exogenous factors. Hence, the price of value added plus energy inputs is determined as a residual. Ideally agricultural output prices and the rates of certain indirect taxes, which together account for a significant share of inputs into the industrial sector, should also appear in this equation. However, preliminary tests did not provide a satisfactory formulation along these lines.

(b) The second stage relates the price of value added in the industrial sector (POI) to the price of value added plus energy inputs using a series of identities where QHIV and QHI are the value and volume, respectively, of value added plus energy inputs in the total industrial sector; EIV and EI are the value and volume, respectively, of energy inputs; and OIV and OI are the value and volume, respectively, of value added in the sector.

$$QHI = QHIV/PQHI$$
$$OIV = QHIV-EIV$$
$$OI = QHI-EI$$
$$POI = OIV/OI$$

This specification implies that the price of value added is largely determined as a function of exogenously determined prices. Endogenous domestic factors only affect it by changing the weights of the different inputs into the sector, a factor which has little effect on the price change in any one year[12].

Industrial export prices (PXI) are determined by the world price of manufactured goods. Because the composition of Irish exports differs from that of world exports, the speed with which inflationary shocks, such as changes in oil prices, feed through into Ireland is different from that of world prices. As a result, both the current and lagged values of world prices of manufactured goods (PWORLD) appear in the equation. As shown in Appendix 2, the weight on current period prices is almost 0.9.

$$PXI = f_4 (PWORLD,PWORLD_{-1})$$

The price of material inputs into the agricultural sector (PQMA) is a function of the price of transportable goods industries output and the lagged value of agricultural output prices (PQGA). The latter variable is included due to the importance of seeds and feedstuffs as inputs into the agricultural sector, though its weight in the estimated equation, shown in Appendix 2 is only 0.16.

$$PQMA = f_5 (PQTI,PQGA_{-1})$$

The deflators for indirect taxes (PTE) and subsidies (PSUB) are determined by a series of identities where TE and TRE are the value and volume of indirect taxes and SUB and SRUB are the value and volume of subsidies. Total expenditure tax revenue is the sum of each individual expenditure tax, which are determined in a series of disaggregated equations. A similar approach is taken to determining the value of subsidies. The constant price, or volume variables, are determined as a weighted average of the bases for indirect taxes and subsidies. The modelling of these latter four variables is described in detail in Chapter 6.

$$PTE = TE/TRE$$
$$PSUB = SUB/SRUB$$

The effective rate of indirect taxes and subsidies affecting personal consumption (TINC) is defined by an identity. The numerator is total indirect tax revenue (TE) less consumer subsidies (total subsidies (SUB) less certain agricultural subsidies (GCSA) and EC subsidies paid to farmers (EECS)). The denominator is the value of total personal consumption (CV).

$$TINC = (TE-(SUB-GCSA-EECS))/(CV+PXS*XTO)$$

The deflator for the adjustment for financial services (PYAFS) is a function of the deflator for GDP at factor cost (PGDPFC, determined in an identity described in Appendix 2).

$$PYAFS = f_6 (PGDPFC)$$

Expenditure Prices:

---

11 This specification allows for the fact that food processing accounts for a substantial part of the output of Irish transportable goods industries (32% of gross output and 18% of net output in 1984, Census of Industrial Production,1984).

12 Ideally, because of the inclusion of the building sector in total industrial output, some domestic factors should have a role in price determination. However, experimentation did not produce a satisfactory specification which captured such an effect.

The number of expenditure categories distinguished in the model is quite large and each of these categories requires its separate price. The approach to modelling the expenditure deflators is quite uniform in that they are "explained" in terms of their component prices. In other words, any such deflator simply incorporates the prices of goods and services which go to make them up, and includes any tax effects. The weights, which are assumed constant, can be obtained by statistical estimation (the approach we have used) or from input-output tables.

The variables determined in this way are the deflators for personal consumption (PC), for investment in buildings (PIBC), for investment in machinery and equipment (PIME), for investment in housing (PIH) and investment in non-agricultural stocks (PSTNADL).m

$$
\begin{aligned}
PC &= f_7\,(PQTI, TINC, UCLSM)\\
PIBC &= f_8\,(UCLI, PMG)\\
PIME &= f_9\,(UCLI, PMG, PMG_{-1})\\
PIH &= f_{10}\,(UCLI, PMG)\\
PSTNADL &= f_{11}\,(PQTI, PMG)
\end{aligned}
$$

The choice of which exogenous or "independent" variables to include was determined by statistical testing. The "independent" variables are industrial output prices (PQTI), unit labour costs in industry (UCLI) and marketed services (UCLSM), the price of imports of goods (PMG), the world output price (PWORLD) and a measure of net indirect taxes (TINC).

In the case of the personal consumption deflator the inclusion of unit labour costs in marketed services takes account of the fact that there is a substantial distribution margin in goods purchased by consumers, as mentioned above. In addition, personal consumption also includes a substantial amount of personal services whose price is assumed to be determined as a mark-up on wage costs. The use of unit labour costs in marketed services is preferred to the value added deflator for that sector because the latter deflator, which is residually determined in the model, is likely to capture all the errors in price determination and could pose stability problems in simulating the model as a whole. Provided that prices in the marketed services sector are determined as a mark up on costs, the use of labour costs will not significantly affect the results due to the importance of labour as a factor input in that sector. In estimation the weight on industrial output prices is rather lower than that on wage costs in services (0.43 compared to 0.57). However, when the model is simulated as a whole, because of endogenity of domestic wage costs, the final effects of a rise in world prices on consumer prices will be considerably higher than this "impact" weight would imply.

The sectoral investment deflators for industry (PII), total services (PIS) and for agriculture (PIAG) are determined as functions of PIBC and PIME. The deflator for total non agricultural stocks is a function of the deflator for the change in non agricultural stocks.

$$
\begin{aligned}
PII &= f_{12}\,(PIBC, PIME)\\
PIS &= f_{13}\,(PIBC, PIME)\\
PIAG &= f_{14}\,(PIBC, PIME)\\
PSTNA &= f_{15}\,(PSTNADL)
\end{aligned}
$$

Other Prices:

In addition to the behavioural equations and identities discussed above, a wide range of additional price equations are included in the model as set out in Appendix 2. All of these additional equations are identities and fall into three categories:

(a) those which relate externally determined prices to an exogenous price in foreign currency terms and an effective exchange rate index.

(b) those which determine prices which are composed of the sum of other components, e.g. the price of total investment, PITOT.

(c) those which define percentage rates of change

Prices and Model Closure:

The deflator of marketed services output (POSM) is determined by the model identity where OSMV is determined in the expenditure-output identity in nominal terms. This means that any inconsistencies (particularly in the modelling of the other price deflators on the output side or on the deflators on the expenditure side of the national accounts) will show up in this variable[13]. Hence,

$$POSM = OSMV / OSM$$

TABLE 3.2 : Incidence of £100 Million Increase in Indirect Taxes (1984)

	£ Million
Personal Consumption	59.80
Government Consumption	5.30
Investment	0.00
Exports	6.90
Net Factor Income	-1.20
GNP	70.80
Output of Market Services	-29.50
Adjustment for Financial	1.40
Services	100.00
Taxes on Expenditure	-1.20
Net Factor Income	70.80
GNP	

One test of the consistency of the above prices sector is to examine the incidence of a change in indirect taxes, as measured by the change in the other price deflators and, in particular, in the price of other marketed services. This is achieved by simulating the prices equations and the equations determining key nominal variables, such as the value of consumption, as a separate model. Set out below in Table 3.2 is the effect of a £100 million change in indirect tax revenue in 1984, holding wage rates and all real variables in the model constant. As can be seen from this table the model suggests that approximately 75 per cent of the change will be borne initially by consumers and that the other 25 per cent by the market services sector in the form of lower margins. Of course, this takes no account of the dynamic effects of such a change through its multiplier effects and its influence on the labour market, etc. However, the results

13 The need to close the model in this way arises from the inclusion of a fully developed output side. In models which are essentially demand determined, the absence of an output side means that there is no possibility of such inconsistencies arising.

are plausible and suggest that the handling of indirect taxes is treated reasonably consistently on both the output and expenditure accounts.

The final test of the consistency of the prices sector of the model is carried out by simulating the restricted prices model, described above, for the historical period 1964 to 1984. All feedbacks through wage rates and real variables in the model are excluded. A full single period (using historical values for lagged dependent variables) simulation results in a root mean square per centage error in the residual other services deflator of 8.3%, an unsatisfactorily high figure. When the price of value added plus energy inputs (PQHI) was exogenised the root mean square percentage error in the price of other marketed services was nearly halved to 4.4%. This indicates that a major part of the problem in the specification of the prices sector lies with the determination of the value added deflator for the industrial sector. This will be given special attention in the next version of the model.

Full equation specifications and estimation results are given in Appendix 2, equations 230 to 264.

[4.1] : Wage Determination

Just as with prices, the Scandanavian model also motivates the determination of sectoral wages in HERMES-IRELAND. Hence, we assume the following:

(a) wage inflation in the tradable sector tends to adjust to the "room" for wage increases (i.e., factor income shares remain on average near "normal" levels)

(b) the economy-wide labour market is assumed homogeneous i.e., wage inflation in the tradable and non-tradable sectors is the same

In most presentations of the Scandanavian model the rate of productivity increase in the tradable sector is assumed to be higher than in the non-tradable sector, both being exogenous to the model, with a cost-accomodating demand side in the domestic economy (Lindbeck,1979). We have attempted to extend the bargaining process underlying the Scandanavian model wage equation broadly as follows:

(a) If one follows Lindbeck,1979 directly and sets

$$dlog(AAEI) = dlog(PQTI) + dlog(OPRI)$$

(where AAEI, PQTI and OPRI are the industrial average annual earnings, price and labour productivity respectively), this implies that the bargaining process is denominated in terms of the employers "price" and workers are indifferent to any wedge driven between the consumption price (PC) and the producer's price (PQTI), i.e. no distinction is made between gross pay and net-of-tax pay. In reality, wage bargaining for factor income shares is a more complex process and our implementation introduces the idea of a tax "wedge" as well as a proxy for labour market tension and trade-union bargaining power in a structural Phillips curve.

(b) Homogeneity in the labour market is a strong assumption but is probably to be expected given the long series of national wage agreements which have characterised wage determination in Ireland. It implies that if wage inflation initiates in the tradable sector, it then spreads to the non-tradable sector.

(c) Finally, productivity is endogenous in our model and emerges from the factor demand system and the output decision. Consequently, while the Scandanavian model survives as a "positive" theory, it becomes dangerous to use as a "normative" theory (Lindbeck,1979,pp 25-27). In policy simulations we drive wages by trend productivity, which is impervious to policy shocks, rather than actual productivity.

In HERMES-IRELAND wages are determined in a bargaining model where employers and employees in industry are in contention for a share of added-value, and where the price of tradables (industrial output prices) is determined in world markets. Wage inflation in the tradables sector adjusts to the "room" for wage increases i.e., an increase which is consistent with a "normal" profit share. We define the "wedge" which is driven between the firm's real labour costs (W/P^*) and the real wage received by the suppliers of labour (W/PC) as follows.

$$WEDGE = \left(\frac{W}{P^*}\right) / \left(\frac{W}{PC}\right)$$

where

$$PC = PCNT * \frac{(1 + t_i)}{(1 - t_d)}$$

PCNT being the deflator of consumption expenditure net of indirect taxes, t_i being an index of net indirect taxes and t_d being the average rate of direct taxation on wages (i.e. income tax and employee's PRSI contributions). We can write

$$P^* = P/(1 + t_e)$$

where P is the deflator of industrial added value and t_e is the average rate of employer's PRSI. Hence, we can write the wedge as

$$WEDGE = (PCNT/P)*(1 + t_e)* \frac{(1 + t_i)}{(1 - t_d)}$$

We can now determine the product wage in industry (AAEI/PQTI) as a function of this wedge variable and of labour market tension or union bargaining power, proxied by the unemployment rate, with a dynamic adjustment, i.e.

$$\log\left(\frac{AAEI}{PQTI}\right) = a_1 + a_2 \log(WEDGE) + a_3 \frac{(UR + UR_{-1})}{2} + a_4 \log(OPRI) + (1 - a_4) \log\left(\frac{AAEI}{PQTI}\right)_{-1}$$

where AAEI is the wage rate in industry, PQTI the output deflator, UR the unemployment rate and OPRI represents labour productivity. The estimation results show that in all cases the tax wedge and the bargaining power proxy are statistically significant[1]. The estimated elasticities on nominal wages are given below.

1 Two variants are estimated and included in the model: the first is as presented in the text while the second has a purely lagged Phillips curve term.

	Impact Elasticity	Long-Run Elasticity
Output Prices	1.000	1.000
Tax Wedge	0.548	0.848
Unemployment	-0.023	-0.035

Wages in the marketed service sector (AAESM) are simply linked to industrial wages:

$$\log\left(\frac{AAESM}{AAEI}\right) = a_1 + a_2 t$$

The wage rate in public administration, AAEPA, is linked directly to AAEI, since the "stop-go" wage policies in the public sector rendered estimation difficult without using many policy dummies. Hence,

AAEPA = WRELPA * AAEI

The exogenous variable WRELPA can be thought of as an incomes policy instrument. Similarly, the wage rate in health & education, AAESHE, is linked directly to AAEPA, i.e.

AAESHE = WRELSHE * AAEPA.

Such linkages do not mean that any wage inflation must initiate within the industry sector. However, it does imply that the long-run maintenance of industrial competitiveness acts as a constraint on intersectoral wage differentials when industrial prices are determined abroad but service prices are a mark-up on domestic costs, as is the case in HERMES-IRELAND.

Complete equation specifications and estimation results are given in Appendix 2, equations 265 - 295.

[4.2] : Consumption

Our treatment of the second main block of the model involves the determination of domestic and foreign absorption. Domestic absorption is defined as the sum of consumption expenditures (by households and government), fixed investment expenditures (by industry, agriculture and services), housing investment (by households and government), and expenditures on inventory investment. Foreign absorption consists of exports of goods and services.

Our consumption function is an aggregate one and is of the conventional permanent income type. Experiments with other consumption functions (Bradley and Fanning,1984, pp 175-184) indicated that our simple approach was not dominated by any other and, in addition, has the desirable virtue of stability. Two versions are included. In the first, personal disposable income is treated as an aggregate, while in the second we isolate transfer income and constrain the MPC out of such transfers to be unity.

$$\frac{C}{NT} = a_1 + a_2\frac{YRPERD}{NT} + a_3 DUM75$$

$$\frac{C}{NT} = b_1 + b_2\frac{YPERD - (GCTPER - GCTW)}{PC.NT} + 1.0\frac{GCTPER - GCTW}{PC.NT} + b_3 DUM75$$

where

C	=	Real Consumption
NT	=	Population
YRPERD	=	Real Personal Disposable Income
YPERD	=	Personal Disposable Income
PC	=	Consumption Price Deflator
GCTPER	=	Total Personal Transfers
GCTW	=	Teachers Salaries (classified in the National Accounts as transfers)
DUM75	=	Dummy Variable to eliminate anomalous year 1975.

The two MPCs take the values 0.657 and 0.786 respectively.

Government consumption is treated in a series of identities, the components of which are the wage bills in public administration and the greater part of health & education (basically numbers employed multiplied by a wage rate) plus other non-wage consumption (which is a policy instrument).

Complete equation specifications and estimations are given in Appendix 2, equations 162 - 171.

[4.3] : Disaggregated Consumption

The estimation of the disaggregated consumer demand system for Ireland has been extensively documented elsewhere (Prendergast,1984). In general the disaggregated consumption data is available in the format required by the original full HERMES specification. Estimation using the Almost Ideal Demand System (AIDS) approach gave promising results.

However, in the absence of the capability of relating sectoral output to final demand (mainly due to the missing I/O matrices), we have not incorporated the consumer expenditure system into the present version of HERMES-IRELAND. Its main future use in the context of the model would be to refine the indirect taxation equations.

[4.4] : Housing Investment

In modelling private housing investment (IHP) we use an expenditure-type relation driven by real *per capita* personal disposable income (YRPERD/NT), but influenced by government housing transfers (RGKTH), interest rates (RPL) and inflation (PIH/PIH_{-1}).

$$\log\left(\frac{IHP}{NT}\right) = a_1 + a_2\log\left(\frac{YRPERD}{NT}\right) + a_3\log(RGKTH) + a_4\log\left(\frac{RPL}{100}\right) - a_4\log\left(\frac{PIH}{PIH_{-1}}\right)$$

Government housing investment is treated as a discretionary policy instrument. Complete equation specifications and estimations are given in Appendix 2, equations 172 - 176.

[4.5] : Labour Supply and Migration

Labour supply is determined in an integrated schema involving population growth, education participation, labour force participation and migration abroad. The participation rate is an aggregate one (males, single females and married females) and is essentially exogenous at present, being simply time-trended[2]. Migration flows are dependent on the relative attractiveness of Irish and UK labour markets in an application of the Harris-Todaro model (Harris and Todaro, 1970). This attractiveness is measured by the product of the Irish employment rate relative to the UK (RE) and Irish real wages relative to those pertaining to the UK (RWN).

$$NMA = a_1 + a_2 RE.RWN + a_3 NMA_{-1}$$

This equation proved to be very unstable in estimation, particularly with respect to the more recent observations. In practical simulations, given the poor statistical estimation results, the labour supply side was often exogenised.

Unemployment is determined as the difference between labour supply (LF) and employment (LTOT), the latter determined by the interaction between labour demand and wage bargaining in the production branches.

Complete equation specifications and estimations, together with all the required identities, are given in Appendix 2, equations 131 - 161.

2 Further work on disaggregation is in progress, which may permit the incorporation of more theory and the estimation of stable econometric relationships.

CHAPTER 5 : EXTERNAL TRADE

[5.1] : Imports Volume

Since the early 1960's the share of imports in GNP has risen from under two fifths to over two thirds by 1984. The bulk of the goods imported are used as inputs into the domestic industrial sector. Hence, imports should ideally be modelled as an intermediate input into that sector with the price of imports appearing as an argument in the related factor demand equations. However, due to the technical problems alluded to previously in modelling a four factor (KLEM) production function, this approach has not been adopted in the current version of HERMES-IRELAND.

Instead, imports are assumed to make up the difference between domestic supply, determined in the output sector, and domestic demand, determined in the absorption sector. Hence, they are determined residually in volume terms in the model[1]. While this approach means that all the errors in the modelling of the volume of output and the volume of expenditure are concentrated in the volume of imports it ensures consistency in the model. This approach is different from that adopted in the earlier MODEL-80 of Ireland due to the absence of a coherently specified output side in that model[2].

In modelling imports we distinguish six broad economic categories, only one of which, imports of non oil materials (MMFPNE) - which constitutes some 60 per cent of total imports - is residually determined by the output expenditure identity. The other 5 categories are:

(a) imports of investment goods (MPCG)
(b) imports of consumption goods (MC)
(c) imports of materials for further production in agriculture (MMFPA)
(d) imports of energy (M3)
(e) imports of services (MS)

Given that total imports are residually determined, changes in the volume of the individual components result in offsetting changes in the MMFPNE category. As a result, the equations for the five other components of imports only affect the composition of imports. It is only through such compositional changes and the resulting changes in the weighted average of the different trade prices that the detailed import equations affect the real economy. However, it was necessary to include this level of detail to allow for a disaggregation of the overall deflator for imports. This was particularly important given the importance of imports of oil in the Irish economy.

Because of the fact that the vast bulk of investment in machinery and equipment is imported (Fitz Gerald,1987), imports of producers capital goods (MPCG) are related purely to the volume of investment in machinery and equipment (IME).

$$Log(MPCG) = f(IME)$$

The share of imports of consumer goods (MC) in the volume of total consumption (C) is modelled as a function of the price of merchandise imports (PMG) relative to the gross output price for transportable goods industries (PQTI), time (t) and a series of dummy variables (D). Because of the fact that the domestic output price used in the equation is itself externally determined this specification is not very satisfactory.

$$Log(MC/C) = f(PMG/PQTI,t,D)$$

The volume of imports of raw materials for use in agriculture (MMFPA) is modelled as a function of the volume of gross agricultural output (QGA) and time. This represents only a small proportion of total imports.

$$Log(MMFPA/QGA) = f(QGA,t)$$

The volume of energy imports (M3) is determined in an identity. In HERMES-IRELAND all energy inputs into the economy are assumed to pass through the industrial sector, which includes the energy transformation sector (oil refining, electricity, gas generation and mining). Hence, the total domestic demand for primary energy (EI) is modelled as an input into the industrial sector. Domestic production of primary energy (QE) is exogenous in the model. It includes natural gas, turf and hydro electricity (see Fitz Gerald,1987, for details). A small amount of the production of the oil refining sector is re-exported and this is treated as exogenous in the model (X3RES). Energy imports are then determined as the difference between total demand for primary energy (EI+X3RES), domestic and exports, and domestic production (QE):

$$M3 = EI+X3RES-QE$$

The volume of imports of total services (MS) is modelled as a function of the volume of consumption, reflecting the fact that a major component of this category of imports is tourism expenditure abroad by Irish residents.

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1 The residual determination of industrial imports can be contrasted with the treatement of inventories as residual in the MACE model of Canada (Helliwell, Boothe and McRae,1982). Given the extreme openness of the Irish industrial sector, we feel that imports provide a more plausible and complete buffer.

2 An alternative import equation included in MODEL-80 adopted a similar approach to that used in HERMES-IRELAND (see Bradley *et al.*,1981).

$$Log(MS) = f(C)$$

Complete equations specifications and estimations are given in Appendix 2, equations 100 - 130.

[5.2] : Exports Volume

The correct approach to the determination of exports has been the subject of much controversy in Ireland and in the international literature (Goldstein and Khan,1978; Browne,1982). The choice of approach lies between supply driven, demand driven or hybrid models. However, choice in this area is circumscribed by other assumptions made in the model. In particular, we have made the small country assumption that domestic producers have no market power on world markets, i.e., that they behave as price takers. While this may not apply to all Irish exporters (Honohan,1982), it is a reasonable assumption at our level of aggregation. Hence, the level of exports is determined by what domestic producers desire to sell at the given world market price.

Conventionally an export supply function is used to close an SOE model and the appropriate relative price variable is taken as the ratio of the export price and the domestic price level. In such a specification, a devaluation would affect exports by raising their price in domestic currency, leaving it unchanged in foreign currency, which would induce domestic producers to increase their supply on the world market. The dynamic effects of a devaluation would depend on how rapidly the domestic price level rises and in the long run the relative price would be expected to return to its pre-devaluation level. However, the microfoundations of the supply determination process can not be easily built into this approach. As a result, when it was adopted in the earlier MODEL-80 model of the Irish economy it led to certain inconsistencies (Fitz Gerald and Keegan,1982).

In HERMES-IRELAND a central role is given to the supply side of the economy. This means that, in the medium term, the chain of causation is treated as running from supply of output to exports and the traditional export demand equation is unecessary. International competitiveness works directly through the supply side of the economy and does not have a direct effect on exports in the medium term.

Exports are divided into four categories. The largest component is industrial exports (XI). Agricultural exports (XA), which were extremely important in the early part of the sample period, have tended to decline in importance over time, though still remaining of considerable significance to the Irish economy. The remaining categories are tourism exports (XTO) and exports of other services (XSO).

The approach to modelling the domestic supply of agricultural produce was outlined above in Section 3.2. Given the domestic supply, the produce is allocated over the possible alternative uses - domestic absorption (QDA), stock changes (STADL and STIVDL) and exports (XA). The allocation procedure makes the share of output (QGA) going to domestic absorption (QDA) a function of time, t:

$$QDA/QGA = f(t)$$

Agricultural exports (XA) are then defined in an identity as the residual after domestic absorption (QDA), changes in agricultural stocks (STADL) and changes in intervention stocks (STIVDL) have been deducted.

$$XA = QGA-QDA-STADL-STIVDL$$

Both the long run and the short run supply decisions for industrial output were described above in Section 3.1. The share of actual industrial output (QHI) going abroad as exports (XI) is a function of time:

$$XI/QHI = f(t)$$

Because of the rapid change in the structure of the industrial sector over the last two decades, this equation when estimated suggests the proportion of gross industrial output which is exported grows at the 7.1% per annum. However, such a rate of growth could not continue for long out of sample and this equation must be treated with caution in using the model for medium term forecasting. In any given year the specification means that a high proportion of any change in the short run supply of industrial goods (QHI) will be exported.

In this specification a devaluation affects exports by increasing the profitability of Irish industrial production through lowering relative labour costs. The dynamics of the devaluation work through the domestic wage bargaining system and will eventually return competitiveness to its original level. Our approach can be thought of as a structural model of the export process. Within the overall model system the controversy over export determination becomes less important than the key issue of the determination of industrial output. In the case where industrial capacity is uninfluenced by domestic absorption (i.e., a "pure" export-led growth model), exporting is a pure supply process. However, allowing domestic absorption to influence industrial capacity (i.e. a "generalised" export-led growth model), would introduce a domestic demand component to the exporting process. The possibility in the future of disaggregating the industrial sector into indigenous firms, with a low propensity to export, and foreign firms, with a very high propensity to export, would greatly facilitate improved modelling in this important area.

The volume of tourism exports (XTO) is made a function of world industrial output (QIW) and a dummy variable for the unrest in Northern Ireland (DUMNI). A long run elasticity with respect to world output of 1.0 is imposed in the specification. The Northern Ireland dummy takes on the value zero prior to 1969 and a value of 1 thereafter. A partial adjustment scheme is incorporated into the specification of the equation:

$$Log(XTO/QIW) = f(DUMNI)$$

A unitary elasticity of other services exports (XSO) with respect to real GNP is imposed. A partial adjustemnt scheme is also incorporated in the specification which, when estimated, suggests a fairly slow speed of adjustment of this component of exports to changes in real GNP.

$$log(XSO/GNP) = a_1 + a_2 \, log(XSO/GNP)_{-1}$$

Full equation specifications and estimations are given in Appendix 2, equations 50-51 and 196-203.

[5.3] : Trade Prices

All import prices are exogenous in foreign currency terms. The price of exports of agricultural goods is also exogenous, being set within the Common Agricultural Policy (CAP) of the EC. The determination of the price of industrial exports has already been discussed in Section 3.6. The price of exports of services (PXS) is determined by the Irish consumption deflator (PC).

$$PXS = f(PC)$$

Full equations specifications and estimations are given in Appendix 2, equations 253-258.

CHAPTER 6 : GOVERNMENT FISCAL ACTIVITIES AND DEBT FINANCING

In this chapter we first consider the direct action of the government on the domestic economy through the range of fiscal variables which cover all of government revenue and expenditure. This requires specification of equations to determine current revenue, current expenditure, capital expenditure and borrowing. We then examine the way the government sector deficit is financed and its implications for the monetary sector of the economy. In addition, there is a series of optional equations which allow for the indexation of a wide range of variables which are normally considered as exogenous policy instruments. This facility is included to facilitate the use of the model out of sample but, naturally, in validating the model the historical values for the exogenous variables are used.

[6.1] : Current Revenue

The approach adopted to modelling the revenue from the major types of taxation is fairly standard; revenue is considered as a function of a rate variable and a variable representing, as far as practicable, the appropriate tax base. A rather higher level of aggregation was chosen for HERMES-IRELAND than for the earlier MODEL-80 to simplify its use for medium term analysis. This higher level of aggregation was made necessary partly by the higher level of aggregation used in modelling consumption.

Revenue from all excise taxes (GTEXT) is made a function of an index of rates of excise taxes (REX), the deflator for personal consumption (PC) and a variable representing the base on which the tax is levied - consumption (C), and expenditure by foreign tourists in Ireland (XTO). The price deflator is included due to the fact that some of the excise taxes have an ad valorem element which could be expected to rise in line with inflation even without a change in the actual rate of tax. The most important of these ad valorem taxes is that on motor vehicles. The index only covers the major specific excise duties.

$$\log GTEXT = -3.89 + 0.7 \log REX + 1.21 \log (C+XTO) + 0.26 \log PC$$

The estimated coefficients are broadly in line with prior expectations. The coefficient on the tax rate index at 0.7 suggests that for a 1.0% rise in the rate of tax, revenue may rise by only 0.7%[1]. The coefficient on the volume of consumption and tourism is significantly greater that 1 and possibly reflects the fact that the goods liable to excise taxes have an income elasticity greater than 1 so that revenue rises faster than the overall volume of consumption. Finally, the fact that the coefficient on the price variable is only 0.26 reflects the fact that only a minority of excise taxes are *ad valorem* in nature.

The VAT revenue equation is similar in structure to that for excise taxes. Because it is an *ad valorem* tax the elasticity of tax revenue with respect to prices should be closer to 1 than in the case of excise taxes. The revenue from the tax accrues to the exchequer with approximately a 1 quarter lag and this is reflected in the specification of the independent variables. VAT revenue (GTEVAT) is a function of the weighted average VAT rate (RVAT), the VAT base (GTEVATB) and consumer prices. The variable GTEVATB is itself a weighted average of personal consumption and tourism exports where the weights take account of the delay in receipts of VAT by the exchequer.

$$GTEVAT = f(RVAT, GTEVATB, PC)$$

For simplicity other indirect taxes have been aggregated into a single variable GTEO. The tax base variables are taken to be the volume of personal consumption (C) and its deflator (PC). The index of tax rates for this other indirect taxes category (RTEO) is necessarily rather crude. As a result, it is not surprising that the equation, described in detail in Appendix 2, is rather poor.

$$GTEO = f(RTEO, C, PC)$$

Motor vehicle registration duties (GTMVD), which are levied annually on all motor vehicles, are modelled as a function of the rate of duty (RCARS) and a proxy for the base, the volume of personal consumption (C).

$$GTMVD = f(RCARS, C)$$

They are partly considered to be an indirect tax (GTEMVDC) and partly considered to be a direct tax (GTYMVDP). The split between the two is on the basis of fixed historical proportions.

Customs duties (GTECUSO) are obtained in an identity where the rate variable (RCUS) is multiplied by the base which is considered to be the value of total merchandise imports (MGV). Since Ireland's entry into the EC in 1973 the importance of this source of revenue has been very much diminished.

$$GTECUSO = RCUS*MGV$$

The total of indirect taxes accruing to the Irish exchequer is composed of the sum of the taxes described above plus local authority rates (GTERATE) and agricultural levies (GTAGLEV), the latter two of which are normally treated as exogenous. Optionally they may be

1 This is consistent with the evidence in Fitz Gerald *et al*,1988 which indicates a significant level of smuggling from Northern Ireland to the Republic of Ireland of goods liable to excise taxes in the face of high rates of excise tax in the Republic. It may also reflect the fact that the index itself only covers part of all the goods liable to excise tax.

indexed to appropriate deflators. From this total must be deducted that part of indirect tax revenue which accrues to the EC as part of Ireland's budgetary contribution (EECBUD), and a special payment to the EC (EECCIC).

$$GTE = GTEXT + GTEVAT + GTEO + GTEMVDC + GTECUSO + GTERATE + GTAGLEV - (EECBUD + EECCIC)$$

The equation determining the revenue from personal income tax makes total revenue a function of average taxable income per head (AAITI), the numbers in nonagricultural employment (LNA) and the total potential amount of income tax allowances claimable (RTPYALL). A coefficient of 1 is imposed on the numbers employed. The coefficient on average taxable income is significantly greater than 1 reflecting the progressive nature of the tax system.

GTYPER = F(AAITI,LNA,RTPYALL)

Revenue from social insurance contributions (GTYSL) is endogenised by means of an identity in which the rate of contribution (RGTYSL) is multiplied by the base, defined as wages and salaries in the market services sector (YWSM) and the industrial sector (YWI).

GTYSL = RGTYSL(YWSM+YWI)

The total revenue from social insurance contributions is divided between employers and employee contributions by a series of identities. Corporation tax (GTYC) is determined in another quasi-identity as the product of an implicit tax rate (RGTYC) and total profits (YC) lagged one year. It is hoped to endogenise this variable using a more sophisticated behavioural equation in the next version of the model.

GTYC = RGTYC*YC(-1)

Total direct tax revenue (GTY) is determined in an identity as the sum of revenue from personal income tax (GTYPER), social insurance contributions (GTYSL), corporation taxes (GTYC), that portion of motor tax duties paid by private households (GTYMVDP), farmers' income tax (GTYA) and DIRT tax (GTYDIRT). The last two are generally treated as exogenous though suitable indexation options are available.

GTY = GTYPER+GTYSL+GTYC+GTYMVDP+ GTYA+GTYDIRT

Total current revenue (GTTOT) is the sum of revenue from indirect and direct taxes (GTE and GTY), wealth taxes (GTW), trading and investment income (GTTI) and current transfers from abroad (GTTABR). The last three variables are exogenous.

GTTOT = GTE+GTY+GTW+GTTI+GTTABR

[6.2] : Current Expenditure

Consumer subsidies (GCSC) are determined as the product of the implicit rate of subsidy (RGCSC) and the base for the subsidy, total personal consumption at constant prices (C)[2].

GCSC = RGCSC*C

The other subsidies paid by the government (GCSO) are disaggregated into agricultural subsidies (GCSA) and other subsidies (GCSONA), both of which are exogenous. Subsidies paid by the EC are treated as a separate exogenous variable (EECS) and are assumed to be paid dierct to the domestic private sector. Total subsidies paid in Ireland (SUB) is then the sum of consumer subsidies (GCSC), other government subsidies (GCSO) and EC subsidies (EECS).

SUB = GCSC+GCSO+EECS

Current transfers paid by the government sector are disaggregated into four categories: unemployment assistance and beneift (GCTUP), pay related benefit (GCTPRB), transfers paid as wages to teachers (GCTW) and other transfers (GCTREST). Unemployment transfers are endogenised as a function of a weighted avergage rate of payment (RUP) and the numbers unemployed (U).

GCTUP = f(RUP,U)

Payments of pay related benefit (GCTPRB) are endogenised as functions of the numbers unemployed (U) and average annual earnings outside agriculture (AAENA) lagged one period.

GCTPRB = f(U,AAENA)

Total personal transfers (GCTPER) is then defined in an identity

GCTPER = GCTUP+GCTPRB+GCTW[3]+GCTREST

In the standard version of the model national debt interest payments on loans denominated in Irish pounds (GCTNDID) is endogenised using the following equation. Because of the timing of borrowing and payments of interest, total payments are a function of the product of the average market yield (RGL) and the debt outstanding (GNL), lagged both one and two periods.

GCTNDID = f (RGL,GNL)

However, an alternative more complex formulation can be used drawing on the output of a special debt model[4]. In this equation the change in interest payments is a function of the product of the average market yield (RGL) lagged one period and the sum of the following variables: the change in the debt outstanding in the previous year and repayments of debt last year (GNLREP). From this total is deducted the debt interest payments which would have been due on the debt repaid last year if it had not been repaid (GCTNDRI).

$$\Delta GCTNDID = RGL_{-1}(\Delta GNL_{-1} + GNLREP_{-1}) - GCTNDRI$$

2 This item includes food subsidies which were introduced in the early 1970's as well as the deficit of CIE, the Irish public transport company.

3 For national accounting reasons the salaries of secondary teachers (GCTW) are treated as a transfer to the personal sector.

4 See Fitz Gerald,1986

National debt interest payable on small savings (GCTNDISS) is equal to the product of the rate of interest on small savings (RGLSSI), expressed in per centage form, and the amount of small savings outstanding (GNSS). Debt interest payable on debt denominated in foreign currency terms (GCTNDIF) is equal to the product of an implicit foreign interest rate (RFI), expressed in percentage terms, and the level of foreign debt outstanding at the end of the previous year expressed in foreign currency terms (GNFF) converted into Irish pound terms using an appropriate exchange rate (FXAFB). For the within sample period the implicit interest rate was obtained by reversing this identity. The exchange rate variable is a weighted average of the different major bilateral exchange rates using the currency composition of the debt as the weights.

$$GCTNDISS = RGLSSI/100*GNSS$$
$$GCTNDIF = RFI/100*(GNFF_{-1}/FXAFB)$$

Total national debt interest paid by the government (GCTNDI) is then the sum of the three components: debt interest on national loans (GCTNDID), on small savings (GCTNDISS) and on foreign debt (GCTNDIF).

$$GCTNDI = GCTNDID+GCTNDISS+GCTNDIF$$

Public consumption expenditure at current prices (GCGV) is disaggregated into three separate categories of expenditure: expenditure on the output of the public administration sector proper (OPAV); other purchases involving expenditure on public sector employment, primarily in health and education (GCGOWV) and other purchases of goods and services (GCGNPV). The derivation of the output of the public administration and health and education sectors has already been discussed in Section 3.4[5]. As discussed above, secondary teachers salaries (GCTW) are treated as current transfers and must be deducted from the total wage and salary bill for the health and education sector (YWSHE) to arrive at public consumption expenditure on health and education employment (GCGOWV). The deflator used to obtain the volume of expenditure on health and education is related directly to average annual earnings in that sector (AAESHE). The volume of expenditure on other goods and services (GCGNP) is obtained by deflating the value figure (GCGNPV) by the relevant deflator (PGCGNP). Finally the volume figure for total public consumption (GCG) is the sum of its components (OPA), defined in Section 3.4, consumption expenditure on health and education at constant prices (GCGOW) and other purchases of goods and services at constant prices (GCGNP).

$$GCGV = OPAV+GCGOWV+GCGNPV$$
$$GCGOWV = YWSHE-GCTW$$
$$PGCGOWV = PGCGOWV_{-1}(AAESHE/AAESHE_{-1})$$
$$GCGOW = GCGOWV/PGCGOWV$$
$$GCGNP = GCGNPV/PGCGNP$$
$$GCG = OPA+GCGOW+GCGNP$$

Total current expenditure by the government sector (GC) is the sum of public consumption (GCGV), subsidies (total subsidies (SUB), less EC subsidies (EECS)), transfers to the personal sector (GCTPER), national debt interest (GCTNDI) and current transfers paid abroad (GCTABR).

$$GC = GCGV+SUB-EECS+GCTPER+GCTNDI+GCTABR$$

[6.3] : Capital Expenditure

The bulk of capital expenditure is treated as exogenous for the within sample period, although an indexation option is available. The only two components which are endogenised are capital transfers to industry (IDA grants: GKTI) and capital transfers for housing (GKTH). In these two cases they are endogenised by multiplying a grant rate variable (RGKTI and RGKTH) by a variable representing the base on which the grants are payable. In the case of industrial grants the base is investment by the industrial sector (IIV), and for grants for housing purposes the base is private sector housing investment (IHPV).

$$GKTI = RGKTI*IIV$$
$$GKTH = RGKTH*IHPV$$

Total capital expenditure (GK) is then the sum of public investment in housing (IHGV), health and education (ISHEV) and investment undertaken by the public administration sector itself (IPAV), together with capital transfers to the industrial sector (GKTI), transfers for housing (GKTH) and other capital expenditure including loans to the private sector (GKREST).

$$GK = IHGV+ISHEV+IPAV+GKTI+GKTH+GKREST$$

[6.4] : Borrowing

In the model, saving by the government - normally borrowing for current purposes with the sign reversed (GBRC) - is equal to the difference between current revenue (GTTOT) and current expenditure (GC). The government's surplus (GBR) - normally a deficit with the sign reversed - is equal to the difference between current (GTTOT) and capital (GR) revenue, on the one hand, and current (GC) and capital (GK) expenditure on the other. In the model capital revenue (GR) is treated as exogenous unles the indexation option is invoked.

GBRC GTTOT-GC
GBR GTTOT+GR-GC-GK

It is this latter variable - with the sign reversed - which represents the amount of borrowing to be funded by the public sector in any one year. This matter is dealt with in the following chapter.

[6.5] : Debt Financing and the Financial Sector

The monetary environment is modelled using a conventional SOE fixed exchange rate approach. Exchange rates are taken as given and interest rates are either related directly to foreign rates or else are treated as exogenous. When treated as exogenous, care is taken to

5 The breakdown of expenditure on the different categories of expenditure is discussed in more detail in Ross,1988.

take account of the close financial links between the Irish financial sector and that of the UK and EMS partners. However, because of the rapid changes in this sector over the last ten years it is not possible to specify a satisfactory model which fully explains current developments. As a result, this key link between the Irish and the world economy must be handled outside the model.

Because of the high level of government debt and the dominance of the Irish financial sector by the market for this debt, the financing of government borrowing is treated in some detail. We here describe the key identities for the domestic banking sector and the capital account of the balance of payments, the flow of funds and the demand for financial assets, and finally the interest rate and exchange rate identities.

[6.5.1] : Financing the Government Debt.

Total national debt (GNT) is considered in two parts: debt denominated in Irish pounds (GND) and debt denominated in foreign currency (GNF). The debt denominated in Irish Pounds is further divided into 2 categories, national loans (GNL) and small savings, including exchequer bills (GNSS). Finally, the change in national loans outstanding at the end of the year is divided between a change in household sector's holdings of government financial assets (GNHGDL)[6], the banks' holdings of such assets (GNBG), the Central Bank's holdings (GNCG) and a variable (KGNL) which ensures that the identity holds for each year. This last variable takes account of the effects of valuation changes and other minor discrepancies in the data. The determination of the changes in the holdings of government debt by the different sectors is discussed later.

$$GNT = GNF+GND$$
$$GND = GNL+GNSS$$
$$GNL = GNL_{-1}+[GNHGDL-\Delta(GNSS)]+\Delta(GNBG)+\Delta(GNCG)+KGNL$$

The government sector finances as much of its borrowing domestically through various Irish pound instruments as it can. Government foreign borrowing is determined residually. Government sector savings (GBR) are determined as described above in Section 6.4[7].

$$FBOR = -GBR-\Delta(GNSS)-\Delta(GNBG)-\Delta(GNCG)-GNHGDL$$

The government sector foreign borrowing (FBOR) is converted into foreign currency terms by multiplying it by an appropriate exchange rate variable (FXAFB, see above). The current value of the government's external debt in foreign currency terms (GNFF) is determined and the Irish pound value of the debt outstanding is then derived by dividing by the appropriate exchange rate.

$$FBORF = FBOR*FXAFB$$
$$GNFF = GNFF_{-1}+FBORF$$
$$GNF = GNFF/FXAFB$$

[6.5.2] : The Capital Account of the Balance of Payments.

The domestic banking sector is not modelled in any detail in this version of HERMES-IRELAND. A single identity describes the balance sheet of the banking system (which consists of licensed banks and the Central Bank). The change in reserves (R) is equal to the change in current and deposit accounts (MON), less the change in domestic credit (DC), plus the change in a residual item (ONLB). This residual (ONLB) includes the foreign liabilities of the banking system (NFLB) together with other net liabilities not included elsewhere. From these liability items lending to the government by the banking system (GNBG+GNCG) is deducted to arrive at the exogenous (ONLB) in the model. Care must be taken in using the model to ensure that the value chosen for the exogenous (ONLB) is consistent with the values of (NFLB), (GNCG) and (GNBG) which appear elsewhere. In the model this equation determines the level of external reserves:

$$\Delta(R) = \Delta(MON)+\Delta(ONLB)-\Delta(DC)$$

Given the change in the level of external reserves (R), the change in the net foreign liabilities of the banking system (NFLB), public authorities net capital receipts from abroad (BPTKNG) and public authorities foreign borrowing (FBOR), the net private capital inflow (BPPK) is determined in an identity. A crude approximation to net non-bank private foreign assets (KBPPK) is derived. The value of these assets at the end of the previous year is revalued by the change in world prices in Irish pound terms (PWORLD). This takes account of the effect of changes in exchange rates as well as changes in world prices. Total private sector net foreign assets (NFLP) are then defined as the difference between private non-bank foreign assets (KBPPK) and the net foreign liabilities of the banking system (NFLB).

$$BPPK = \Delta(R)-BP-\Delta(NFLB)-BPTKNG-FBOR$$
$$KBPPK = [KBPPK_{-1}/PWORLD_{-1}*PWORLD]-BPPK$$
$$NFLP = KBPPK-NFLB$$

[6.5.3] : Flow of Funds and Demand for Financial Assets.

An innovation in this version of HERMES-IRELAND is the inclusion of a set of identities describing the flow of funds in the economy. This allows a more sophisticated approach to the modelling of the demand for financial assets, although this section of the model only considers the flow of funds at a very aggregate level and does not identify different financial intermediaries.

The source of funds for the company sector (FFSC) is identified and is equal to the total of company savings (SAVC) - retained profits after tax, industrial depreciation (DEPI), an estimate of the proportion of services

6 Because GNHGDL includes the change in small savings held by the personal sector these must be netted out in determining the take up of national loans.

7 Note that GBR represents government revenue less expenditure, i.e., the government's surplus. The negative of GBR represents the government's borrowing requirement.

depreciation (DEPS) attributable to the company sector[8], capital transfers from the government sector to the industrial sector (GKTI) and other capital transfers by the government sector to the personal sector (GKREST). This definition, while slightly different from that used by O'Connell,1986, is the best possible given the restrictions of the model structure. The use of funds by the company sector (FFUC) is the sum of investment in the industrial and the market services sectors (IIV and ISMV), nonagricultural stock building (STNAVDL) and the change in intervention stocks (STIVVDL). This latter item is included due to the fact that the intervention agency is treated as part of the private sector in the Irish and SOEC national accounts. The net acquisition of financial assets by the company sector (FFAQT) is then the difference between that sector's source and use of funds.

Household sector source of funds (FFSH) is the sum of personal saving (SAV), agricultural depreciation (DEPAG) and capital transfers by the government sector to the household sector (GKTH). The use of funds by the household sector (FFUH) consists of private housing investment (IHPV), agricultural investment (IAGV) and the change in agricultural stocks (STAVDL). The net acquisition of financial assets by the household sector (FFAQH) can then be defined by an identity.

The total acquistion of financial assets by the private sector is then the sum of the acquisitions by the company and houshold sectors (FFAQT) and the net acquisitions of financial assets as a proportion of total funds available in each sector are defined as (RFFAQC) and (RFFAQH)

FFSC = SAVC+DEPI+0.55*DEPS+ GKTI+GKREST
FFUC = IIV+ISMV+STNAVDL+ STIVVDL
FFAQC = FFSC-FFUC
FFSH = SAV+DEPAG+GKTH
FFUH = IHPV+IAGV+STAVDL
FFAQH = FFSH-FFUH
FFAQT = FFAQC+FFAQH
RFFAQH = 100*(FFAQH/FFSH)
RFFAQC = 100*(FFAQC/FFSC)

The demand for current and deposit accounts (MON) by the non-bank private sector, deflated by (PGDPM), is a function of the volume of GDP at market prices (GDPM), and its rate of inflation (the change in PGDPM). The inclusion of the rate of inflation is intended to take account of the fact that the cost of holding cash or similar assets is the loss due to erosion in value of the asset consequent on inflation.

$$\log(MON/PGDPM) = 1.776 + 0.755 \log(GDPM) - 0.334 \log(PGDPM/PGDPM_{-1})$$

Two equations are included in the model, on an optional basis, which determine the uptake of government stock by the banks (GNBG) and the household sector (GNHGDL) as functions of appropriate variables. There is also an optional equation which determines the level of small savings by the personal sector (GNSS). Banks' holdings of government stocks are assumed to be a parameter (KGNB) times the level of current and deposit accounts (MON). For the personal sector the acquistion of government stocks is set equal to a parameter (KGNH) times the net acquistion of financial assets by the household sector. In the case of small savings (GNSS) it is also a proportion (KGNSS) times the household sector's acquisition of financial assets. The parameters can be altered from year to year. Ideally, the portfolio behaviour of the personal sector should be modelled in a more sophisticated fashion taking account of the differences in the rates of return on different financial instruments. However, such a development must await more research into this area of the Irish economy.

GNBG = KGNB*MON
GNHGDL = KGNH*FFAQH
GNSS = $KGNSS*FFAQH+GNSS_{-1}$

[6.5.4] : Interest Rates and Exchange Rates.

Interest Rates

Up to the break in the link with sterling and Ireland's entry into the EMS in 1979, the relationships determing Irish interest rates were reasonably straightforward since Irish rates were equal to those in the UK plus a small margin. However, since joining the EMS the situation has been much less clear. While, as a small open economy, Irish rates since 1979 have been strongly influenced by rates in the outside world, the relationship has not been transparent. Domestic economic circumstances have had greater scope for influencing key rates of interest in the economy[9]. However, the amount of research undertaken to date does not allow us to specify a satisafctory model of the interest rate determination process. As a result, in HERMES-IRELAND we have included a number of options on the determination of interest rates concerned more with handling different types of policy simulation than providing possible behavioural models.

The first option makes all the interest rate variables exogenous. This is the option used in testing the model. The second option sets the interest rates equal to a fixed, exogenous, level plus the devaluation in the exchange rate. This option is useful when examining the effects of changes in exchange rates on the economy. The third option makes the foreign rate of interest equal to a fixed, exogenous, world **real** rate of interest plus the weighted average world rate of inflation. For domestic interest rates a similar option is included making interest rates equal to a fixed domestic real rate of interest plus the domestic rate of inflation. This last option is useful in policy simulations which affect prices. The expected prime lending rate (ERPL) is defined as a three year moving average of the prime lending rate (RPL). The real prime lending rate (RRPL) is defined as equal to the nominal rate less the rate of increase in the delator for GDP at factor cost (PGDPFC).

	Option	Definition
RFI	1	Exogenous
	2	RFIF-FXAEFFDT
	3	RRWINT+PWB7FDOT

8 See Dowling,1973, and Honohan,1981.

9 Fitz Gerald,1986.

RGL	1	Exogenous
	2	RGLF-FXAEFFDT
	3	RRINT+100*DEL(PGDPE) /$PGDPE_{-1}$
RGLI	1	Exogenous
	2 & 3	RMGLI+RGL
RGLSSI	1	Exogenous
	2 & 3	RMGLSSI+RGL
RPL	1	Exogenous
	2 & 3	RMPL+RGL
RD	1	Exogenous
	2 & 3	RMD+RGL
ERPL		$(RPL+RPL_{-1}+RPL_{-2})/3$
RRPL		RPL-PGDPFCDT

where

ERPL	Expected prime lending rate.
FXAEFFDT	Effective exchange rate, percentage change.
PGDPE	Deflator for GDP at market prices on an expenditure basis.
PGDPFCDT	Deflator for GDP at factor cost, percentage change.
PWB7FDOT	World prices, major 7 OECD countries, percentage change
RD	Rate of interest on bank deposits.
RFI	Implicit rate of interest on foreign debt.
RFIF	Foreign currency version of RFI.
RGL	Market yield on medium term government stocks.
RGLF	RGL adjusted for exchange rate changes.
RGLI	Implicit rate of interest on government stocks.
RGLSSI	Rate of interest on small savings.
RMD	Margin between RGL and RD.
RMGLI	Margin between RGL and RGLI.
RMGLSSI	Margin between RGL and RGLSSI.
RMPL	Margin between RGL and RPL.
RPL	Prime lending rate.
RRINT	Real rate of interest on government stocks.
RRWINT	Real world rate of interest.
RRPL	Real prime lending rate.

Exchange Rates.

Exchange rates are treated as exogenous in the model. Three different exchange rates are used: (FXA), the number of $ per £IR and two weighted average exchange rates (FXAWD) and (FXAFB). They are described in Appendix 2, as also are a number of related identities.

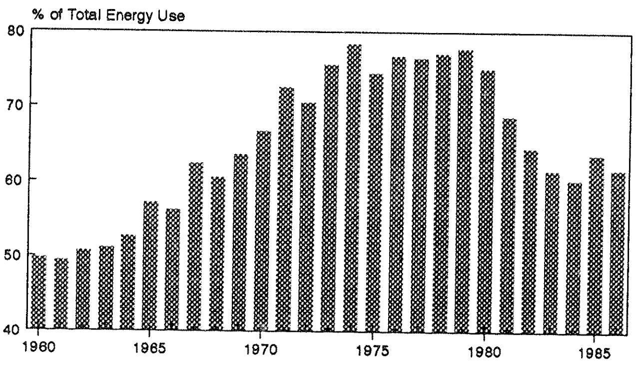
CHAPTER 7 : THE STRUCTURE OF ENERGY SUPPLIES

The importance of identifying energy as a separate factor of production in a macro-economic model became clear in the years after the first oil price crisis of the 1970s. As outlined in Chapter 2, the HERMES model stucture was designed with this in mind. However, both because of data problems and the special characteristics of the Irish economy, it proved necessary to model the demand for energy in a slightly different way in HERMES-IRELAND. This Chapter considers the role of energy in the Irish economy and the special factors which are taken into account in HERMES-IRELAND.

[7.1] : Energy and the Economy

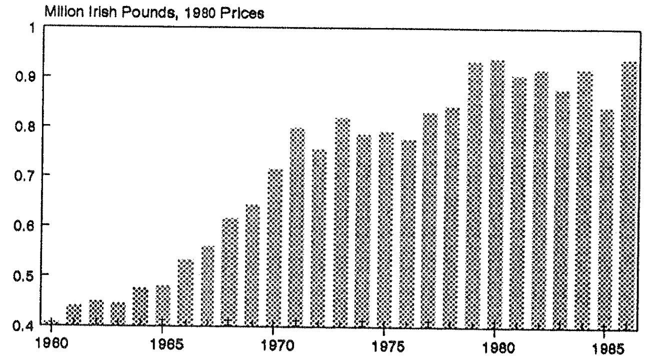
Ireland has been traditionally very dependent on imports to provide the energy needs of the economy. With no significant domestic supplies of coal little or no heavy industry developed in Ireland in the 19th and the first half of the twentieth centuries. With the reduction in the relative price of oil in the 1950s and 1960s, imported oil began to replace imported coal as the major source of primary energy. By 1960 (see Figure 7.1) fifty per cent of gross primary energy used (i.e., total energy usage before deducting exports of energy) in the economy was accounted for by imported oil. By 1974, imported oil had increased its share to almost 80 per cent of energy usage. Imported oil maintained its dominant position over the rest of the 1970s. However, with the discovery of an offshore natural gas field, which began production in 1979, domestic energy production began to rise. While this somewhat reduced the dominant role of oil in the first half of the 1980's, oil still remains by far the single biggest source of energy for the Irish economy.

FIGURE 7.1
SHARE OF OIL IN DOMESTIC ENERGY USE



As can be seen from Figure 7.2, net domestic consumption of energy grew rapidly over the period preceding the first OPEC oil crisis. However, from 1973 onwards it has shown a much slower rate of growth, presumably due to the effects of the increased real price of oil.

FIGURE 7.2
NET DOMESTIC ENERGY CONSUMPTION



As a result of its dependence on imported energy, the Irish economy was very exposed to changes in the terms of trade which arose due to the rise in energy prices in the early 1970s. The income effect of the rise in oil prices on the Irish economy was very severe and took place immediately. The substitution effect, as in most other countries, took much longer to work itself out and there is evidence that the economy is still adjusting to the shocks of the price changes of the 1970s.

The absence of a large (and cheap) domestic supply of energy in the past affected the historical development of the Irish manufacturing sector. In particular, the energy intensive heavy industries which characterise the industrial sectors of a number of other EEC members never developed in Ireland, and this has affected the demand for energy by the industrial sector in Ireland. The discovery of natural gas has not changed the structure of Irish industry, much of the gas output being used initially to replace imported oil in generating electricity.

Because of the small size of the Irish economy and its limited demand for energy, there has only been one oil refinery in Ireland which operated for some, but not all, of the last thirty years. Because of economies of scale in the operation of the refinery, part of its output was re-exported. This must be taken into account in determining the volume of net domestic energy usage.

Over 80% of energy imports were used as an input into the productive sector of the economy in 1975 (Fitz Gerald,1987). However, the bulk of this 80% underwent further transformation in either the oil refining or utilities sectors before being used to provide final energy, either to the rest of the productive sectors or direct to consumers. When allowance is made for the fact that the bulk of the domestic production of energy has been used as an input into the utilities sector, the role of the industrial sector as a whole is seen to be crucial in determining the domestic demand for energy and the response of the Irish economy to price shocks.

Even when allowance is made for that portion of energy which passed directly into consumption from the utilities and oil refining sectors, the proportion of energy imports used directly in the domestic production sectors was still around 60% in 1975. (35 % of the output of oil refining in 1975 passed directly to final demand, as did 43% of the output of the utilities sector).

[7.2] : Modelling the Demand for Energy.

The above analysis suggests that the demand for energy will be heavily affected by changes in the technology of the energy transformation sectors and by factors affecting the demand for energy in the rest of the productive sector, primarily manufacturing industry. This would suggest the necessity for a three-way breakdown of the economy for the purpose of modelling the total demand for energy:

(a) the energy transformation sector
(b) the manufacturing industries sector
(c) the rest of the economy which buys the products of the other two sectors. (This sector could be broken down into a number of different sectors for other reasons).

As indicated above, it is probably not too severe a restriction to assume that all the energy used in the economy passes through the first two of these sectors and to model them accordingly. However, there are a number of problems with this approach due to the lack of available data. In particular, it is not possible to separate out oil refining from the rest of manufacturing industry due to absence of suitable data. For confidentiality reasons, the details of the operation of the oil refinery are not distinguished in official data. This leaves three alternatives:

(a) treat utilities and manufacturing industries as one sector whose behaviour can be represented by a single production function.
(b) attempt to separate out the oil refining sector from the manufacturing sector on the basis of crude assumptions
(c) treat utilities and manufacturing industries (including oil refining) as two separate sectors having separate underlying production functions

As outlined in Chapter 3 the approach we have adopted in the current version of HERMES-IRELAND is the first of those outlined above: utilities and manufacturing industries (including building) are treated as one sector having a single underlying production technology. All domestic consumption of primary energy is assumed to pass through this sector and the demand for primary energy is modelled jointly with the demand for capital and labour by the composite sector. Domestic production of energy is treated as exogenous.

In the future it is hoped to develop the second and third of these approaches, treating utilities and manufacturing as separate sectors. This would probably involve the development of a consumer demand system which would take account of the changes in personal consumption of the outputs of these sectors due to changes in relative prices, consequent on the rise in oil prices.

Finally, the interfuel substitution model has been estimated for Ireland and is documented elsewhere (Bradley and Reilly,1983). The constant price energy data were taken from the OECD Energy Balance Sheets and it was possible to distinguish four branches: agriculture, industry, transport and other services. The quality of the data was poor and there appeared to be many discontinuities in the period 1960-1980 rendering estimation suspect. However, the energy sub-model could be incorporated into HERMES- IRELAND without much difficulty but would add very little to the economic properties of the model.

CHAPTER 8 : RETROSPECTIVE SIMULATIONS : 1967-1984

In this section we examine how well HERMES-IRELAND tracks historical data for the simulation period 1967-1984. The full estimation period was 1964-1984, but three years are lost because of lags in non-estimated equations. Below, in Chapters 9 and 10, we will examine the economic properties of the model as a system and how it responds to shocks administered to exogenous variables and model parameters.

The examination of the within-sample tracking performance of an econometric model is a conventional heuristic, if somewhat limited, method of evaluating its likely performance in out-of-sample forecasting. Tracking errors enter an econometric model only through the stochastic errors in the stochastic or estimated behavioural equations. If the model consisted of non-stochastic identities then within sample tracking would give a perfect reproduction of the endogenous variables. Hence, the standard regression diagnostics, together with the stochastic errors of the behavioural equations, treated individually in isolation from the rest of the model system into which they are embedded, provide a first evaluation of tracking performance. These are shown in the table on the next page.

If we now perform model system simulations the individual stochastic errors can either reinforce or partially offset each other both for each separate time period and between time periods. There is no simple method of predicting *ex ante* what the outcome will be before performing the simulations. Two types of simulation are used to examine system tracking performance. *Static* simulations use the complete system but restart the simulation each year, using the historical values of the exogenous and endogenous variables. *Dynamic* simulations also use the complete model system but start from a specified base year (1967 in the case of the simulations reported below) and use the models own predictions of the endogenous variables to form lagged values.

The usual summary statistic used to evaluate tracking performance is the root-mean squared percentage error (RMSPE) defined as follows:

$$RMSPE = \frac{1}{T}\sqrt{\sum_{t=1}^{T}\left\{\frac{(Y_{it}^{*}-Y_{it})}{Y_{it}}\right\}^{2}}$$

where

Y_{it}^{*} = simulated value of the i th endogenous variable at time t

Y_{it} = actual value of the i th endogenous variable at time t

T = number of time periods in the simulation

However, for variables which alter sign over the period of simulation (e.g., net migration abroad, stock changes, net factor income from abroad) a more appropriate measure is the root-mean squared error (RMSE):

$$RMSE = \frac{1}{T}\sqrt{\sum_{t=1}^{T}(Y_{it}^{*}-Y_{it})^{2}}$$

Since the dynamic simulation test is a more searching test of the model's performance, one would expect the RMSPE to be greater for the dynamic simulation compared with the static. In the tabulated results presented below, this turns out to be invariably the case in practice.

(i) Tracking Performance for Major Aggregates: Note (*) Denotes RMSE

	RMS % ERROR	
	Static	Dynamic
GNP Gross National Product (£m,1980)	1.85	2.42
GDP Gross Domestic Product (£m,1980)	1.83	2.60
GNPDOT GNP Growth Rate (Percent)*	1.70	1.72
MGS Total Imports (£m,1980)	4.00	5.08
XGS Total Exports (£m,1980)	3.78	3.86
C Private Consumption (£m,1980)	2.45	2.86
ITOT Total Fixed Investment (£m,1980)	3.81	5.70
PC Consumption Deflator (1980=1)	2.71	4.36
LTOT Total Employment (000)	0.96	1.74
UR Unemployment Rate (Percent)*	0.89	1.61
U Unemployment Numbers ('000)	15.8	28.1
GBR Public Sector Borrowing (£m)	9.59	15.85
GBRR Public Sector Borrowing (% of GNP)*	0.79	1.75
BPRR Balance of Payments Surplus (% of GNP)*	1.60	2.14

HERMES-IRELAND : RMSPE FOR BEHAVIOURAL VARIABLES FROM ESTIMATION

Variable	*Description*	*RMSPE*
AAEI	Average annual earnings in industry (version 1)	1.99
AAEI	Average annual earnings in industry (version 2)	1.94
AAESM	Average annual earnings in market services	2.95
C	Personal consumers expenditure	1.71
DEPAG	Depreciation in agriculture	6.43
DEPI	Depreciation in industry	9.26
DEPS	Depreciation in Services (market + non-market)	5.46
EI	Energy inputs in industry	3.38
EOPRI	Trend growth in labour productivity (industry)	3.87
EOPRSM	Trend growth in labour productivity (m. servs)	4.66
GCTNDID	National loan debt interest	9.43
GCTUP	Unemployment transfer payments	5.71
GTEO	Residual indirect tax revenue	9.28
GTEVAT	VAT revenue	5.53
GTEXT	Excise duty revenue	1.98
GTMVD	Motor taxation revenue	6.57
IHP	Private housing investment	8.02
II	Industrial investment	7.73
ISM	Market services investment	9.52
KAG	Capital stock in agriculture	0.66
LAG	Employment in agriculture	1.40
LFPR	Labour force participation rate	0.55
LI	Employment in industry	0.93
LSM	Employment in marketed services	0.69
MC	Imports of consumption goods (version 1)	4.22
MC	Imports of consumption goods (version 2)	4.01
MMFPA	Imports of agricultural materials (version 1)	11.83
MMFPA	Imports of agricultural materials (version 2)	11.65
MON	Money supply	4.14
MPCG	Imports of producers capital goods	5.96
MS	Imports of services	9.11
N1564	Population aged between 15 and 64 years	0.29
NEDPR	Participation rate in full-time education	2.48
NLE14	Population aged less than or equal to 14 years	0.22
NMA	Net migration abroad	8.22
NT	Total population	0.19
OPA	Added-value in public administration	1.76
OSM	Added-value in marketed services	1.35
PC	Deflator of consumption	1.97
PIAG	Deflator of agricultural investment	3.07
PIBC	Deflator of building investment	1.87
PIH	Deflator of total housing investment	3.70
PII	deflator of industrial investment	0.89
PIME	Deflator of investmenty in machinery and equip.	2.85
PIS	Deflator of total services investment	0.57
PQHI	Deflator of gross industrial output	3.75
PQMA	Deflator of material inputs in agriculture	3.70
PQTI	Deflator of transportable goods sector output	2.65
PSTNA	Deflator of non-agricultural stock level	8.21
PSTNADL	Deflator of non-agricultural stock changes	7.39
PXI	Deflator of industrial exports	2.06
PYAFS	Deflator of adjustment for financial services	9.29
QDA	deflator of domestic absorption of ag. output	8.12
QGA	Deflator of gross agricultural output	4.72
QHI	Gross output in industry	2.18
QMA	Material inputs into agriculture	6.57
QSTARI	Planned output capacity in industry (version 1)	1.08
QSTARI	Planned output capacity in industry (version 2)	1.75
QSTARI	Planned output capacity in industry (version 3)	1.93
SRUB	Total subsidies in real terms	4.26
STNADL	Non-agricultural stock changes in real terms	59.70
TRE	Total indirect tax revenue in real terms	1.64
XI	Industrial exports	4.01
XSO	Exports of services, excluding tourism	8.88
XTO	Exports of tourism	6.52
YAFS	Adjustment for financial services	9.85
YCU	Undistributed profits	20.11

We now examine the tracking performance of the two key production sectors: industry and services.

(ii) : Tracking Performance for Industry Aggregates:

	RMS % ERROR	
	Static	Dynamic
QHI Gross Industrial Output (£m,1980)	2.94	5.17
OI Added Value in Industry (£m,1980)	3.19	6.60
II Industrial Investment (£m,1980)	9.87	12.6
LI Industrial Employment (000)	1.79	6.16
EI Industrial Energy Inputs (£m,1980)	4.61	5.02
PQHI Industrial Output Deflator (1980=1)	5.51	5.51
POI Added Value Deflator (1980=1)	3.78	4.52
AAEI Average Annual Earnings (£K)	3.66	6.82

(iii) Tracking Performance for Marketed Services Aggregates:

	RMS % ERROR	
	Static	Dynamic
OSM Added Value in Services (£m,1980)	1.56	1.68
ISM Services Investment (£m,1980)	9.98	12.61
LSM Services Employment (000)	2.01	1.51
EI Industrial Energy Inputs (£m,1980)	4.61	5.02
POSM Added Value Deflator (1980=1)	7.07	9.39
AAESM Average Annual Earnings (£K)	3.69	6.12

The above tracking results were compared with those from the previously used Irish model (Bradley, et-al, 1981) and were found to be very similar.

(iv) Comparison of HERMES-IRELAND with MODEL-80:

	RMSPE	
	HERMES	MODEL-80
QHI Gross Industrial Output (£m,1980)	2.96	2.27
OSM Added-Value, Marketed Services (£m,1980)	1.85	1.42
C Personal Consumers Expenditure (£m,1980)	2.68	1.95
GBR* Public Authorities Surplus (% of GNP)	39.0	20.2
MGS Imports of Goods & Services (£m,1980)	4.24	2.90
XI Industrial Exports (£m,1980)	4.44	5.13
PCDOT* Inflation Rate of Consumption	3.95	0.97
YC Total Non-Agricultural Profits (£m)	149.0	23.1
UR Unemployment Rate (% of Labour Force)	0.66	0.44
GNPDOT* Growth Rate of GNP	1.93	1.18

where the "*" denotes the use of the RMSE instead of the RMSPE. Comparisons of this sort are difficult to make since different variable classifications are used in the two models. More importantly, the relevant simulations (static) take place over different periods: 1961-77 for MODEL-80 and 1966-84 for HERMES-IRELAND. As the more recent years were ones of greater instability it is inevitable that the tracking performance errors will tend to be higher in the case of HERMES-IRELAND. Also, the greater structural complexity of HERMES-IRELAND (e.g., the endogenisation of the supply side) will serve to increase tracking errors.

There are obvious difficulties with certain variables, in particular sectoral fixed investment. These tracking results are constantly under review and provide a "test-bed" for alternative equation specifications. It should be noted however that in calculating multipliers, the stochastic errors can be automatically added back to the behavioural equations and the model can be forced to track the historical data exactly.

CHAPTER 9 : THE BEHAVIOUR OF THE HERMES-IRELAND MODEL

In Chapters 3 to 6 we discussed the detailed specification of the HERMES-IRELAND model. We then considered in some detail the reasons for the specification chosen for each major equation. However, when all the equations are put together in a full integrated model the role and significance of the individual equations may change. As a result, it is important to consider the model as a whole to understand the major channels whereby shocks in key exogenous variables percolate through the economy. In this chapter we identify what we consider to be the key mechanisms and channels in the model. This exposition is not intended to be a comprehensive guide to the model's characteristics but is designed to set the background for Chapter 10 which examines the empirical results of perturbing the model in a variety of ways.

The key aspects of the model discussed here are: the industrial sector; the operation of the standard multiplier in the model and the determination of services sector output; the determination of prices; the operation of the labour market; the government sector; and the financial sector.

[9.1] : The Industrial Sector

A very important link between the Irish economy and the outside world is through the determination of industrial output. As explained in Chapter 3, in the long run the output of this sector is a function of the level of world output and of the competitiveness of the Irish economy. This mechanism contrasts with that in many other models where the volume of output is driven by demand which is, in turn, driven by the volume of exports. In HERMES-IRELAND the level of capacity (supply) is a function of world output and the chain of causation in the long term is seen as running from world output to domestic supply to exports[1]. In the short-term exports are influenced directly by variations in world output. When linking HERMES-IRELAND into the full HERMES for Europe this mechanism will require some modification given the vital role of bilateral trade flows in linking together the different economy sub-models within the European model.

Any shock to the rate of growth in the rest of the world is transmitted to the Irish economy through its effects on industrial output. In the short run a rise in world output results in a temporary rise in exports and a rise in capacity utilisation in the industrial sector above its long run norm. If the rise in world growth is sustained, the capacity of the Irish industrial sector rises over a period of years to increase the long run output potential of the economy. This rise in capacity restores the level of capacity utilisation to its normal level while permitting a sustained increase in domestic output.

While a temporary increase in domestic demand, for whatever reason, does lead to a short-term increase in capacity utilisation and industrial output, this effect is not sustained as there is no effect on the level of industrial capacity. This is clearly unrealistic in the case of certain shocks. However, we feel that it is reasonably realistic at an aggregate level given that it proved difficult to break the industrial sector into a series of subsectors. The evidence of econometric testing of alternative specifications bears this out. This necessary simplification poses special problems when modelling the effects of shocks which especially affect the building industry. Clearly it is unrealistic to have the long term level of building output determined directly by world output. As a result, in examining the effects of shocks which primarily affect the building industry it is necessary to make *ad hoc* adjustments to coefficients or fixing factors to take account of their long term impact on capacity output.

The measure of competitiveness used to determine Ireland's share of world output is the profitability of the industrial sector, defined as the operating surplus relative to total added-value. As the operating surplus is the residual left over after deducting the cost of labour and energy inputs into the industrial sector it takes account of the effects of any changes in these costs on the long run level of output. It does not directly allow for the effects of certain other costs, such as the cost of borrowed capital or the cost of transport to foreign markets. However, it is possible to take the effects of these factors on competitiveness into account by means of adjustments to coefficients or fixing factors[2].

A very important additional channel which is modelled in HERMES-IRELAND is the repatriation of profits earned by foreign multinationals operating in the Irish industrial sector. As foreign firms accounted for more than 50% of gross output in all manufacturing industries in 1985, this is a very important factor in the Irish economy (Census of Industrial Production,1985). It means that a substantial part of the benefits to the Irish economy of an increase in the long run productive capacity of the industrial sector leaks abroad directly as profit repatriations. This leakage must be viewed alongside the very high import content of the gross output of the manufacturing sector and means that, while

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1 In the MODEL-80 model of the Irish economy exports were also seen as being supply determined, being a function of the installed capital stock.

2 For example, the treatment of the effects of changes in interest rates on industrial output in Bradley, Fitz Gerald and Storey, 1987.

the growth of industrial output is the vital factor in driving the long term growth of the Irish economy, the effects of the growth are much less significant than in other more closed economies (Fitz Gerald,1987).

[9.2] : Keynesian Multiplier and the Services Sector

In the early economic models of the Irish economy a key economic relationship was the Keynesian income multiplier (Bradley and Fanning,1982). In HERMES-IRELAND, as in all macro-economic models, it remains an important conduit for the transmission of shocks from exogenous variables to the domestic economy. While the precise behaviour of personal consumption and savings in the short run remains uncertain, a major part of any increase in domestic income is spent on consumer goods and services. In so far as this expenditure generates additional domestic output and, therefore, increased domestic income, it continues to circulate in the economy. However, as discussed above, changes in domestic demand do not have any direct effect on the long run output capacity of the industrial sector.

In HERMES-IRELAND changes in domestic demand have their major direct impact on the level of output through their effects on the marketed services sector. Even when consumers buy food, cars, or other goods, a substantial part of that expenditure goes to the marketed services sector due to the existence of a substantial distribution margin on all such products. In addition, purchases of services account for a substantial part of consumers' expenditure.

Because the output of the services sector is demand determined, it changes to meet any alteration in domestic consumption. To the extent that increased consumers' expenditure goes on services, the output of the economy increases. To the extent that it goes on goods it only serves largely to increase imports or reduce exports.

While this is an unduly simplistic approach, exaggerating the scope for increased domestic demand to raise services output and underestimating its scope for raising industrial output, these two factors tend to cancel out. However, because HERMES-IRELAND gives considerably more weight to the importance of the domestic supply constraint than did any previous Irish models, it shows smaller multipliers than did MODEL-80. This is in line with the econometric evidence documented earlier.

[9.3] : Price Determination

In HERMES-IRELAND the determination of prices is broadly in line with that of previous models of the Irish economy, such as MODEL-80 (Bradley, *et al*,1981). The price of tradable goods is determined externally in line with the standard SOE model. Long-run purchasing power parity is imposed in the model. Because consumption has a large services sector content it is not a uniformly tradable good and prices are affected by domestic wage cost developments. Changes in the level of capacity utilisation in the economy only affect the price level indirectly through their effects on the labour market, i.e., on wages.

In addition to the effects of foreign prices, the domestic price level is affected by the level of taxes domestically. As discussed in Chapter 3, part of the incidence of indirect taxation falls on the productive sector of the economy and partly on the consumer so that the effects on consumer prices are not clear-cut.

[9.4] : The Labour Market

The labour market plays a crucial role in HERMES-IRELAND. The demand for labour is determined in the supply block and is a function of the level of output, the price of labour and other factor prices, and technical change. The supply of labour is determined by a migration decision and a series of participation rate decisions. As discussed in Chapter 4, the level of migration and, therefore, the supply of labour is affected by domestic and foreign economic factors.

Wage rates are determined primarily in the industrial sector with wage rates in other sectors following those in industry. The wage bargaining model makes wage rates a function of prices, a tax wedge, the change in the level of unemployment and the trend growth in productivity. The effect of changes in unemployment on wage rates (i.e., the Phillips curve) plays an important equilibrating role in the model's behaviour. For example, when the economy is deflated by cuts in public sector employment, the demand for labour falls and the level of unemployment tends to rise. This in turn has the effect of reducing wage rates in the economy which leads to some offsetting increase in employment in the private sector. On the other hand, the rise in unemployment tends to reduce the labour force by encouraging emigration which, in turn, attenuates the increase in unemployment. This mechanism plays a very important role in determining the final equilibrium point reached by the economy after a period of adjustment to any external shock.

The tax wedge effect in the wage bargaining equation means that any attempt to increase taxation implies some knock-on increase in wage rates, which in turn leads to some loss of employment in the private sector[3]. One implication of this specification is that the effects of changes in government expenditure (not related to public employment) have little or no direct effect on wage bargaining in contrast to the effects of tax changes. This contrast may be artificial: clearly, if cuts in expenditure affect the level or quality of public services then this too may have a knock-on effect on wage rates.[4]

3 Obviously if there was an overall ceiling on public expenditure it would also affect the level of employment in the public sector.

4 For example, if privatisation of certain aspects of the health services requires consumers to increase their personal expenditure to maintain the same (desired) level of services, employees will be worse off to the extent of that necessary increase in expenditure and could, on past evidence, be expected to look for some compensatory increase in wage rates.

[9.5] : The Government Sector

The model incorporates a fairly detailed specification for both the revenue and the expenditure sides of the Government sector's accounts. The specification chosen is quite standard and differs little from the approach adopted in MODEL-80.

In the present version of HERMES-IRELAND the effects of direct government investment in changing the productive potential of the economy is not directly modelled. For example, increased infrastructural investment which reduces transport costs for the private sector is not treated any differently from increased investment on recreational projects. As a result, when examining the effects of government capital expenditure care must be taken to incorporate such cost effects through altering other variables or parameters in the model.

An innovation in HERMES-IRELAND is the detailed treatment of the financing of the governments sector's borrowing and its interaction with the level of debt interest payments. The domestic absorption of government securities is determined by the flow of domestic savings while foreign borrowing or debt repayments are residually determined. The effects of increased foreign debt interest payments on the level of GNP is endogenous and this considerably alters the long run multipliers of the model. In earlier models, such as MODEL-80, this channel of economic causation was not explicitly included and, thus, the effects of increased government expenditure on the real economy were exaggerated as no account was taken of the offsetting rise in foreign debt interest payments.

[9.6] : Financial Sector

Interest rates are still exogenously determined in HERMES-IRELAND. Prior to Ireland's entry into the EMS, during the era of monetary union with the UK up to 1979, it was possible to relate Irish interest rates directly to UK rates. However, the relationship to rates of interest in the outside world has been much more complex over the last 10 years. While it is still true that interest rates in the Irish economy, as in any other SOE, are determined in the long run by international trends, the precise relationship which now exists remains unclear. Much more research will be required before a suitable complete model of the financial sector can be developed which will endogenise the level of Irish interest rates.

In HERMES-IRELAND interest rates can be set in either nominal or real terms. While the difference may not be that important in using the model for forecasting purposes, it is very important in looking at the effects of shocks which affect the level of prices in the economy. Because interest rates have a big impact on the government sector's financial position, failure to allow for the effects of price changes on nominal interest rates can distort the model's estimate of the effects of such shocks.

The flow of funds within the economy is specified at a fairly general level in the model. The uptake of government securities is then a function of the funds available to the private sector. In the current version of the model the proportion of private sector funds being invested in a range of financial instruments is treated as exogenous. However, as more research findings become available it is hoped to endogenise this portfolio behaviour within the model. The effect of this new channel in the model is that any factor which changes the amount of funds available in the private sector for investment in financial assets affects the funding of the government sector's borrowing requirement. However, as the residual element in both the private and government sectors' portfolios is foreign assets/liabilities, a shift of private sector funds from investment abroad to lending to the government sector will result in a matching repayment of foreign debt by the government with no direct effect on Ireland's net foreign indebtedness.

A corollary of the specification of the flow of funds is the symmetrical treatment of interest flows from foreign investment (or borrowing) by the private sector and foreign borrowing of the government sector. In HERMES-IRELAND changes in foreign investment by the private sector change the level of net factor income and, therefore, the level of GNP. This has important implications for the treatment of shocks which change the level of the current balance of payments. For example, any shock which increases the current balance of payments surplus must generate an offseting capital outflow. This outflow will have beneficial effects on GNP in later years as the returns from this outflow accrue to either the public or private sector. This channel of economic causation enhances the effects of measures which change the indebtedness of the government sector.

CHAPTER 10 : DYNAMIC MECHANISMS - THE MODEL'S MULTIPLIERS

In Chapter 8 we tested how well the model performed over the historical period used for estimating the equations (1964 to 1984). The next stage in examining the model, described in this Chapter, is to carry out a series of tests on the behaviour of the model as a complete system. This is normally implemented by applying a series of shocks to key variables or parameters and measuring the effects which these shocks have over time on all aspects of the economy. The results of this exercise are vital in testing that the model, when treated as a system, conforms to economic theory and, where available, to results obtained from other studies of the economy[1].

To the extent that the model is a good representation of the real economy, this process assists our understanding of how the real economy behaves. It prepares the ground for using the model to quantify the effects of many possible policy changes on the Irish economy, a major purpose in developing HERMES-IRELAND.

Section 10.1 of this chapter describes the methodology used to carry out the perturbations. Section 10.2 sets out the results of carrying out a range of standard perturbations beginning in 1988. The results are generally presented for the period 1988 to 1992 to explore the medium-term properties of the model. Section 10.3 compares the multiplier, or perturbation, results obtained from HERMES-IRELAND with those obtained from the MODEL-80 model.

[10.1] : Methodology

There are two different approaches used in carrying out the multiplier analysis, the difference concerning the benchmark simulation with which the perturbation results are compared. The approach adopted here is similar to that used by Bradley *et al*,1985 and involves using historical data for 1986 and 1987 for the exogenous variables and using the *Medium Term Review*[2] forecast for 1988 - 1992 to derive a benchmark. In this benchmark the domestic policy stance was one of indexation while the projections (as of October 1987) for the (exogenous) world economy were derived from OECD, EC and IMF sources. The projected exogenous variables are then perturbed and the model resimulated over the period 1988-92. These new results are compared with the original benchmark. The advantage of this approach, adopted in this Chapter, is that the results obtained are more applicable to real world circumstances.

In an alternative approach, used by Fitz Gerald and Keegan,1982, all the exogenous variables, including time, are held fixed at their base year values. The advantage of using this approach is, firstly, that the multiplier calculations can be carried out with a long time horizon without having to prepare a benchmark simulation for the full period. Secondly, it eliminates the effects which changing levels of variables in the benchmark simulation may have on the behaviour of the model. This latter consideration was especially important in the 1970s and early 1980s when inflation rates were high. However, for the period of the simulations discussed here, this is a much less important consideration.

In carrying out these multiplier simulations all exogenous variables and parameters, other than those being perturbed, are held constant. However, in the real world many exogenous variables are changed simultaneously. For example, when examining the effects of a particular government budget many different exogenous variables may change and some crucial parameters may also be affected, for example, through the effect of perceived fiscal policy on consumer confidence. As a result, when using the model to examine real life policy changes or exogenous shocks to the Irish economy, it is necessary to carry out a full simulation, considering the effects of the policy change (or shock) on all the exogenous variables and parameters in the model.

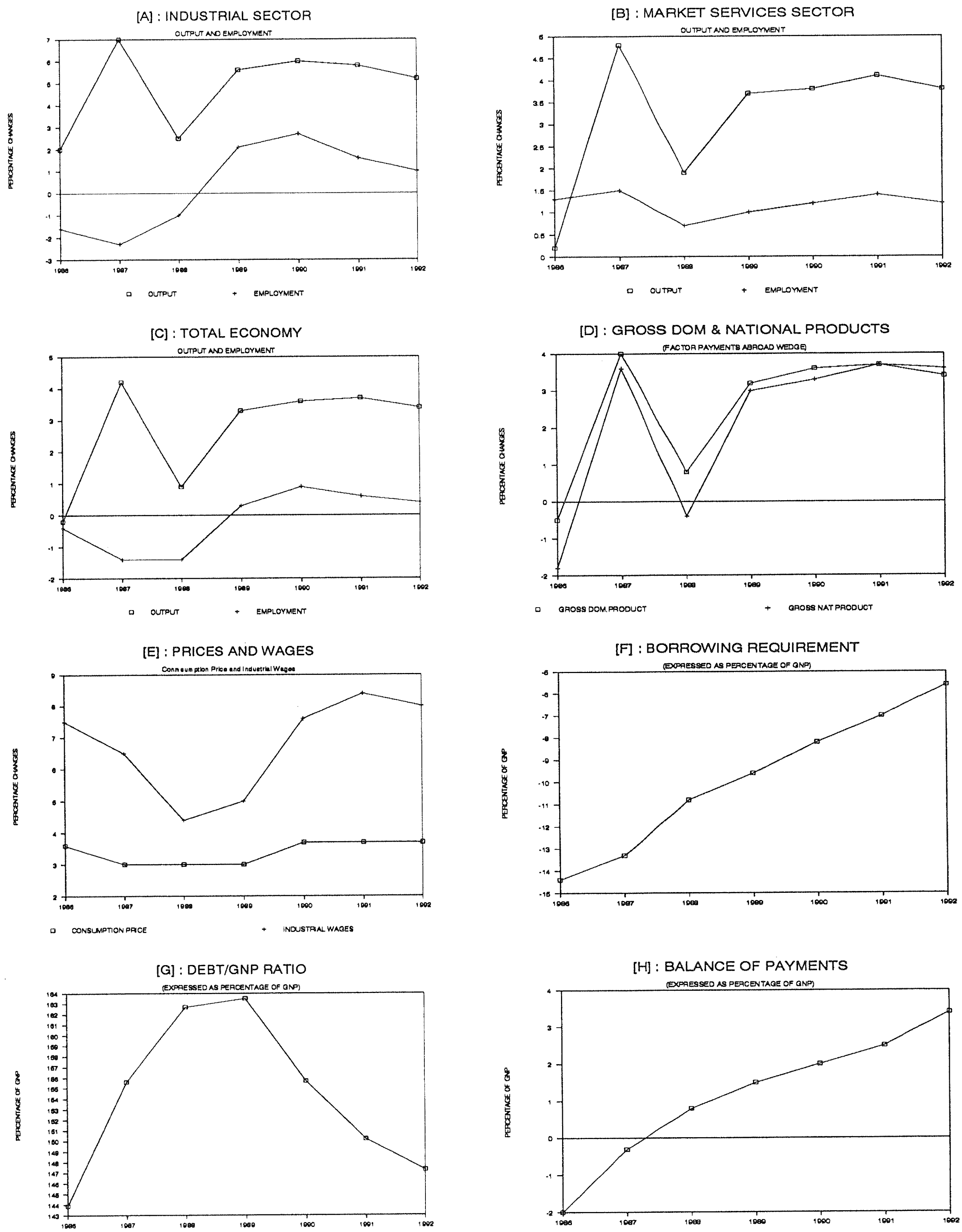
The complexity of real world simulations means that it is not possible to sum the results obtained from a number of individual multiplier runs, each of which holds all but one of the exogenous variables constant, to arrive at the cumulative effects of the changes taken together. When many variables or parameters are changed simultaneously the results of the interaction of the different changes can be quite nonlinear. As a result, multipliers are no substitute for a proper model based simulation of the effects of changes in exogenous variables.

In using HERMES-IRELAND there are a wide range of different options available, discussed fully in Appendix 2. Examples of such options include the type of policy indexation chosen, selections among alternative versions of behavioural equations, etc. The effects of any particular perturbation will depend on the set of options actually chosen. In each case where the range of options actually used in carrying out the perturbations of the model differs from the standard set, the differences will be made clear.

1 In Fitz Gerald and Keegan,1982 the use of such shocks in testing the MODEL-80 model was discussed in detail.

2 Bradley, Fitz Gerald, and Storey,1987.

FIGURE 10.1 : BENCHMARK PROJECTION FOR 1987 - 1992



An important decision or option is whether or not the fiscal instruments are indexed. Generally the policy stance assumed is one of indexation to price changes. Hence, any price effects caused by the shock are not allowed to have any *real* impact on the public sector, many of whose instruments are denominated in nominal terms. Where indexation is used the fiscal instruments have been indexed to their benchmark values for the current year. This means that a perturbation which changes the relevant price variable by x% from its benchmark value in the current year will also change the fiscal instrument by x%. In the case of the multiplier analysis of changes in the fiscal instruments themselves, indexation is generally not assumed for the relevant instrument.

Another issue is the rate of interest used in the benchmark projection or scenario. The results, especially for GNP, are very sensitive to this assumption. For example, the higher the rate of interest the more important the negative offset to GNP from the debt interest arising from an increase in government expenditure. With negative real interest rates, as in the 1970s, the stimulatory effects in the short to medium-term of an increase in government expenditure are much greater than is the case with the current real rates of interest (see Section 10.2.5). In the longer-term the level of interest rates may even determine whether a particular shock raises or reduces the level of GNP.

One of the failings of the current version of HERMES-IRELAND is the labour supply section of the model. The estimated equations in this section proved to be quite unstable and, in preparing the *Medium Term Review*, it was necessary to make *ad hoc* adjustments to the results generated by the model. As a result, labour supply has been held exogenous for the six shocks discussed below. Hence, for example, any change in total employment is mirrored exactly in changes in unemployment. The closing off of this channel for the transmission of shocks significantly affects the multipliers so this shortcoming must be borne in mind in interpreting the results presented in this Chapter. In using the model to examine different economic scenarios or policy changes, this channel could, of course, be taken into consideration and *ad hoc* adjustments incorporated, as in the *Medium Term Review*.

[10.2] : Multipliers for 1988-1992.

The multipliers were calculated using as a basis the becnhmark projection in the *Medium Term Review*. The results for each of the different multipliers are presented in a standard set of 8 graphs. Figure 10.1 shows the becnhmark levels for each of the endogenous variables considered below. The effects of each perturbation on a wide range of economic variables are shown[3]. In each case the multiplier results are presented as changes compared to the benchmark, e.g. the change in GNP resulting from the shock. Unless otherwise specified, each perturbation is initiated in 1988 and the results are then examined for the 5 year period 1988 to 1992, holding the perturbation unchanged over that period. In interpreting the graphs it should be noted that a positive sign denotes a reduction in the balance of payments deficit (or, equivalently, an increase in the surplus) and a reduction in the government borrowing requirement (or, equivalently, an increase in the financial surplus).

Set out below are the results of applying 6 different types of shock to HERMES-IRELAND using as a benchmark the *Medium Term Review* projection for the 1987-1992 period. The 6 shocks are:

1) An increase in the rate of world industrial growth of 1%.
2) A fall in the personal savings ratio of 1 percentage point.
3) A reduction in energy prices of 10%.
4) A cut in wage rates of 1%.
5) A reduction in Public Administration employment of 5,000.
6) A cut in the average rate of direct taxation of 1 percentage point.

[10.2.1] : Increase in World Output.

For the purpose of this perturbation it was assumed that any increase in domestic wage rates and costs, due to the foreign stimulus, would be counterbalanced by similar movements abroad, preserving Irish competitiveness *vis à vis* the outside world.

The results of this exercise are presented in Figure 10.2 which shows the deviations of variables from their benchmark values. (The 8 graphs in this Figure will be referred to by letter in the discussion below.) As can be seen from Graph a, the effect of this perturbation in world output is to raise the volume of net output (GDP arising) of the industrial sector by approximately 0.7% in the first year with the effect after 5 years (1992) being somewhat lower at around 0.5%.[4]

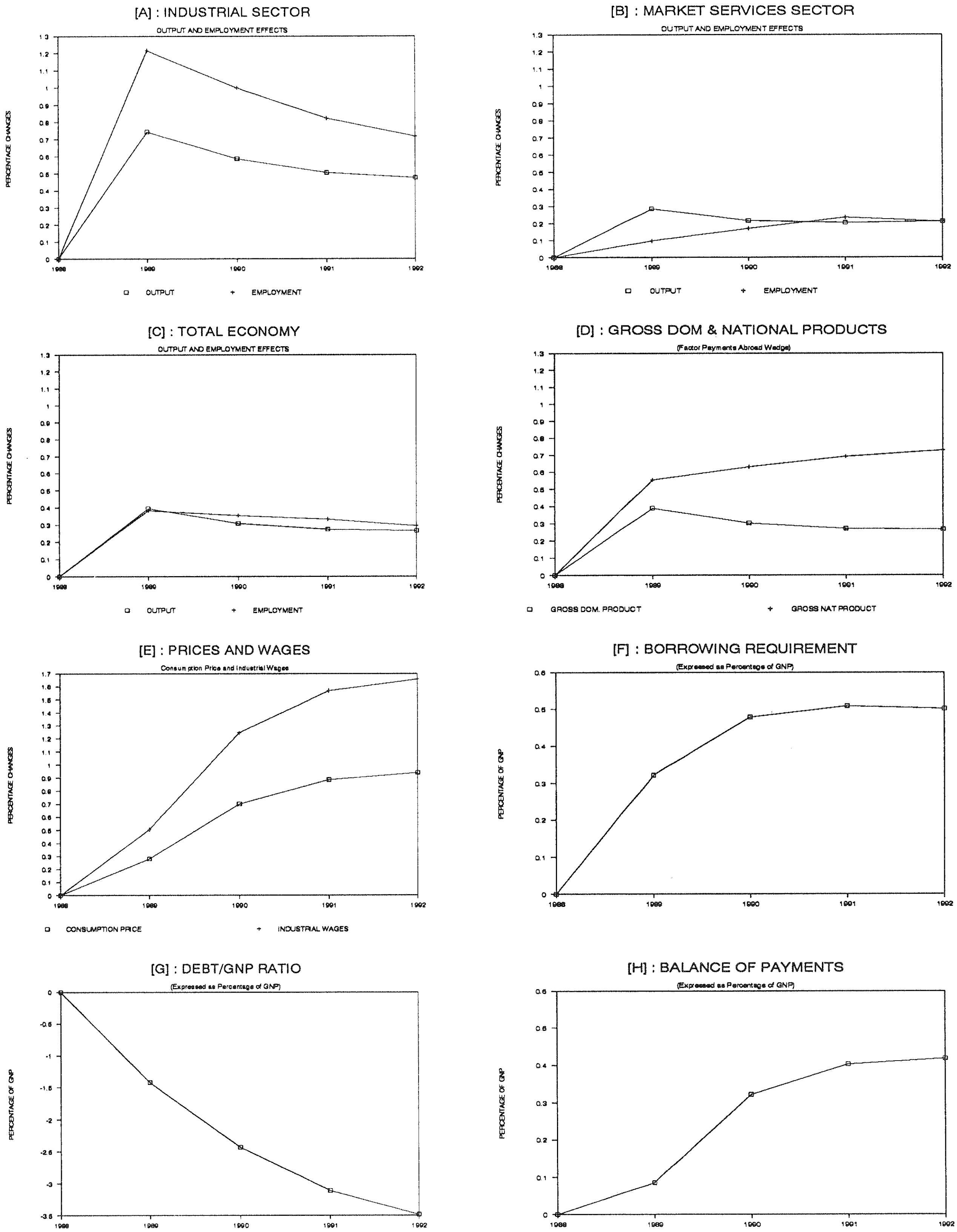
It is through the output of the industrial sector that world output initially affects the Irish economy. In the first year of the shock (1988) employment in industry rises by 1.2%, Graph a, a much bigger increase than that in output. In the medium term the effect on employment is somewhat lower at +0.7%. This pattern of adjustment arises from the fact that the capital stock in industry is slow to adjust. To achieve the desired level of output in the short term, before new capacity can be installed, the utilisation of existing capacity has to rise above the long term trend through the employment of additional labour. However, as the new plant is installed this additional labour is replaced.

The impact of the rise in world activity on output in the market services sector is around 0.2% throughout the 5 years (Graph b). This occurs as the increased employment and wages in the industrial sector feeds into consumption raising demand for the output of market services. Employment rises in market services but by slightly less than the rise in output due to the substitution of capital for labour. As in the industrial sector, this

3 The effects on all the other variables in the model are available, on request, from the authors.

4 While it is not shown here, the long run equilibrium effect on the volume of net output is somewhat higher than the outturn for 1992, being closer to the initial impact. A reason for the long run effect on net output being significantly less than 1% is that the growth in energy inputs in the long term is more rapid than that in labour inputs. This arises from the adverse trend in domestic costs.

FIGURE 10.2 : INCREASE IN WORLD OUTPUT



substitution takes place because wage rates rise as a result of the reduction in unemployment (Graph e)[5]. By 1992 total employment in the economy is 0.27% higher than in the benchmark scenario while the volume of GDP at factor cost rises by 0.26% (Graph c).

It is assumed that there is no change in fiscal policy other than through indexation. As a result, with the increase in revenue buoyancy, the borrowing requirement as a percentage of GNP falls by 0.55 percentage points (Graph f). This reduction in the borrowing requirement feeds on itself, as the lower borrowing results in lower interest payments which in turn leads to lower borrowing. By 1992 the debt/GNP ratio has fallen by 3.5 points (Graph g) which results in a substantial fall in foreign debt interest payments as the debt is reduced. Given the continuing high real rate of interest, the long term impact on GNP is very substantial. As can be seen from Graph d, by 1992 GNP is up by 0.7 per cent in volume as a result of the 1 per cent increase in world output, whereas the volume of GDP is only up by 0.25 per cent. This indicates the importance in the medium-term of the reduction in foreign indebtedness arising from higher world growth.

As can be seen from Graph h, the improvement in the balance of trade is much smaller than that in the balance of payments. This is due to the big reduction in Government foreign interest payments which more than compensates for the rise in industrial profit repatriations.

The level of consumer prices is raised by approximately 0.84% by the end of the period (Graph e). This is chiefly due to the rise in wage rates which is, in turn, caused by the fall in unemployment. If the sector of the model which determines the supply of labour were brought into play, the result could be rather different. The increased wage rates and the reduction in unemployment might attract more workers into the labour force, resulting in a somewhat lower increase in wage rates. The net result could be higher employment and output than shown in this simulation.

[10.2.2] : Fall in the Savings Ratio.

The results of this perturbation are presented in Figure 10.3. For technical reasons this perturbation was carried out beginning in 1989 rather than in 1988. It involved a permanent reduction of the personal savings ratio by 1 percentage point in 1989. The savings ratio was maintained 1 percentage point below that in the benchmark scenario for each of the following 3 years to 1992. This simulation is particularly interesting because of the uncertainty surrounding the behaviour of the consumption function in Ireland.

In this simulation the channel whereby changes in private sector foreign wealth affect factor payments from abroad was not taken into account. As a result, the effects of the reduced balance of payments surplus, consequent on the perturbation, are not fully taken into account and the stimulus to the economy may be substantially exaggerated.

As can be seen from Graph a, the fall in the savings ratio results in a temporary rise in industrial output of 0.35% in 1989. However, because changes in domestic demand have no direct effect on the optimal long-run industrial capacity this effect disappears over time. In addition, because of the effect of the increased level of activity in the economy in reducing unemployment and raising wage rates (Graph e), the optimal level of industrial capacity in fact falls below that in the benchmark scenario by the end of the period. Thus there is some "crowding out" of the domestic tradable sector. This crowding out effect is exagerated due to the fact that long-run capacity is not affected by domestic demand.

The increase in personal consumption affects the economy through the traditional multiplier effect. There is a sustained increase in the output of the market services sector of between 0.4% and 0.5% (Graph b). There is a related rise in employment in the market services sector of nearly 0.5% by 1992. The impact effect on real GDP at factor cost is 0.33% but, as the temporary increase in industrial output disappears, this falls to 0.18% in 1992 (Graph c). Total employment is 0.17% above the benchmark in 1992.

The impact on real GNP is much greater than on real GDP (Graph d) because the rise in consumption and the general level of activity in the economy greatly improves the government sector's budgetary position (Graph f). The improved budgetary position reduces the debt/GNP ratio (Graph g) producing a cumulative saving on foreign debt interest payments. It is interesting to compare the effects on the balance of payments surplus in 1992, -0.17 percentage points (Graph h), with the effect on the government borrowing requirement, -0.62 percentage points. The bulk of the benefits in the medium term from a rise in consumption flow to the government sector rather than to the foreign sector. However, as noted above, this benefit is exaggerated because it does not take into account the longer term effects of the reduction in private foreign investment on the flow of profits and interest income from abroad.

[10.2.3] : Fall in Energy Prices.

The results of this perturbation are presented in Figure 10.4. In simulating the effects of a fall in world energy prices it is necessary that the indirect effects arising from an increase in world industrial activity are also taken into account. As a result, we simulate the effects of a combined 10% fall in world energy prices together with a 2% rise in world industrial output. If the fall in energy prices is treated on its own it has a somewhat counter-intuitive effect on the Irish economy. Because it represents a fall in the price of a foreign input it results in a substantial substitution of this foreign factor of production for the domestic factors, capital and labour. This tends to offset the benefits which accrue from the improvement in the terms of trade. It is the general increase in world industrial output as a result of the fall in energy prices which provides the major stimulus to the domestic economy.

5 It is assumed that this rise in domestic wage rates is similar to that in the rest of the world so that there is no impact on the volume of industrial output.

FIGURE 10.3 : FALL IN THE SAVINGS RATIO

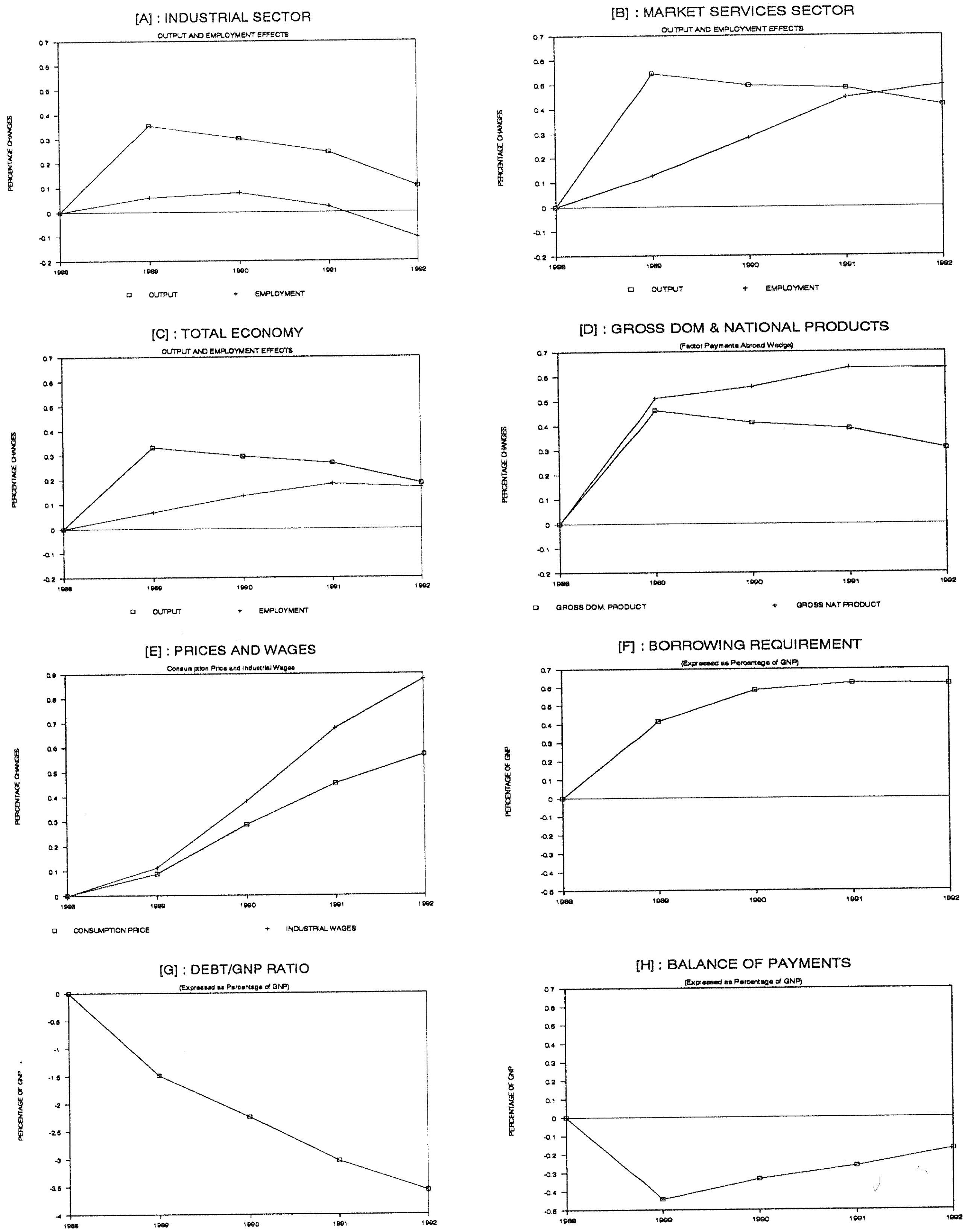
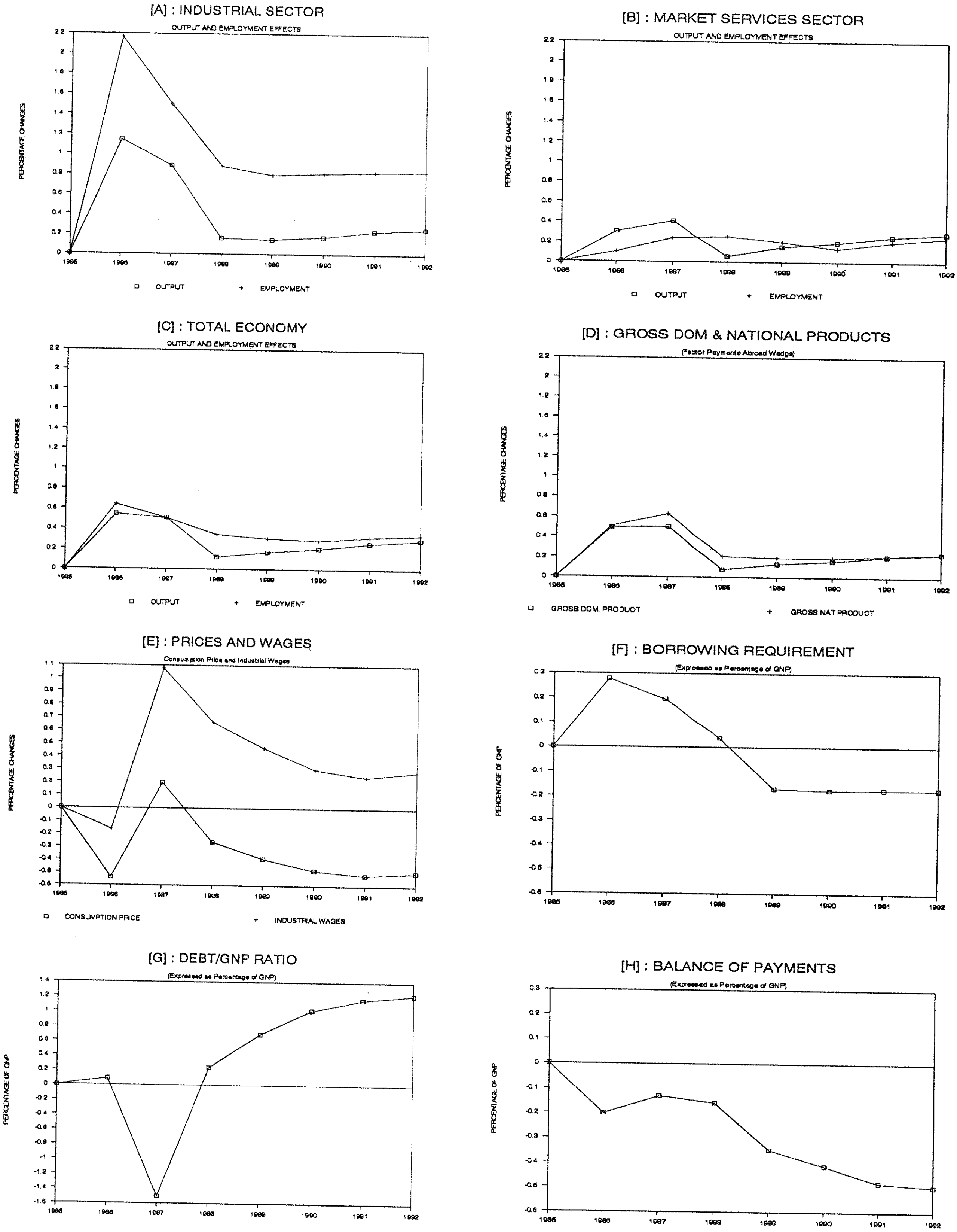


FIGURE 10.4 : FALL IN ENERGY PRICES



For technical reasons this simulation was commenced in 1986, a year in which there was a big fall in oil prices. In carrying out this joint simulation two additional assumptions have been made:

1) It was assumed that any change in domestic profitability due to the fall in energy prices, would be counterbalanced by similar movements abroad, preserving Irish competitiveness *vis à vis* the outside world.

2) Profit repatriation from industrial profits continues at its average rate.

As can be seen from Graph a, the combined effect of the fall in energy prices and the rise in world economic activity is to give a substantial initial boost to domestic industrial output of 1.15%. However, it might be argued that the change in world output would take place over a number of years suggesting a lagged impact on domestic industrial output. This appears to have been the experience following the fall in oil prices in 1986. The fall off in domestic industrial output (added value rather than gross output) from its initial peak shown for the 1986-88 period is due to the substitution of energy for other domestic factors of production. These results suggest that the model's elasticity of substitution between energy and the other factors of production is probably unrealistically high.

The initial effect of the growth in world output is first felt by labour. In 1986 industrial employment is boosted by 2.2%. However, as the capital stock adjusts to the new desired level and as energy is substituted for the domestic factors of production, there is a tendency for industrial employment to fall back to around 0.8% above the benchmark level in 1992.

Taken together, the changed external growth and energy price environment leads to around a 0.5 per cent initial growth in real GDP at market prices (Graph d). As a result of the adjustment in industrial output over time, the long-term impact on GDP is around 0.24%. The effects on GNP are almost identical.

While the impact effect of the fall in energy prices is to reduce the borrowing requirement by a small amount (Graph f), the fall in prices results in a fall in GNP at current market prices. However, these unfavourable medium-term effects on the public finances seem unrealistic and are probably due to the exaggeration of the substitution effect of the fall in energy prices which dominates the income effect from the improved terms of trade.

Despite the *caveats*, these results help explain the impact of the actual 1986 fall in oil prices on the Irish economy. The reduction in the rate of inflation, even with fiscal indexation, has a deleterious effect on the government borrowing requirement. If the induced effect on world output is slow to materialise this can result in a deterioration in the public finances of longer duration than shown here. This was one important factor in the overshoot in the government borrowing requirement in 1986. Clearly the impact of changes in energy prices on the Irish economy is more complex than had been thought and the benefits may be longer accruing than had heretofore been thought likely (see Bacon, 1986, pp. 33-4).

[10.2.4] : Increase in Industrial Wage Rates.

In this exercise industrial wage rates were exogenised and the baseline value was then increased by 1 percentage point compared to the benchmark projection for the period 1988-92. By taking this approach the possible feedback effect of the perturbation through wage rates is prevented. The results are presented in Figure 10.5.

This change affects the economy through its effects on competitiveness as reflected in the rate of profit in the industrial sector. It is this variable which plays a crucial role in determining Ireland's share of world output.

The rise in wage rates above the benchmark affects the industrial sector initially in two ways: it reduces the volume of output due to its adverse effects on competitiveness, and it leads to substitution of capital (and energy) for labour. Of these two effects, the output effect is much the most important. As can be seen from Graph a, the initial effect of the rise in wage rates on industrial output is small, -0.07%. However, it rises to -0.43% by 1992 and the long term effect is even greater. The effect on employment in the industrial sector shows a similar time profile to that of output with, however, the effect being somewhat greater in percentage terms due to the substitution of other factors of production for labour.

While the volume of GDP shows only a small initial fall, the situation deteriorates continuously over the period, as can be seen in Graph d. By 1992 real GDP is reduced by 0.25% and real GNP by 0.14%. The negative impact on the borrowing requirement is slow to materialise as revenue is increased by the higher wage rates and increased rate of inflation of 0.5% (Graphs e and f). However, it is clear that in the longer term the effects on the public finances will be unfavourable.

[10.2.5] : Reduction in Public Administration Employment.

In this perturbation the numbers employed in Public Administration were reduced by 5,000 from the beginning of 1988 and were maintained 5,000 below the benchmark level to the end of 1992. The results are shown in Figure 10.6. This perturbation directly affects the volume of GNP and GDP by reducing the volume of public consumption by the full amount of the cut in public administration wages. This reflects the assumed loss in services consequent on any such cutback. As a result there is a very substantial cut in the volume of GDP and GNP in the first year of 0.48% and 0.63% respectively (Graph d). The second round effects of this measure arise from the reduction in purchasing power due to the reduction in the public administration wage bill. The volume of consumption in the first year is, as a result, down by 0.34%.

FIGURE 10.5 : INCREASE IN INDUSTRIAL WAGE RATES

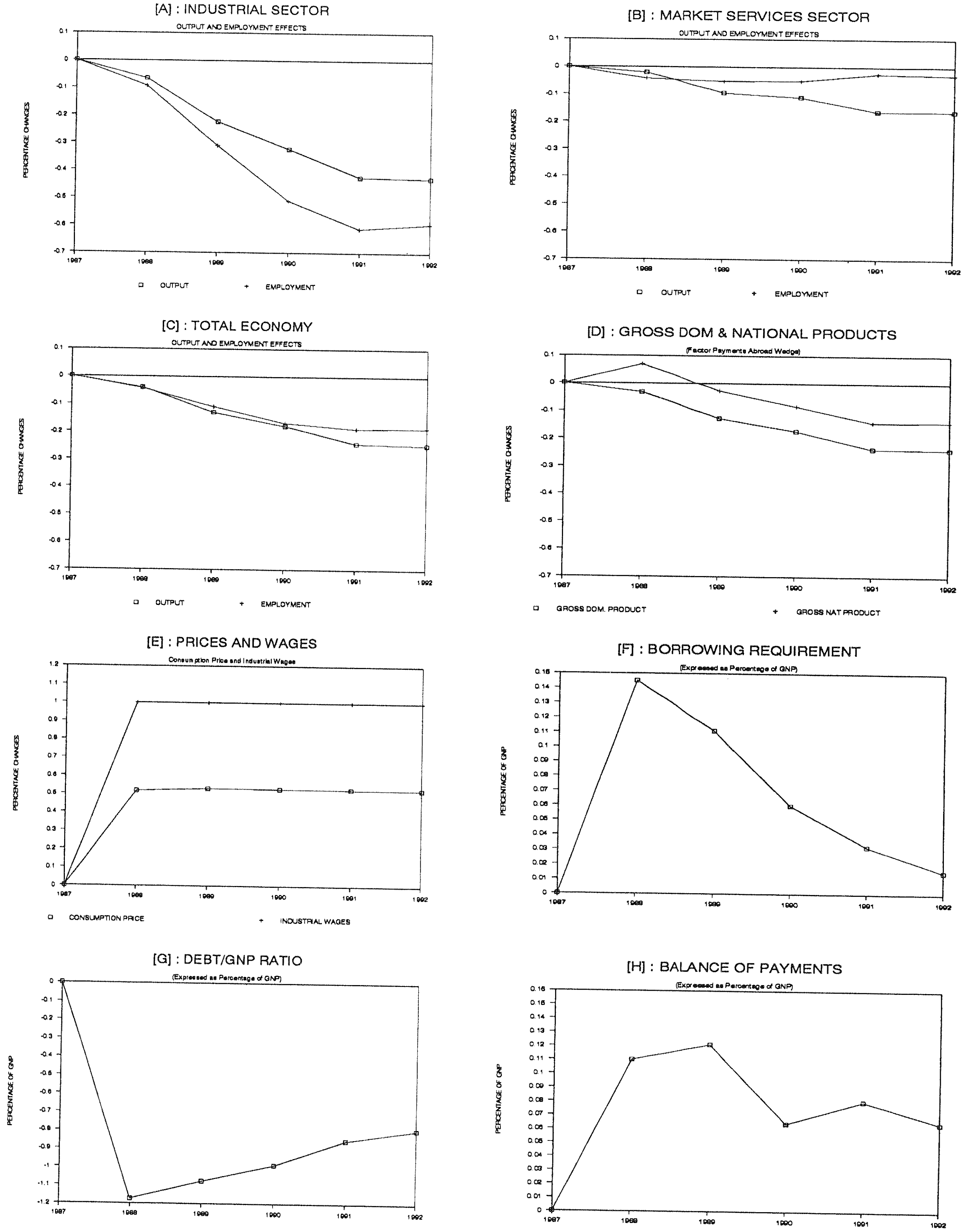
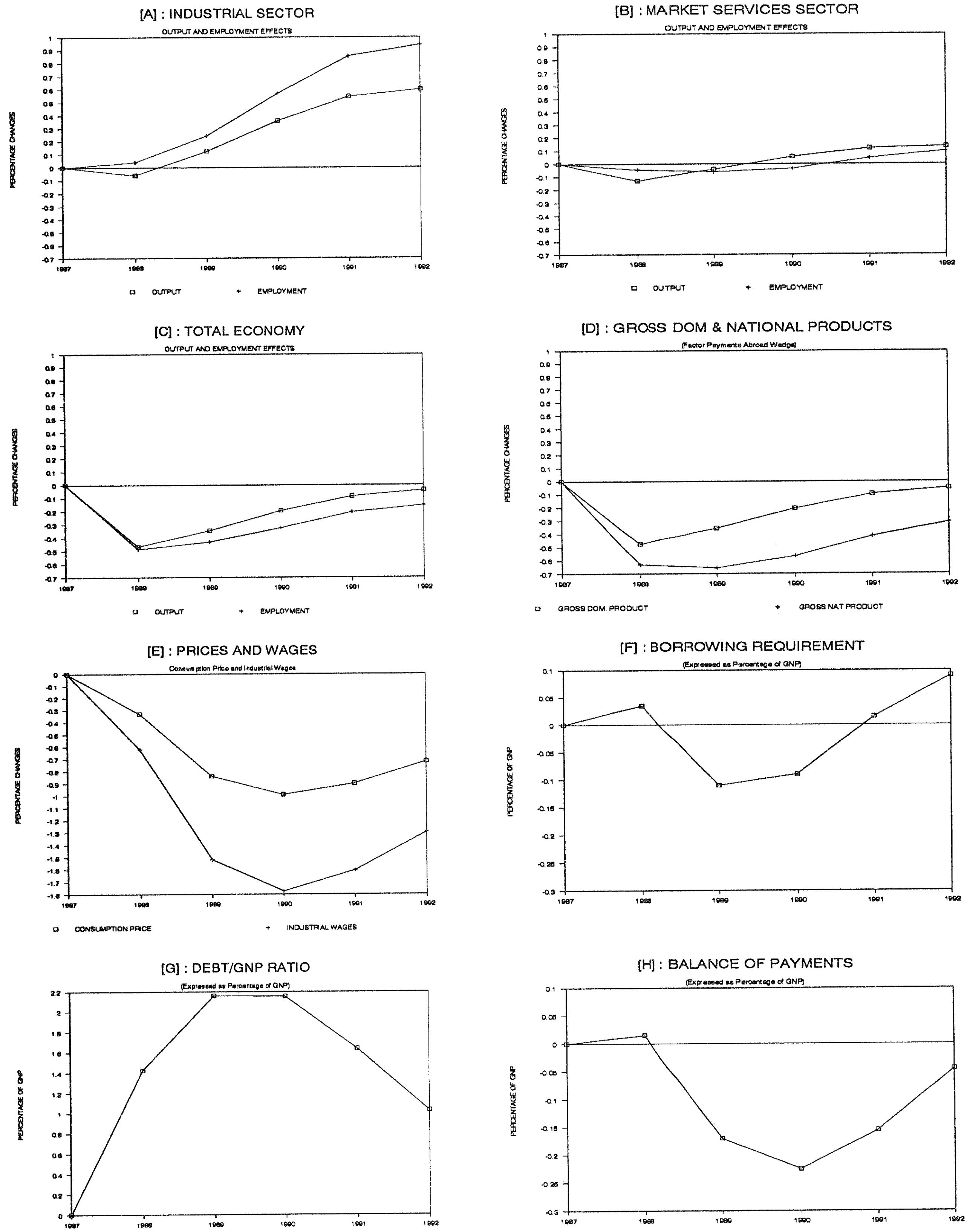


FIGURE 10.6 : REDUCTION IN PUBLIC ADMINISTRATION EMPLOYMENT



However, the cut in employment affects the economy in a range of other ways. The cut obviously increases the level of unemployment generally in the economy in the short term. The initial rise in unemployment is slightly greater than the 5000 cut in numbers in public administration. This rise in unemployment, in turn, affects industrial wage rates through the Phillips curve effect leading to a cut in wage rates in the first year of 0.62% (Graph e). The cut in wage rates serves to reduce prices by 0.33% in the first year. This cut in the inflation rate rises in the second year to 0.84% as the Phillips curve effect continues to reduce wage rates. The strength of this Phillips curve effect would obviously be reduced if account were taken of the effects of the changed labour market conditions on migration. The higher unemployment would lead to higher emigration which would, in turn, result in lower unemployment and a smaller reduction in wage rates than shown here.

The cut in wage rates improves industrial competitiveness resulting in a gradual increase in the volume of industrial output and employment (Graph a). By 1992 industrial employment is nearly 1% above the benchmark level. This rise in industrial employment goes a long way to offsetting the cut in employment elsewhere and sets in train a slight reversal of the induced improvement in competitiveness. While the level of GDP and GNP is still below that in the benchmark in 1992, the gap is closing (Graph d). In the long-term GNP is actually higher than in the benchmark reflecting the "crowding in" of the private sector.

The gap between the effects on GDP and the effects on GNP is probably exaggerated. The fall in wage rates leads to a rise in private sector profitability. The model assumes that a constant percentage of the increase in profits in the industrial sector is repatriated by foreign multinationals. However, in the case of this perturbation, the rise in profits would be felt most by the relatively more labour intensive domestic firms than the foreign multinationals, with a resulting lower repatriation of profits abroad. A greater disaggregation of the industrial sector is needed to take account of this problem.

The initial reduction in the borrowing requirement of £25 Million arising from the cut in employment is less than a third of the saving in the public pay bill of £87 Million. Tax revenue falls due to the fall in the inflation rate acting through the indexation assumption. However, as the level of borrowing (and, consequently, of debt interest) is reduced, the reduction in the borrowing requirement continues in the medium to long term. Because of the fall in prices and the value of GNP, the relatively small initial improvement in the borrowing requirement in nominal terms is not enough to prevent it rising as a percentage of GNP as shown in Graph f. However, this is only a temporary phenomenon, and the borrowing requirement begins to fall, even as a percentage of GNP, from 1991 onwards. This highlights the fact that cutting public service employment must be seen in the context of a medium-term approach to the public finances.

The multiplier effects of this cut on real GDP and real GNP at current market prices are shown in Table 10.1. In this table the effects of saving £1 Million in 1988 by cutting public service employment or increasing income taxes are presented[6]. In the first year GDP is cut by £1.1 Million for a £1 Million cut in the pay bill. In the second year, as the economy adjusts, this falls to £0.83 Million. The multiplier effects on GNP are -£1.28 Million and -£1.35 Million in the first and second years respectively. These are much higher multipliers than those observed for the change in direct taxation discussed below. This is in line with the results from all previous models.

Table 10.1: Effects of a Change in Budgetary Instruments, £ Million

The Change in the instruments amounts to £1 Million in 1988

	Real GDP		Real GNP		Borrowing Requirement	
Change in:	1988	1989	1988	1989	1988	1989
Rate of Income Tax	0.62	0.76	0.25	0.27	-0.93	-0.88
Employment in Pub.Ad.	-1.10	-0.83	-1.28	-1.35	+0.28	+0.06

[10.2.6] : Cut in Rate of Direct Taxation.

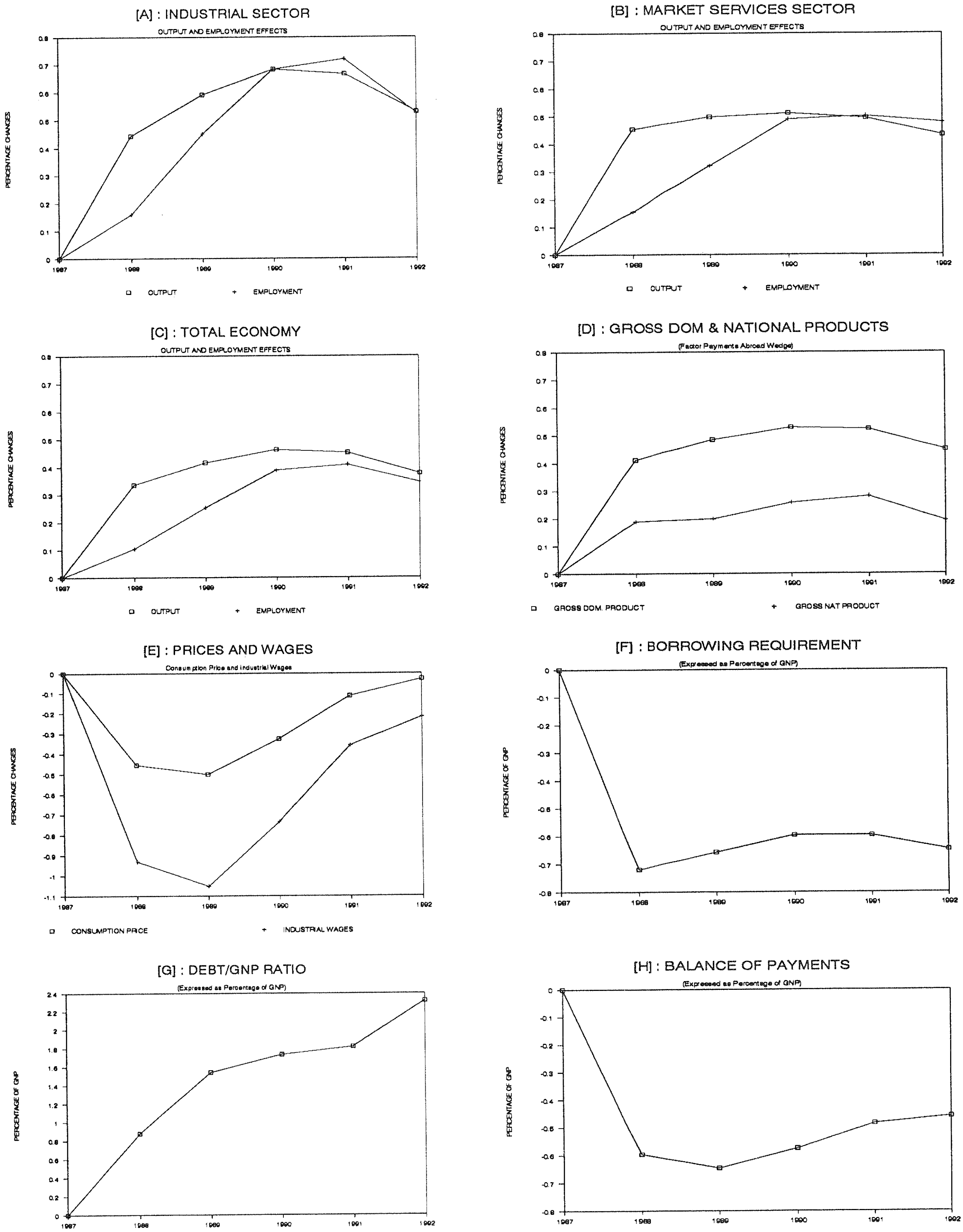
In this perturbation the average rate of income tax was cut by 1 percentage point in 1988[7]. The results are presented in Figure 10.7. The first point of impact of this tax cut is on personal income, since it results directly in an increase in purchasing power and, consequently, a rise in the volume of consumption. This, in turn, boosts the output of the market services sector by 0.45% in 1988 (Graph b). The medium-term impact on the volume of market services output remains substantial.

As discussed in Chapter 9, because of the *tax wedge* effect in the wage rate equations, the wage earners pass on some of the benefits of the tax reduction by reducing the rate of increase in wage demands below the benchmark rate. They maintain their purchasing power relatively unchanged. In the first two years wage rates are lower by a full one per cent (Graph e). This results in a gain in competitiveness and a consequential rise in the volume of industrial output. By 1992 industrial output is up 0.53% (Graph a) and industrial employment is up by the same percentage. The rise in employment reduces unemployment which, in turn, puts upward pressure on wage rates through the Phillips curve effect. This cycle, while dampened, continues in the long-term. Over the period 1988 to 1992 the impact on the volume of GDP is between +0.41% and +0.53% (Graph d).

6 The advantage of this presentation is that it allows multipliers from different models to be readily compared.

7 This cut differs considerably from the effects of a cut in the standard or marginal tax rates. The average tax rate is defined as total tax revenue divided by the tax base. The policy change assumed here involves either an increase in allowances or tax bands, or else a reduction in rates sufficient to reduce income tax revenue by 1% of taxable income.

FIGURE 10.7 : CUT IN AVERAGE RATE OF DIRECT TAXATION



The effect on industrial wage rates in 1992 is only -0.22% indicating that the bulk of the incidence (in this case benefit) of the change in tax is on the income tax payer. By 1992 prices have almost returned to their benchmark level (Graph e) The government borrowing requirement deteriorates by between 0.6 and 0.7 percentage points of GNP (Graph f) and the debt/GNP ratio rises steadily as the interest on the increased borrowing cumulates (Graph g). The inexorable increase in foreign debt interest reduces the stimulatory effects of the tax reduction on GNP. In addition, because of the big rise in industrial profitability, there is a substantial increase in profit repatriations by firms operating in that sector so that GNP is only 0.19% above the benchmark in 1992 (Graph d). In the long-term it will actually fall below the benchmark as debt interest rises. Obviously if the underlying real interest rate were higher this reversal would occur much earlier.

The multiplier effects of this change in tax are shown in Table 10.1. A £1 Million ex post reduction in revenue from income tax would increase the volume of GDP by £0.62 Million in the first year and £0.76 Million in the second. The corresponding effects on GNP are £0.25 Million and £0.27 Million. The net effect on the borrowing requirement of the tax increase is not much less than the loss in income tax revenue arising directly from the change in the rate of tax.

[10.3] : Comparison of HERMES-IRELAND and MODEL-80 Multipliers.

The Irish MODEL-80 model was used extensively in the Department of Finance and the ESRI from 1981 to early 1987. It is interesting to compare the multipliers from that model with those from HERMES-IRELAND since such an exercise gives a useful indication of how our understanding of the working of the Irish economy has changed over the 1980s. However, because of the major differences in the specifications of the two models, quite a number of assumptions must be made to make the results from the two models roughly comparable. These assumptions mean that the multiplier results shown for HERMES-IRELAND are very different from those discussed above. This highlights the sensitivity of the multipliers to changes in the assumptions which underly them.

In the case of MODEL-80 the exports and wage rate equations had proved most unsatisfactory in use and, as a result, these variables were exogenised for simulations in recent years. *Ad hoc* adjustments had to be made to take account of factors affecting these crucial variables. To allow a proper comparison of the two models we have exogenised wage rates in HERMES-IRELAND when generating the multiplier results shown below. In addition, in recent years, in using MODEL-80 the elasticity of imports with respect to final demand was changed. This was required because of the tendency for the model to overpredict consistently the volume of imports. It is this modified version of MODEL-80 which is used here. For technical reasons, the multipliers presented here reflect the impact effects of changes in fiscal instruments in 1987, the last year in which MODEL-80 was extensively used. Finally, fiscal instruments are not indexed in either model as used in this Section.

HERMES-IRELAND generally shows lower multiplier effects for the different fiscal instruments than does MODEL-80. In the case of expenditure on public employment the difference in the effects on GDP in the first year is not very great. The bigger difference in the case of the effects on GNP arises because HERMES-IRELAND takes account of the change in debt interest and profits paid abroad.

While it is not shown above, the evidence from Fitz Gerald and Keegan,1981, indicates that there is a much bigger difference in the multiplier effects in later years. The MODEL-80 results showed relatively little change by the fifth year after the shock whereas, as shown in the previous Section, HERMES-IRELAND shows that the medium-term and long-term multiplier effects of such a cut in expenditure are much lower than the initial effects.

Because the MODEL-80 multipliers are higher than those derived from HERMES-IRELAND, the effects of the cut in public service employment on reducing the borrowing requirement are smaller. With greater deflation, tax revenue falls further in MODEL-80 and unemployment transfers are higher.

The lower multiplier effects of a cut in income tax, derived from HERMES-IRELAND, can be explained by two factors. Firstly, the consumption functions differ. In HERMES-IRELAND the short-term marginal propensity to consume is much lower than in MODEL-80. Secondly, HERMES-IRELAND allows for a substantial leakage in national debt interest paid abroad as a result of the cut in income tax rates. The effects on employment are much lower using HERMES-IRELAND.

It should be remembered that in the results presented in this Section wage rates were exogenised in HERMES-IRELAND to allow a direct comparison between the two models. If wage rates were treated as endogenous, as in the simulations presented in Section 10.2, the employment effects of the cut in taxation would be higher.

Generally, the HERMES-IRELAND multipliers highlight the increased complexity of that model compared to MODEL-80. Many of the channels whereby fiscal changes or shocks affect the economy, which had to be handled outside the MODEL-80 model, are now handled endogenously. The change in the new model's behaviour is most striking when it is used for medium-term simulations, something which the MODEL-80 model was not designed to handle and which it treated in a very unsatisfactory fashion.

The fact that these new multipliers differ significantly from those derived from earlier models does not necessarily signal a major change in our understanding of how the Irish economy works. It rather reflects the fact that HERMES-IRELAND embodies the mechanisms which had to be handled outside the context of previous models. While such off-model exercises were quite feasible when examining the effects of shocks to the economy in the short-term, it was almost impossible to handle them consistently in a medium to long term context.

Table 10.2: Comparison of HERMES-IRELAND and MODEL-80 Multipliers, £ miilion.

The Instruments Are Changed by £1 Million in 1987

	Real GDP 1987 prices		Real GNP 1987 prices		Gov.Borrowing Current prices		Employment (000)	
Change in:	HERMES	M-80	HERMES	M-80	HERMES	M-80	HERMES	M-80
Employment in Pub.Ad.	-1.26	-1.44	-1.15	-1.50	+0.52	+0.32	-0.061	-0.070
Rate of Income Tax	+0.39	+0.93	+0.25	+0.96	-0.81	-0.55	+0.003	+0.010

CHAPTER 11 : CONCLUSION

In this paper we have described the first fully operational version of HERMES-Ireland. In its sectoral coverage and its underlying theoretical assumptions HERMES-IRELAND attempts to provide a formal operational description of how the Irish economy functions. Its primary purpose is to assist policy analysts in economic forecasting and policy evaluation. In this role it has been extensively used in the preparation of two issues of the ESRI's *Medium-Term Review* (Bradley, Fitz Gerald and Storey,1987; Bradley and Fitz Gerald,1989) and we refer the reader to these documents for extensive accounts of how a macroeconometric model is used in practical policy analysis.

Applications of the model as it is exposed to practical problem solving has tended to point to certain weaknesses and current limitations. Of course, any policy model is of necessity in a state of continual development and refinement as better data and more precise theoretical models become available. The following are some of the stages in its development and use:

(a) The model has been implemented by the ESRI for the use of the Irish Department of Finance and has replaced the previous model (MODEL-80; Fitz Gerald and Keegan,1982) for routine policy and budgetary analysis for short and medium-term work;

(b) The model is maintained in the ESRI and is used for the Institute's own short and medium-term forecasting work, in particular the preparation of the ESRI's *Medium-Term Review* every two years.

(c) The top priority for further development of HERMES-IRELAND concerns the desirability of disaggregating the present aggregate industrial sector along the following lines:

(i) splitting out manufacturing, building and construction and utilities from the present aggregate industrial sector.

(ii) further splitting out indigenous and foreign-owned components of manufacturing, and focussing on the multinational aspects of the foreign-owned sector with a more precise theoretical formulation.

The possibility of obtaining good quality national accounts data is slight. Nevertheless, the above decomposition will have to be done, if necessary using imposed parameters as well as statistical estimation. It may be necessary to use Census of Industrial Production data and to link them in an *ad hoc* manner to the national accounts data which underpin the rest of the model.

(d) The prospect of the harmonisation of European tax systems by 1992 means that HERMES-IRELAND will have to be used to study the massive shift in the structure of the Irish indirect tax system which this will entail. Preliminary work is already in progress in this important area.

(e) The analysis of the impact of *1992* on the Irish economy and the role and impact of the EC Structural Funds is also a priority area for further research. Some preliminary results are reported in Bradley and Fitz Gerald,1989.

(f) Finally, the prospect of having HERMES-IRELAND functioning as part of a set of linked models means that the task of forecasting Irish developments contingent on the world environment will be greatly facilitated. An example where this will be of use is in quantifying the impact on the aggregate world growth of the fall in energy prices, the difficulties of which were reported in Chapter 10 above.

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APPENDIX 1 : LISTING OF VARIABLES

The variables in HERMES-IRELAND can be classified into two general categories: *endogenous* and *exogenous*.

Within the class of endogenous variables there are three sub-classifications:

(a) *Behavioural Endovars*, of TYPE B or ENDOB in the following alphabetical listing. These are variables determined by equations in the model which contain estimated coefficients.

(b) *Technical Endovars*, of TYPE T or ENDOT: In some cases variables are endogenous in the model, but only "technically" so. For example, certain policy instruments have indexation options available for use, as well as exogenous options. Certain tax revenues and expenditures are written in terms of implicit rates and bases in lieu of proper estimation. Such variables are referred to as "technical" endovars.

(c) *Identity Endovars*, of TYPE I, or ENDOI: By far the largest sub-class, these are variables determined by model identities.

Within the class of *exogenous* variables, there are four sub-classifications:

(i) TYPE 1, or EXO1 Exovars: This includes all the "world" variables, exchange rates, interest rates, etc.

(ii) TYPE 2, or EXO2 Exovars: This includes all the fiscal policy instruments in the model.

(iii) TYPE H, or EXOH Exovars: This contains "exogenised" versions of certain other endovars. For example, the behavioural endovar "C" can occur as a TYPE H exovar in the form "CH".

(iv) TYPE D, or EXOD Exovars: This contains dummy variables and indexation switches.

VARIABLE	VARIABLE DESCRIPTION	UNITS	TYPE
AAEAGIMP	Implicit average annual earnings in agriculture	£k	ENDOI
AAEI	Average annual earnings in industry	£k	ENDOB
AAEIDOT	Rate of change of AAEI	Percent	ENDOI
AAEIR	Average annual earnings in industry, in constant prices	£k,1980	ENDOI
AAEIRDOT	Rate of change of AAEIR	Percent	ENDOI
AAENA	Average annual earnings in the non-agriculture sector	£k	ENDOI
AAENADOT	Rate of change of the variable AAENA	Percent	ENDOI
AAEPA	Average annual earnings in public administration	£k	ENDOT
AAESHE	Average annual earnings in health and education	£k	ENDOT
AAESM	Average annual earnings in marketed services	£k	ENDOB
AAESMDOT	Rate of change of the variable AAESM	Percent	ENDOI
AAESO	Average annual earnings in services, excluding public administration	£k	ENDOI
BP	Balance of payments surplus	£m	ENDOI
BPPK	Net capital inflow on the non-banking private sector	£m	ENDOI
BPR	Balance of payments surplus as percent of GNP	Percent	ENDOI
BPT	Balance of trade surplus	£m	ENDOI
BPTCK	Net foreign capital transfers	£m	ENDOT
BPTCKH	Equivalent to BPTCK - represents exogenised version	£m	EXO1
BPTKNG	Public authorities net capital receipts from abroad	£m	ENDOT
BPTKNGH	Equivalent to BPTKNG - represents exogenised version	£m	EXO1
BPTPRNE	Private international current transfers	£m	ENDOT
BPTPRNEH	Equivalent to BPTPRNE - represents exogenised version	£m	EXO1
BPTR	Balance of trade as percentage of GNP	Percent	ENDOI
C	Personal consumers' expenditure	£m,1980	ENDOB
COMAAEI	Ratio of "world" to Irish hourly earnings	Index	ENDOI
COMTCI	Industrial competitiveness measure (defined as PWORLD/PCKEL)	Index	ENDOI
COMUCLI	Ratio of "world" to Irish unit labour costs	Index	ENDOI
CPC	Parameter used for indexation to PC (normally set to unity)		EXOD
CPGNP	Parameter used for indexation to PGNP (normally set to unity)		EXOD
CURH	Rate of capacity utilisation in industry	Index	ENDOI
CV	Personal consumers' expenditure	£m	ENDOI
CVH	Equivalent to CV-represents exogenised version	£m	EXOH
DC	Private sector domestic credit	£m	ENDOT
DCH	Equivalent to DC-represents exogenised version	£m	EXOH
DEP	Total depreciation allowances	£m	ENDOI
DEPAG	Depreciation allowances in agriculture, forestry and fishing	£m	ENDOB
DEPI	Depreciation allowances in industry	£m	ENDOB
DEPS	Depreciation allowances in services	£m	ENDOB
DFR	Average debt-financing ratio in the industrial sector	Fraction	EXOD
DISI	Discrepancy between NIE and OECD investment totals	£m,1980	EXOD
DISIV	Discrepancy between NIE and OECD investment totals	£m	EXOD
DUM73	Dummy variable to eliminate the year 1973		EXOD
DUM74	Dummy variable to eliminate the year 1974		EXOD
DUM75	Dummy variable to eliminate the year 1975		EXOD
DUMED	"Free" secondary education dummy variable (5 year build up from 1969)		EXOD
DUMNI	Dummy variable for start of Northern Ireland violence (zero prior to 1969 and unity thereafter)		EXOD
EAAEIDOT	Expected value of the variable AAEIDOT	Percent	ENDOI
ECOMAAEI	Expected value of the variable COMAAEI	Index	ENDOI
ECOMTCI	Moving average of the variable COMTCI	Index	ENDOI
ECOMUCLI	Expected value of the variable COMUCLI	Index	ENDOI
EECBUD	Irish EEC budget contribution	£m	ENDOT
EECBUDH	Equivalent to EECBUD-represents exogenised version	£m	EXO2
EECCIC	EEC International Cooperation Fund	£m	ENDOT
EECCICH	Equivalent to EECCIC-represents exogenised version	£m	EXO2
EECS	Subsidies from the EEC	£m	ENDOT
EECSH	Equivalent to EECS-represents exogenised version	£m	EXO2
EECTE	EEC taxes on expenditure	£m	ENDOT
EECTEH	Equivalent to EECTE-represents exogenised	£m	EXO2
EGSOSM	Expected value of the variable GSOSM	£m,1980	ENDOI
EI	Energy inputs in the industrial sector	£m,1980	ENDOB

EIV	Energy inputs in the industrial sector	£m	ENDOI
EOPRI	Trend in labour productivity in industry (constant exponential growth)		ENDOB
EOPRSM	Trend in labour productivity in marketed services (constant exponential growth)		ENDOB
ERAW	Trend in relative agricultural-non agricultural earnings	Fraction	ENDOI
ERPL	Moving average of the variable RPL	Percent	ENDOI
EVIN	Vintage-based energy requirement in industry	£m,1980	ENDOT
EW1	Expectational weight used in calculating EGSOSM		EXOD
EW2	Expectational weight used in calculating EGSOSM		EXOD
EW3	Expectational weight used in calculating EGSOSM		EXOD
FBOR	Net foreign borrowing by the public authorities	£IRm	ENDOI
FBORF	Net foreign borrowing by the public authorities, converted to existing debt currency basket	Curr baskt	ENDOI
FXA	$ US per £ IR exchange rate (1980 equals unity)	Index	ENDOT
FXADOT	Rate of change of the variable FXA	Percent	ENDOI
FXAEFF	Effective Irish exchange rate against a basket of "rest of the world" currencies	Index	ENDOI
FXAEFFDT	Rate of change of variable FXAEFF	Percent	ENDOI
FXAFB	Exchange rate of the £IR against a weighted basket of Irish foreign debt currencies (basket per £ IR)	Index	ENDOT
FXAFBH	Equivalent to FXAFB - represents exogenised version	Curr baske	EXO1
FXAH	Equivalent to FXA-represents exogenised version	Index	EXO1
FXAWD	Exchange rate of "rest of the world" currencies against the $ US ($ US per basket)	Index	ENDOT
FXAWDDOT	Rate of change of the variable FXAWD	Percent	ENDOI
FXAWDH	Equivalent to FXAWD-represents exogenised version.	Index	EXO1
GBR	Public authorities' surplus	£m	ENDOI
GBRC	Public authorities' current surplus	£m	ENDOI
GBRCR	Public authorities' current surplus as a percentage of GNP	Percent	ENDOI
GBRH	Equivalent to GBR-represents exogenised version	£m	EXOH
GBRR	Public authorities' surplus as a percentage of GNP	Percent	ENDOI
GC	Public authorities' total current expenditure	£m	ENDOI
GCG	Public authorities' net current expenditure on goods and services	£m,1980	ENDOI
GCGNP	Public authorities' non-wage consumption expenditures	£m,1980	ENDOI
GCGNPV	Public authorities non-pay consumption	£m	ENDOT
GCGNPVH	Equivalent to GCGNPV-represents exogenised version	£m	EXO2
GCGOW	Public authorities' consumption: wages other than public administration and defence	£m,1980	ENDOI
GCGOWV	Public authorities' consumption: wages other than public administration and defence	£m	ENDOI
GCGV	Public authorities' net current expenditure on goods and services	£m	ENDOI
GCSA	Total agricultural subsidies	£m	ENDOI
GCSANS	Agricultural subsidies, not related to sales	£m	ENDOT
GCSANSH	Equivalent to GCSANS-represents exogenised version	£m	EXO2
GCSAS	Agricultural subsidies related to sales	£m	ENDOT
GCSASH	Equivalent to GCSAS-represents exogenised version	£m	EXO2
GCSC	Total consumer subsidies	£m	ENDOT
GCSO	Residual category of subsidies	£m	ENDOI
GCSONA	Other non-agricultural subsidies	£m	ENDOT
GCSONAH	Equivalent to GCSONA-represents exogenised version	£m	EXO2
GCTABR	Public authorities current transfers abroad	£m	ENDOT
GCTABRH	Equivalent to GCTABR-represents exogenised version	£m	EXO2
GCTNDI	Total debt interest payments by the public authorities	£m	ENDOI
GCTNDID	Total debt interest payments on national loans by the public authorities	£m	ENDOB
GCTNDIF	Total debt interest payments on foreign currency debt	£m	ENDOT
GCTNDIFH	Equivalent to GCTNDIF-represents exogenised version	£m	EXOH
GCTNDISS	Debt interest on small savings	£m	ENDOT
GCTPER	Total personal transfer payments	£m	ENDOI
GCTPRB	Pay-related benefit	£m	ENDOT
GCTREST	Residual category of personal transfers (pension, etc.)	£m	ENDOT
GCTRESTH	Equivalent to GCTREST-represents exogenised version	£m	EXO2
GCTUP	Unemployment assistance and benefit payments	£m	ENDOB
GCTW	Secondary and higher education salaries paid as transfers	£m	ENDOI
GDA	Gross domestic absorption	£m,1980	ENDOI
GDAV	Gross domestic absorption	£m	ENDOI
GDPE	Gross domestic product on an expenditure basis	£m,1980	ENDOI
GDPEV	Gross domestic product on an expenditure basis	£m	ENDOI
GDPFC	Gross domestic product at factor cost (output basis)	£m,1980	ENDOI
GDPFCV	Gross domestic product at factor cost (output basis)	£m	ENDOI
GDPFCVH	Equivalent to GDPFCV-represents exogenised version	£m	EXOH
GDPM	Gross domestic product at market prices (output basis)	£m,1980	ENDOI
GDPMDOT	Rate of change of variable GDPM	Percent	ENDOI
GDPMV	Gross domestic product at market prices (output basis)	£m	ENDOI
GFD	Gross final demand	£m,1980	ENDOI
GFDV	Gross final demand	£m	ENDOI
GK	Public authorities' total capital expenditure	£m	ENDOI
GKREST	Residual category of public authorities capital expenditure	£m	ENDOT
GKRESTH	Equivalent to GKREST-represents exogenised version	£m	EXO2
GKTH	Capital transfers to households for housing purposes	£m	ENDOT
GKTI	Capital transfers to industry	£m	ENDOT
GNBG	Net lending to the government by the commercial banks	£m	ENDOT
GNBGH	Equivalent to GNBG - represents exogenised version	£m	EXO1
GNCG	Net lending to the government by the Central Bank	£m	ENDOT
GNCGH	Equivalent to GNCG - represents exogenised version	£m	EXO1
GND	Total government national loans outstanding	£m	ENDOI
GNF	Stock of foreign debt outstanding	£m	ENDOI
GNFF	Total government foreign loans outstanding, converted to existing foreign debt basket	Curr baske	ENDOI
GNFH	Equivalent to GNF-represents exogenised version	£m	EXOH
GNHGDL	Change in households'holdings of national debt	£m	ENDOT
GNHGDLH	Equivalent to GNHGDL - represents exogenised version	£m	EXO1
GNL	National loans outstanding	£m	ENDOT
GNLH	Equivalent to GNL-represents exogenised version	£m	EXO1
GNP	Gross national product (output basis)	£m,1980	ENDOI
GNPDOT	Rate of change of the variable GNP	Percent	ENDOI
GNPV	Gross national product (output basis)	£m	ENDOI
GNPVH	Equivalent to GNPV-represents exogenised version	£m	EXOH
GNSS	Total of small savings	£m	ENDOT
GNSSH	Equivalent to GNSS-represents exogenised version	£m	EXO1
GNT	Total national debt	£m	ENDOI
GR	Public authorities' total capital revenue	£m	ENDOT
GRH	Equivalent to GR-represents exogenised version	£m	EXO2
GSOIBD	Gross expenditure on the output of the building and construction sector, excluding industrial exports (1975 I/O weights)	£m,1980	ENDOI
GSOID	Gross expenditure on the output of the industrial sector, excluding	m,1980	ENDOI

	industrial exports (1975 I/O weights)		
GSOIMMUD	Gross expenditure on the output of the industrial (MMU) sector, excluding industrial exports (1975 I/O weights)	£m,1980	ENDOI
GSOSM	Gross expenditure on the output of the marketed services sector	£m,1980	ENDOI
GTAGLEV	Agricultural levies, from the NIE	£m	ENDOT
GTAGLEVH	Equivalent to GTAGLEV-represents exogenised version	£m	EXO2
GTE	Public authorities' total revenue from indirect taxes	£m	ENDOI
GTEARL	Revenue from agricultural levies (includes EEC levies)	£m	ENDOT
GTEARLH	Equivalent to GTEARL-represents exogenised version	£m	EXO2
GTECUSO	Revenue from customs duties	£m	ENDOT
GTEMVDC	Portion of road tax duties paid by the company sector	£m	ENDOI
GTEO	Revenue from a residual category of indirect taxes	£m	ENDOB
GTERAT	Indirect taxes as a percentage of total taxes	Percent	ENDOI
GTERATE	Revenue from property taxes, i.e. rates	£m	ENDOT
GTERATEH	Equivalent to GTERATE-represents exogenised version	£m	EXO2
GTEVAT	Revenue from value-added tax	£m	ENDOB
GTEVATB	Tax base for value-added tax	£m	ENDOI
GTEXT	Revenue from a range of the major excise duties (oil, tobacco and alcohol)	£m	ENDOB
GTMVD	Total revenue from road taxation on motor vehicles	£m	ENDOB
GTTABR	Public authorities' current receipts from abroad	£m	ENDOT
GTTABRH	Equivalent to GTTABR-represents exogenised version	£m	EXO2
GTTI	Public authorities' trading and investment income	£m	ENDOT
GTTIH	Equivalent to GTTI-represents exogenised version	£m	EXO2
GTTOT	Public authorities' total current revenue	£m	ENDOI
GTW	Revenue from wealth taxation	£m	ENDOT
GTWH	Equivalent to GTW-represents exogenised version	£m	EXO2
GTY	Total revenue from taxation on incomes	£m	ENDOI
GTYA	Revenue from taxes on agricultural incomes	£m	ENDOT
GTYAH	Equivalent to GTYA-represents exogenised version	£m	EXO2
GTYC	Revenue from company taxes	£m	ENDOT
GTYDIRT	Revenue from DIRT tax (post 1986 only)	£m	ENDOT
GTYDIRTH	Equivalent to GTYDIRT-represents exogenised version	£m	EXO2
GTYMVDP	Portion of road taxation paid by the household sector	£m	ENDOT
GTYPER	Revenue from taxation on personal non-agricultural incomes	£m	ENDOT
GTYRAT	Proportion of direct taxes in total taxes	Percent	ENDOI
GTYSE	Employers' social security contributions	£m	ENDOT
GTYSL	Total revenue from social security contributions	£m	ENDOT
GTYSP	Employee's social insurance contributions	£m	ENDOI
HEW	Weighted measure of "world" hourly earnings	Index	ENDOT
HEWDOT	Rate of change of the variable HEW	Percent	ENDOI
HEWF	Weighted measure of "world" hourly earnings, denominated in foreign currency	Index	EXO1
IAG	Fixed investment in agriculture, forestry and fishing	£m,1980	ENDOI
IAGV	Fixed investment in agriculture, forestry and fishing	£m	ENDOI
IBC	Fixed investment in building and construction	£m,1980	ENDOI
IGIN	Total fixed investment by public authorities, health, education and sanitary services	£m,1980	ENDOI
IH	Total housing investment	£m,1980	ENDOI
IHG	Public authorities' housing investment	£m,1980	ENDOI
IHGV	Public authorities' housing investment	£m	ENDOT
IHGVH	Equivalent to IHGV-represents exogenised version	£m	EXO2
IHP	Private housing investment	£m,1980	ENDOB
IHPV	Private housing investment	£m	ENDOI
IHV	Total housing investment	£m	ENDOI
II	Fixed investment by the industrial sector	£m,1980	ENDOB
IIV	Fixed investment by the industrial sector	£m	ENDOI
IME	Fixed investment in machinery and equipment	£m,1980	ENDOT
IPA	Fixed investment by the public administration sector	£m,1980	ENDOI
IPAV	Fixed investment by the public administration sector	£m	ENDOT
IPAVH	Equivalent to IPAV-represents exogenised version	£m	EXO2
IS	Total fixed investment in the service sector	£m,1980	ENDOI
ISHE	Fixed investment by the health and education sectors	£m,1980	ENDOI
ISHEV	Fixed investment by the health, education and sanitary services sectors	£m	ENDOT
ISHEVH	Equivalent to ISHEV-represents exogenised version	£m	EXO2
ISM	Fixed investment by the marketed services sector	£m,1980	ENDOB
ISV	Total fixed investment in the service sector	£m	ENDOI
ITNG	Total fixed investment, excluding public administration, health, education and sanitary services	£m,1980	ENDOI
ITOT	Total fixed investment, including housing	£m,1980	ENDOI
ITOTV	Total fixed investment, including housing	£m	ENDOI
K2	Variable used in the equation for pay-related benefit (GCTPRB/(U*AAENA(-1))		EXO2
KAG	Fixed capital stock in agriculture, forestry and fishing	£m,1980	ENDOB
KDC	Variable for the indexation of domestic credit (normally set to unity)		EXOD
KDIRT	Ratio of revenue from DIRT to GNPV*RD**EDIRT		EXO2
KECB	Variable for the indexation of the EEC budget contribution (normally set to unity)		EXOD
KECS	Variable for the indexation of EEC subsidies (normally set to unity)		EXOD
KECT	Variable for the indexation of EEC transfers (normally set to unity)		EXOD
KEQSTAR	Optimal ratio of the capital-energy (KE) bundle to gross industrial output		ENDOT
KEVIN	Vintage bundle of capital and energy in industry	£m,1980	ENDOT
KGCTABR	Variable used for indexation of GCTABR (normally set to unity)		EXOD
KGTTABR	Variable used for indexation of GTTABR (normally set to unity)		EXOD
KI	Fixed capital stock in industry	£m,1980	ENDOI
KIBAR	Two-year moving average of the fixed capital stock in industry	£m,1980	ENDOI
KKESTAR	Optimal ratio of capital stock to the capital-energy (KE) bundle		ENDOT
KMTO	Proportion of services' imports attributable to tourism	Fraction	EXOD
KNFLB	Variable used in the indexation of NFLB (normally set to unity)		EXOD
KONLB	Variable used in the indexation of ONLB (normally set to unity)		EXOD
KPGNP	Variable used for indexation with the deflator PGNP (normally set to unity)		EXOD
KQSTAR	Optimal capital-output ratio in industry (set equal to KKESTAR*KEQSTAR)		ENDOI
KQSTARSM	Optimal capital-output ratio in marketed services		ENDOT
KSM	Fixed capital stock in marketed services	£m,1980	ENDOI
KSTARI	Optimal capital stock in industry (set equal to KQSTAR*QSTARI)	£m,1980	ENDOI
KSTARSM	Optimal capital stock in marketed services (set equal to KQSTARSM*OSTARSM)	£m,1980	ENDOI
KYCI	Proportion of industrial profits which are repatriated		EXOD
KYCSHE	Ratio of operating surplus to added-value in the health and education services sector		EXOD
KYFNM	Ratio of the deflators of MGSV and YFN (from NIE)		EXOD
KYFNX	Ratio of the deflators of XGSV and YFN (from NIE)		EXOD
KYSEAG	Proportion of agricultural income earned by the self-employed in agriculture	Fraction	EXOD

LAG	Employment in agriculture, forestry and fishing	Thousands	ENDOB
LF	Total labour force	Thousands	ENDOI
LFPR	Labour force participation rate	Percent	ENDOB
LFPRH	Equivalent to LFPR-represents exogenised version	Percent	EXO1
LI	Employment in industry	Thousands	ENDOB
LM	Employment in the market sector (agriculture, industry and marketed services)	Thousands	ENDOI
LMNA	Employment in the non-agricultural market sector (industry and marketed services)	Thousands	ENDOI
LNA	Non-agricultural employment	Thousands	ENDOI
LNM	Employment in the non-market sector (public administration, health and education)	Thousands	ENDOI
LPA	Employment in public administration	Thousands	ENDOT
LPAH	Equivalent to LPA-represents exogenised version	Thousands	EXO2
LQSTAR	Optimal labour-output ratio in industry		ENDOT
LQSTARSM	Optimal labour-output ratio in marketed services		ENDOT
LS	Total employment in the services sectors	Thousands	ENDOI
LSHE	Employment in health and education	Thousands	ENDOT
LSHEH	Equivalent to LSHE-represents exogenised version	Thousands	EXO2
LSM	Employment in marketed services	Thousands	ENDOB
LSO	Employment in the services sectors excluding public administration	Thousands	ENDOI
LSTARI	Optimal labour demand in industry (set equal to LQSTAR*QSTARI)	Thousands	ENDOI
LSTARSM	Optimal labour demand in marketed services (set equal to LQSTARSM*OSTARSM)	Thousands	ENDOI
LSVAI	Labour's share of added-value in industry	Fraction	ENDOI
LTEACH	Number of teachers whose salaries are paid through Government transfers (implicit)	Thousands	EXO2
LTOT	Total employment	Thousands	ENDOI
M3	Total energy imports	£m,1980	ENDOI
M3V	Total energy imports	£m	ENDOI
MC	Imports of consumption goods	£m,1980	ENDOB
MG	Total imports of goods	£m,1980	ENDOI
MGS	Total imports of goods and services	£m,1980	ENDOI
MGSV	Total imports of goods and services	£m	ENDOI
MGV	Total imports of goods	£m	ENDOI
MMFPA	Imports of agricultural materials for further production	£m,1980	ENDOB
MMFPNE	Imports of industrial materials for further production, excluding energy	£m,1980	ENDOI
MON	Broad money supply	£m	ENDOB
MPCG	Imports of producers' capital goods	£m,1980	ENDOB
MS	Imports of services	£m,1980	ENDOB
MSO	Imports of services, excluding tourism	£m,1980	ENDOI
MTO	Imports of tourism services	£m,1980	ENDOT
N1564	Population aged between 15 and 64 years	Thousands	ENDOB
N1564A	Population aged between 15 and 64, less those in full time education	Thousands	ENDOI
N1564H	Equivalent to N1564-represents exogenised version	Thousands	EXO1
NDPFCV	Net domestic product at factor cost	£m	ENDOI
NEDPR	Participation rate in full-time education by working age population	Percent	ENDOB
NEDPRH	Equivalent to NEDPR-represents exogenised version	Percent	EXO1
NFLB	Net foreign liabilities of the commercial banks	£m	ENDOT
NFLBH	Equivalent to NFLB-represents exogenised version	£m	EXOH
NGE65	Population aged greater than or equal to 65	Thousands	ENDOI
NLE14	Population aged less than or equal to 14	Thousands	ENDOB
NLE14H	Equivalent to NLE14-represents exogenised version	Thousands	EXO1
NLF	Population of working age but not in the labour force	Thousands	ENDOI
NLFED	Population of working age in full-time education	Thousands	ENDOI
NMA	Net migration abroad ("+" for outmigration "-" for inward migration)	Thousands	ENDOB
NMAH	Equivalent to NMA-represents exogenised version	Thousands	EXO1
NNPFCV	Net national product at factor cost before adjustment for stock appreciation	£m	ENDOI
NT	Total population	Thousands	ENDOB
NTH	Equivalent to NT-represents exogenised version	Thousands	EXO1
OA	Added-value in agriculture	£m,1980	ENDOI
OAFF	Added-value in forestry and fishing	£m,1980	ENDOT
OAFFH	Equivalent to OAFF-represents exogenised version	£m,1980	EXOH
OAFFV	Added-value in forestry and fishing	£m	ENDOT
OAFFVH	Equivalent to OAFFV-represents exogenised version	£m	EXOH
OAG	Added-value in agriculture, forestry and fishing	£m,1980	ENDOI
OAGV	Added-value in agriculture, forestry and fishing	£m	ENDOI
OAH	Equivalent to OA-represents exogenised version	£m,1980	EXOH
OAV	Added-value in agriculture	£m	ENDOI
OAVH	Equivalent to OAV-represents exogenised version	£m	EXOH
OI	Added-value in the industrial sector	£m,1980	ENDOI
OIV	Added-value in the industrial sector	£m	ENDOI
ONLB	Other net domestic liabilities of the banking system	£m	ENDOT
ONLBH	Equivalent to ONLB-represents exogenised version	£m	EXOH
OPA	Added-value in the public administration sector	£m,1980	ENDOB
OPAV	Added-value in the public administration sector	£m	ENDOI
OPRI	Labour productivity in the industrial sector		ENDOI
OPRSM	Labour productivity in the marketed services sector		ENDOI
OSHE	Added-value in the health and education sectors	£m,1980	ENDOT
OSHEV	Added-value in the health and education sectors	£m	ENDOI
OSM	Added-value in the marketed services sector	£m,1980	ENDOB
OSMV	Added-value in the marketed services sector	£m	ENDOI
OSO	Added-value in the services sector, excluding public administration	£m,1980	ENDOI
OSOV	Added-value in the services sector, excluding public administration	£m	ENDOI
OSTARSM	Three year moving average of output in marketed services	£m,1980	ENDOI
PC	Deflator of the variable CV	Index	ENDOB
PCDOT	Rate of change of the variable PC	Percent	ENDOI
PCH	Equivalent to PC-represents exogenised version	Index	EXOH
PCKE	Price of the optimal capital-energy bundle	Index	ENDOI
PCKEL	Price of the optimal capital-energy-labour bundle (i.e., output)	Index	ENDOI
PE	Price of energy inputs in industry (equivalent to PM3)	Index	ENDOT
PEDOT	Rate of change of the variable PE	Percent	ENDOI
PGCG	Deflator of the variable GCGV	Index	ENDOI
PGCGNP	Deflator of the variable GCGNPV	Index	ENDOT
PGCGNPH	Equivalent to PGCGNP-represents exogenised version	Index	EXOH
PGCGOW	Deflator of the variable GCGOWV	Index	ENDOI
PGDPE	Deflator of the variable GDPEV	Index	ENDOI
PGDPFC	Deflator of the variable GDPFCV	Index	ENDOI
PGDPFCDT	Rate of change of the variable PGDPFC	Percent	ENDOI
PGDPM	Deflator of the variable GDPMV	Index	ENDOI
PGNP	Deflator of the variable GNPV	Index	ENDOI
PGNPH	Equivalent to PGNP-represents exogenised version	Index	EXOH
PIAG	Deflator of the variable IAGV	Index	ENDOB

PIBC	Deflator of the variable IBCV	Index	ENDOB
PIH	Deflator of the variable IHV	Index	ENDOB
PII	Deflator of the variable IIV	Index	ENDOB
PIME	Deflator of fixed investment in machinery and equipment	Index	ENDOB
PIPA	Deflator of the variable IPAV	Index	ENDOT
PIS	Deflator of the variable ISV	Index	ENDOB
PISHE	Deflator of the variable ISHEV	Index	ENDOT
PISM	Deflator of the variable ISMV	Index	ENDOT
PITOT	Deflator of the variable ITOTV	Index	ENDOI
PKAG	User cost of capital in agriculture, forestry and fishing	Index	ENDOI
PM3	Deflator of the variable M3	Index	ENDOT
PM3F	Deflator of the variable M3V, in foreign currency	Index	EXO1
PMG	Deflator of the variable MGV	Index	ENDOI
PMGNE	Deflator of imports of non-energy industrial intermediate inputs	Index	ENDOT
PMGNEF	Deflator of industrial non-energy intermediate inputs, in foreign currency	Index	EXO1
PMGS	Deflator of the variable MGSV	Index	ENDOI
PMS	Deflator of the variable MSV	Index	ENDOT
PMSF	Deflator of the variable MSV, in foreign currency	Index	EXO1
POAG	Deflator of the variable OAGV	Index	ENDOI
POI	Deflator of the variable OIV	Index	ENDOI
POSM	Deflator of the variable OSMV	Index	ENDOI
POSO	Deflator of the variable OSOV	Index	ENDOI
PQGA	Deflator of the variable QGAV	Index	ENDOT
PQGAF	Deflator of the variable QGAV, in foreign currency	Index	EXO1
PQGAH	Equivalent to PQGA-represents exogenised version	Index	EXOH
PQHI	Deflator of the variable QHIV	Index	ENDOB
PQMA	Deflator of the variable QMAV	Index	ENDOB
PQTI	Deflator of output of transportable goods industries	Index	ENDOB
PRGERS	Share of gross industrial profits in industrial output in West Germany	Fraction	EXO1
PRIRL	Share of gross industrial profits in industrial output	Fraction	ENDOI
PRIRLS	Moving average of the variable PRIRL	Fraction	ENDOI
PRUKS	Share of gross profits in industrial output in the U.K.	Fraction	EXO1
PRUSAS	Share of gross industrial profits in industrial output in the U.S.	Fraction	EXO1
PRWORS	Share of gross profits in industrial output in the "world" economy (Germany, United Kingdom and the USA)	Fraction	EXO1
PRXI	Measure of the profitability of exporting (i.e. PXI/UCLI)		ENDOI
PSTDL	Deflator of the variable STVDL	Index	ENDOI
PSTNA	Deflator of the variable STVNA	Index	ENDOB
PSTNADL	Deflator of the variable STNAVDL	Index	ENDOB
PSUB	Implicit deflator of total subsidies, SUB	Index	ENDOI
PTE	Implicit deflator of total indirect taxes, TE	Index	ENDOI
PWORLD	"World" industrial output price	Index	ENDOT
PWORLDDT	Rate of change of the variable PWORLD	Percent	ENDOI
PWORLDF	Foreign currency version of PWORLD	Index	EXO1
PWORLDH	Equivalent to PWORLD - represents exogenised version	Index	EXOH
PXA	Deflator of the variable XAV	Index	ENDOT
PXAF	Foreign currency version of PXA	Index	EXO1
PXGS	Deflator of the variable XGSV	Index	ENDOI
PXI	Deflator of the variable XIV	Index	ENDOB
PXNA	Deflator of the variable XNAV	Index	ENDOI
PXS	Deflator of the variable XSV	Index	ENDOT
PYAFS	Deflator of the variable YAFS	Index	ENDOB
QDA	Domestic absorption of gross agricultural output	£m,1980	ENDOB
QE	Domestic production of energy	£m,1980	EXO1
QGA	Gross agricultural output	£m,1980	ENDOB
QGAV	Gross agricultural output	£m	ENDOI
QGAVH	Equivalent to QGAV-represents exogenised version	£m	EXOH
QGCA	Gross agricultutal output at full capacity	£m, 1980	ENDOI
QHI	Added-value plus energy inputs in the industrial sector (referred to as "gross" output)	£m,1980	ENDOB
QHIV	Added-value plus energy inputs in industry (referred to as "gross" output)	£m	ENDOI
QIW	Index of total gross industrial output for the "world" (OECD "big-7")	£m,1980	EXO1
QMA	Total inputs into agriculture	£m,1980	ENDOB
QMAV	Total inputs into agriculture	£m	ENDOI
QSTARI	Planned output capacity in the industrial sector	£m,1980	ENDOB
QVIN	Vintage-based synthetic supply in industry (referred to as "normal" output)	£m,1980	ENDOI
QWSTARI	Three-year moving average of the variable QIW (i.e.industrial output for the "world" economy).	£m,1980	ENDOI
R	Official external reserves	£m	ENDOI
RATAAEI	Real after tax average annual earnings in industry	£k,1980	ENDOI
RATAAESM	Real after tax average annual earnings in marketed services	£k,1980	ENDOI
RAW	Average annual earnings in agriculture relative to non-agriculture		ENDOI
RCARS	Motor vehicle road tax rate	Index	ENDOT
RCARSH	Equivalent to RCARS-represents exogenised version	Index	EXO2
RCORP4	Effective corporate tax rate	Fraction	ENDOT
RCORP4H	Equivalent to RCORP4-represents exogenised version	Fraction	EXO2
RCUS	Implicit rate of customs duties	Fraction	ENDOT
RCUSH	Equivalent to RCUS-represents exogenised version	Fraction	EXO2
RD	Ordinary deposit rate of interest	Percent	ENDOT
RDEBT	Public authorities' debt-GNP ratio	Percent	ENDOI
RDEBTF	Foreign debt as a percentage of GNPV	Percent	ENDOI
RDEBTFL	Foreign debt per person employed	£	ENDOI
RDEBTFNT	Foreign debt per capita of population	£	ENDOI
RDEBTFX	Foreign debt as a percentage of total exports	Percent	ENDOI
RDEBTL	Total public authorities' debt per person employed	£	ENDOI
RDEBTNT	Total public authorities' debt per capita of population	£	ENDOI
RDEBTX	Total public authorities' debt as a percentage of total exports	Percent	ENDOI
RDEPEND	Dependency ratio (non working age population as a percentage of working age population)	Percent	ENDOI
RDF	Foreign currency version of RD	Percent	EXO1
RDH	Equivalent to RD-represents exogenised version	Percent	EXOH
RE	Employment rate in Ireland relative to the United Kingdom		ENDOI
RES	A residual calculated so that on average all factor payments exhaust total output in industry over the sample period (1960 to 1984)		EXOD
RETRAT	Average non-agricultural earnings retention ratio	Fraction	ENDOI
REX	Effective rate on a range of major excise duties (oil, tobacco and alcohol)	Index	ENDOT
REXH	Equivalent to REX-represents exogenised version	Index	EXO2
RF	Rate of interest on new foreign borrowing	Percent	ENDOT
RFF	Foreign currency version of RF	Percent	EXO1
RFH	Equivalent to RF-represents exogenised version	Percent	EXOH
RFI	Average implicit rate of interest on foreign loans outstanding	Percent	ENDOT
RFIF	Foreign currency version of RFI	Percent	EXO1
RFIH	Equivalent to RFI-represents exogenised version	Percent	EXOH
RGC	Public authorities' total current expenditure as a percentage of GNP	Percent	ENDOI
RGCSC	Implicit rate of consumer subsidies	Fraction	ENDOT
RGCSCH	Equivalent to RGCSC-represents exogenised version	Fraction	EXO2

RGKTH	Capital transfers to housholds for housing purposes as a proportion of private housing investment	Fraction	ENDOT
RGKTHH	Equivalent to RGKTH-represents exogenised version	Fraction	EXO2
RGKTI	Capital transfers to industry as a proportion of investment in industry	Fraction	ENDOT
RGKTIH	Equivalent to RGKTI-represents exogenised version	Fraction	EXO2
RGL	Eight-year government bond rate	Percent	ENDOT
RGLF	Foreign currency version of RGL	Percent	EXO1
RGLH	Equivalent to RGL-represents exogenised version	Percent	EXOH
RGLI	Implicit average rate of interest on national loans outstanding	Percent	ENDOT
RGLIF	Foreign currency version of the variable RGLI	Percent	EXO1
RGLIH	Equivalent to RGLI-represents exogenised version	Percent	EXOH
RGLSSI	Implicit average rate of interest on small savings	Percent	ENDOT
RGLSSIF	Foreign currency version of the variable RGLSSI	Percent	EXO1
RGLSSIH	Equivalent to RGLSSI-represents exogenised version	Percent	EXOH
RGTTAX	Total tax revenue as a percentage of GNP	Percent	ENDOI
RGTYC	Implicit average rate of corporation tax	Fraction	ENDOT
RGTYCH	Equivalent to RGTYC-represents exogenised version	Percent	EXO2
RGTYSE	Implicit average employer's social insurance rate	Fraction	ENDOT
RGTYSEH	Equivalent to RGTYSE-represents exogenised version	Fraction	EXO2
RGTYSL	Implicit total average rate of social insurance contributions	Fraction	ENDOI
RGTYSP	Implicit average employee's social insurance rate	Fraction	ENDOT
RGTYSPH	Equivalent to RGTYSP-represents exogenised version	Fraction	EXO2
RNDI	Total public authorities debt interest as a percentage of GNP	Percent	ENDOI
RNDIF	Foreign debt interest as a percentage of GNP	Percent	ENDOI
RPL	Prime lending rate of interest	Percent	ENDOT
RPLF	Foreign currency version of RPL	Percent	EXO1
RPLH	Equivalent to RPL-represents exogenised version	Percent	EXOH
RR	Official external reserves as a percentage of total imports	Percent	ENDOI
RRPL	Real interest rate	Percent	ENDOI
RTEO	Implicit rate of indirect taxation on the residual category	Index	ENDOT
RTEOH	Equivalent to RTEO-represents exogenised version	Index	EXO2
RTYPER	Implicit average rate of direct income tax	Fraction	ENDOT
RTYPERH	Equivalent to RTYPER-represents exogenised version	Fraction	EXO2
RTYPTOT	Total implicit average rate of taxation on incomes i.e. includes social insurance contributions by employees	Fraction	ENDOI
RUP	Unemployment transfer payment rate (£ per week)	£	ENDOT
RUPH	Equivalent to RUP-represents exogenised version	£	EXO2
RVAT	Effective rate of value-added tax	Fraction	ENDOT
RVATH	Equivalent to RVAT-represents exogenised version	Fraction	EXO2
RW	Real earnings rate in Ireland relative to the United Kingdom		ENDOI
RWN	Real earnings rate in Ireland relative to the United Kingdom, net of Irish direct taxation	Fraction	ENDOI
RYCI	Real industrial profits per unit of the industrial capital stock		ENDOI
RYCSM	Ratio of added-value deflator to unit labour costs in marketed services		ENDOI
SAV	Personal savings	£m	ENDOI
SAVC	Company savings	£m	ENDOI
SAVG	Gross savings (total available for investment)	£m	ENDOI
SAVNET	Net national savings	£m	ENDOI
SAVRAT	Personal savings ratio	Percent	ENDOI
SAVTOT	Gross national savings	£m	ENDOI
SRUB	Total subsidies in real terms (includes EEC subsidies)	£m,1980	ENDOB
STADL	Agricultural stock changes, excluding intervention	£m,1980	EXO1
STATDIS	Statistical discrepancy (i.e. NIE GDPE less NIE GDPM)	£m,1980	EXOD
STATDISV	Difference between GDPEV and GDPMV (due to transformations of NIE)	£m	EXOD
STAVDL	Agricultural stock changes, excluding intervention	£m	EXO1
STDL	Net stock changes	£m,1980	ENDOI
STIVDL	Intervention stock changes	£m,1980	EXO1
STIVVDL	Intervention stock changes	£m	EXO1
STNA	Level of non-agricultural stocks	£m,1980	ENDOI
STNADL	Non-agricultural stock changes	£m,1980	ENDOB
STNAV	Level of non-agricultural stocks	£m	ENDOI
STNAVDL	Non-agricultural stock changes	£m	ENDOI
STVDL	Total stock changes	£m	ENDOI
SUB	Total subsidies (includes EEC subsidies)	£m	ENDOI
T	Variable denoting year (starting value T=1947)		EXOD
TE	Total indirect tax revenue (includes EEC indirect taxes)	£m	ENDOI
TIME	Time (Starting value = 1 in 1960)		EXOD
TINC	Average net indirect tax rate on private consumption		ENDOI
TOTRADE	Terms of trade, i.e. ratio of total export price to import price		ENDOI
TPC	Variable used in the process of indexation to PC (normally set to unity)		EXOD
TPGNP	Variable used in the process of indexation to PGNP (normally set to unity)		EXOD
TPQGA	Variable used in the process of indexation to PQGA (normally set to unity)		EXOD
TRE	Total indirect tax revenue in real terms (includes EEC taxes)	£m,1980	ENDOB
TREEC	Transfers from the EEC	£m	ENDOT
TREECH	Equivalent to TREEC-represents exogenised version	£m	EXO2
U	Numbers unemployed	Thousands	ENDOI
UCCI	User cost of capital in industry	Index	ENDOI
UCCS	User cost of capital in services	Index	ENDOI
UCLI	Unit labour costs in industry	£/£,1980	ENDOI
UCLIDOT	Rate of change of variable UCLI	Percent	ENDOI
UCLSM	Unit labour costs in marketed services	£/£,1980	ENDOI
UCLW	"World" unit labour costs measure	Index	ENDOT
UCLWDOT	Rate of change of the variable UCLW	Percent	ENDOI
UCLWF	Foreign currency version of the variable UCLW		EXO1
UCOSTI	Average unit cost, relative to output price, of producing gross output	Index	ENDOI
UCOSTIMA	Three-year moving average of UCOSTI	INDEX	ENDOI
UR	Rate of unemployment	Percent	ENDOI
URNAT	Four-year moving average of the unemployment rate	Percent	ENDOI
URUK	Rate of unemployment in the United Kingdom	Percent	EXO1
WEATH3	Index of weather (degree-days above 6 deg. C)	Index	EXO1
WEDGE	"Wedge" between the net-of-tax consumption and the industrial output deflators		ENDOI
WIRUK	Real industrial wages in the United Kingdom	Index	EXO1
WK1	Proportion of social insurance contributions paid by employers	Fraction	EXOD
WL1	Proportion of road tax duties paid by the company sector	Fraction	EXOD
WRELPA	Ratio of public administration average annual earnings to industrial earnings		EXO2
WRELSHE	Ratio of average annual earnings in health and education to those in public administration		EXO2
WTEMV	Value of energy imports as a proportion of the value of total merchandise imports	Fraction	EXOD
WTIME	Fraction of total non-housing fixed investment which consists of machinery and equipment	Fraction	EXOD

X3RES	Re-exports of energy	£m,1980	EXO1
XA	Exports of agricultural goods	£m,1980	ENDOI
XGS	Exports of goods and services	£m,1980	ENDOI
XGSV	Exports of goods and services	£m	ENDOI
XI	Exports of industrial goods	£m,1980	ENDOB
XNA	Exports of non-agricultural goods	£m,1980	ENDOI
XNAV	Exports of non-agricultural goods	£m	ENDOI
XS	Total exports of services	£m,1980	ENDOI
XSO	Exports of services, excluding tourism	£m,1980	ENDOB
XTO	Exports of tourism	£m,1980	ENDOB
YAFS	Adjustment for financial services	£m	ENDOB
YAG	Income arising in agriculture, forestry and fishing	£m	ENDOI
YASA	Adjustment for stock appreciation	£m	ENDOI
YASAIV	Adjustment for stock appreciation for intervention stocks	£m	EXO1
YC	Total non-agricultural profits	£m	ENDOI
YCI	Industrial profits, gross of depreciation	£m	ENDOI
YCIR	Industrial profits deflated by the industrial investment deflator	£m,1980	ENDOI
YCIREP	Gross outflow of profits, dividends and royalties (NIE Table 28)	£m	ENDOT
YCR	Total non-agricultural profits deflated by the investment deflator	£m,1980	ENDOI
YCSHE	Profits in the health and education sector	£m	ENDOT
YCU	Undistributed profits	£m	ENDOB
YFN	Net factor income from abroad ("-" indicates a net outflow)	£m	ENDOI
YFNPO	Net factor income from abroad, excluding foreign debt interest on government borrowings and gross profit repatriation	£m	ENDOT
YFNPOH	Equivalent to YFNPO - represents exogenised version	£m	EXO1
YP	Private income	£m	ENDOI
YPER	Personal income	£m	ENDOI
YPERD	Personal disposable income	£m	ENDOI
YPERT	Taxable income	£m	ENDOI
YPO	Non-wage taxable income	£m	ENDOI
YRAFS	Adjustment for financial services	£m,1980	ENDOI
YRFN	Net factor income from abroad ("-" indicates a net outflow)	£m,1980	ENDOI
YRPERD	Personal disposable income	£m	ENDOI
YSEAG	Income of the self-employed in agriculture	£m	ENDOT
YWAG	Wage income in agriculture	£m	ENDOI
YWDIS	Disequilibrium measure of "world" demand	Index	ENDOI
YWI	Wage bill in industry	£m	ENDOI
YWNA	Wage bill in the non-agricultural sector	£m	ENDOI
YWPA	Wage bill in public administration	£m	ENDOT
YWPAH	Equivalent to YWPA-represents exogenised version	£m	EXOH
YWSHE	Wage bill in health and education	£m	ENDOT
YWSHEH	Equivalent to YWSHE - represents exogenised version	£m	EXOH
YWSM	Wage bill in the marketed services sector	£m	ENDOI
YWSO	Wage bill in the services sector, excluding public administration	£m	ENDOI

APPENDIX 2 : ANNOTATED MODEL LISTING

The assembled HERMES-Ireland model can be considered conveniently as consisting of three main blocks:

(1) The Supply Block
(2) The Absorption Block
(3) The Income Distribution Block

Each of the three main blocks is subdivided as follows: the **Supply Block** has five components;

Industry (eqns 1-46)
Agriculture (eqns 47-70)
Services (eqns 71-99)
Imports (eqns 100-130)
Labour Supply (eqns 131-161)

where **Services** is further subdivided as follows:

Marketed Services (eqns 71-90, and 96-99)
Health and Education (eqns 91-93)
Public administration (eqns 94-95)

The **Absorption Block** is organised around the main expenditure components and determines GDP on an expenditure basis:

Private Consumption (eqns 162-165)
Public Consumption (eqns 166-171)
Investment (eqns 172-189)
Stock Changes (eqns 190-195)
Exports (eqns 196-203)
Expenditure Identities (eqns 204-220)

The **Income Distribution Block** determines prices, wages, and the necessary GDP income identities:

Prices (eqns 221-264)
Wages (eqns 265-295)
Fiscal (eqns 296-404)
Income Identities (eqns 405-442)
Monetary (eqns 443-469)

where the **Fiscal Block** is further subdivided as follows:

Instrument Indexation Rules (eqns 296-328)
Tax Revenue (eqns 329-357)
Subsidies and Transfers (eqns 358-373)
Borrowing and Debt Financing (eqns 374-404)

The model equations are organised in the above sequence, which also corresponds to the most logical economic sequence for solving the model, being the dominant causal structure.

The following are some further points concerning the manner in which the model has been operationalised:

(a) Multiple choices have been provided for certain behavioural equations where a degree of uncertainty surrounded the specification and estimation: these are as follows: industrial capacity output (QSTARI); imports of consumption goods (MC); imports of agricultural materials (MMFPA); private consumption (C); industrial wage rates (AAEI); and interest on domestic debt (GCTNDID).

(b) Multiple selections are available for setting policy indexation rules by means of parameters whose values may be selected at the time of simulation;

(c) A distinction is made between government debt interest paid to residents and to foreigners, the latter representing a negative net factor income from abroad;

(d) The gap between GNP and GDP in Ireland is of major policy significance. It is modelled in three parts: industrial profit repatriations by multinational companies (YCIREP); foreign debt interest outflows (GCTNDIF); and other private factor income flows from abroad (YFNPO).

(e) A simple model of the flow of funds within the company, household and government sectors is provided.

THE SUPPLY BLOCK

(1) : THE INDUSTRIAL SECTOR

The underlying trend in world industrial output, QWSTARI, is defined as a three-year moving average of actual output (QIW). Deviations from trend (YWDIS) are defined as the ratio of actual to trend world output.

```
1:    QWSTARI = KQCIW*(QIW+QIW(-1)+QIW(-2))

2:    YWDIS = QIW/QWSTARI
```

Three variants of the equation determining planned gross industrial output (i.e., added-value plus energy) are available. The first is driven by domestic profitability (PRIRLS) relative to three major economies: the United States, Germany and the United Kingdom. The second is driven by profitability relative to a single aggregate measure of profitability in the above three economies (i.e., PRWORS). The third simply determines the Irish share of world capacity output as a time trend, unaffected by profitability considerations. Equation 3 is the default choice (i.e., VE01 = 1).

```
3:    DV01A = QWSTARI*(AI1+AI2*(PRUSAS/PRIRLS)**0.5+AI3*(PRGERS/PRIRLS)**0.5+AI4*(PRUKS/PRIRLS)**0.5+AI5*(T-ZT1))*AI6-(AI6-
      AI7)*QWSTARI(-1)*(AI1+AI2*(PRUSAS(-1)/PRIRLS(-1))**0.5+AI3*(PRGERS(-1)/PRIRLS(-1))**0.5+AI4*(PRUKS(-1)/PRIRLS(-1))**
      0.5+AI5*(T(-1)-ZT1(-1)))+(1-AI7)*QSTARI(-1)+FQSTARA

     QSTARI = QWSTARI*(AI1+AI2*(PRUSAS/PRIRLS)**0.5+AI3*(PRGERS/PRIRLS)**0.5+AI4*(PRUKS/PRIRLS)**0.5+AI5*T)*AI6-(AI6-AI7)*QWSTARI
(-1)*(AI1+AI2*(PRUSAS(-1)/PRIRLS(-1))**0.5+AI3*(PRGERS(-1)/PRIRLS(-1))**0.5+AI4*(PRUKS(-1)/PRIRLS(-1))**0.5+AI5*T(-1))+(1-AI7)*
QSTARI(-1)
```

```
NOB = 22                   NOVAR = 7                    RANGE:  1963  TO  1984
RSQ =             0.999896 CRSQ =              0.999854 F(7/15) =       NA          PROB>F =         NA
SER =            42.4669   SSR =           27051.6      DW(0) =         2.52524     COND =           288.71
MAX:HAT =         0.62805  RSTUDENT =          2.7003   DFFITS =        2.14349
```

COEF	ESTIMATE	STER	TSTAT
AI1	8936.	1172.43	7.62176
AI2	2575.41	1043.49	2.46807
AI3	-6663.82	938.7	-7.09899
AI4	-2240.99	946.391	-2.36793
AI5	62.2396	8.67601	7.17376
AI6	0.103115	0.114052	0.90411
AI7	0.661099	0.094784	6.9748

```
4:      DV01B = QWSTARI*(BI1+BI2*(PRWORS/PRIRLS)**0.5+BI3*(T-ZT1))*BI4-(BI4-BI5)*QWSTARI(-1)*(BI1+BI2*(PRWORS(-1)/PRIRLS(-1))
        **0.5+BI3*(T(-1)-ZT1(-1)))+(1-BI5)*QSTARI(-1)+FQSTARB

    QSTARI = QWSTARI*(BI1+BI2*(PRWORS/PRIRLS)**0.5+BI3*T)*BI4-(BI4-BI5)*QWSTARI(-1)*(BI1+BI2*(PRWORS(-1)/PRIRLS(-1))**0.5+BI3*T(
-1))+(1-BI5)*QSTARI(-1)

NOB = 22              NOVAR = 5                 RANGE:  1963  TO  1984
RSQ =          0.999687 CRSQ =         0.999614  F(5/17) =        NA         PROB>F =       NA
SER =          69.158   SSR =          81308.    DW(0) =          1.11554    COND =         131.319
MAX:HAT =      0.411342 RSTUDENT =     -2.10235  DFFITS =         -1.61292
```

COEF	ESTIMATE	STER	TSTAT
BI1	5391.27	1776.83	3.03421
BI2	-4200.95	1432.33	-2.93296
BI3	97.6015	11.0107	8.86425
BI4	0.434216	0.157523	2.75653
BI5	0.402301	0.145014	2.77422

```
5:      LOG(DV01C/QWSTARI) = CI1+CI2*(T-ZT1)+RHO01C*R01C(-1)+LOG(FQSTARC)

    LOG(QSTARI/QWSTARI) = CI1+CI2*T

NOB = 20              NOVAR = 3                 RANGE:  1964  TO  1984
RSQ =          0.992949 CRSQ =         0.99212   F(1/17) =        1197.09    PROB>F =       0.
SER =          0.020167 SSR =          0.006914  DW(0) =          1.39718    COND =         10.0754
MAX:HAT =      0.185714 RSTUDENT =     -2.92967  DFFITS =         -1.39911
```

COEF	ESTIMATE	STER	TSTAT
CI1	7.04675	0.050445	139.692
CI2	0.0386	0.00172	22.4468
RHO1	0.558044	0.144486	3.86228

```
6:      QSTARI = IF VE01 EQ 1 THEN DV01A ELSE (IF VE01 EQ 2 THEN DV01B ELSE DV01C)
```

The technology underlying the industrial sector is a three-factor bundled CES-CES type. Capital (KI) and energy (EI) are combined in one vintage bundle, and the resulting capital-energy composite is combined with labour, assuming Harrod neutral technical progress. In equations 7-14 below, the capital stock and investment are determined. The optimal capital-output ratio (KQSTAR) is the product of the optimal capital-KE ratio and the optimal KE-output ratio, the latter two variables being determined as functions of expected capital, energy and labour prices. The crucial optimal capital stock (KSTARI) is the product of the optimal capital-output ratio (KQSTAR) and planned output (QSTARI).

```
7:      KKESTAR = (BI+CI*(CI/BI*(EUCCI/EPE))**(SI-1))**(SI/(1-SI))

8:      KEQSTAR = (BCI+BBI*(BBI/BCI*(EPCKE/(EAAEI/EXP(GI*TIME))))**(TI-1))**(TI/(1-TI))

9:      KQSTAR = KKESTAR*KEQSTAR

10:     KSTARI = KQSTAR*QSTARI
```

Actual investment (II) is a dynamic function of the optimal capital stock (KSTARI) and deviations from trend in unit production costs.

```
11:     DEL( LOG(II)) = A031I+A032I*DEL( LOG(KSTARI))+A033I*LOG(KSTARI(-1)/II(-1))+A034I*LOG(UCOSTI/UCOSTIMA)+LOG(FII)

    DEL(1 : LOG(II)) = A031I+A032I*DEL(1 : LOG(KSTARI))+A033I*LOG(KSTARI(-1)/II(-1))+A034I*LOG(UCOSTI/UCOSTIMA)

NOB = 21              NOVAR = 4                 RANGE:  1964  TO  1984
RSQ =          0.505148 CRSQ =         0.417821  F(3/17) =        5.78457    PROB>F =       0.006476
SER =          0.077319 SSR =          0.10163   DW(0) =          2.13711    COND =         58.6099
MAX:HAT =      0.446369 RSTUDENT =     2.82846   DFFITS =         -1.76783
```

COEF	ESTIMATE	STER	TSTAT
A031I	-0.706731	0.412024	-1.71526
A032I	2.26163	0.724919	3.11983
A033I	0.320624	0.206399	1.55341
A034I	-1.88391	0.944254	-1.99513

The perpetual inventory method generates the actual capital stock (KI), assuming a given, fixed, rate of economic depreciation RSCRI.

```
12:     KI = II+(1-RSCRI)*KI(-1)

13:     KIBAR = (KI+KI(-1))/2.
```

Finally, a vintage measure of the capital-energy bundle (KEVIN) is defined, where a fraction RETRO (currently 20%) of the capital stock can be retro-fitted in lined with optimal capital-energy ratios.

```
14:     KEVIN = (1-RSCRI-RETRO)*KEVIN(-1)+(II+RETRO*KI(-1))*(BI+CI*(CI/BI*(EUCCI/EPE))**(SI-1))**(SI/(SI-1))
```

A vintage measure of energy inputs is determined by the rate of economic depreciation of the capital stock (RSCRI), the rate of retro-fitting (RETRO), and the expected relative cost of capital to energy (EUCCI/EPE).

```
15:     EVIN = (1-RSCRI-RETRO)*EVIN(-1)+(II+RETRO*KI(-1))*(CI/BI*(EUCCI/EPE))**SI
```

Actual energy inputs (EI) depends on the vintage measure (EVIN) and the rate of capacity utilisation (CURH).

```
16:     LOG(EI) = A051I*LOG(EVIN)+A052I*LOG(CURH)+LOG(FEI)

    LOG(EI) = A051I*LOG(EVIN)+A052I*LOG(CURH)

NOB = 21              NOVAR = 2                 RANGE:  1964  TO  1984
RSQ =          0.999974 CRSQ =         0.999972  F(2/19) =        NA         PROB>F =       NA
SER =          0.035529 SSR =          0.023984  DW(0) =          1.38827    COND =         4.03338
MAX:HAT =      0.212393 RSTUDENT =     -2.0307   DFFITS =         0.629697
```

COEF	ESTIMATE	STER	TSTAT
A051I	0.991384	0.002469	401.465
A052I	0.381271	0.113804	3.35026

The optimal labour-output ratio (LQSTAR) is a function of the expected relative price of the KE bundle (EPCKE) to labour (EAAEI), and an exponentially declining function of time (the Harrod-neutrality). The optimal labour input (LSTARI) is the product of LQSTAR and planned output (QSTARI).

```
17:    LQSTAR = EXP((-GI)*TIME)*((1-BCI*(BCI+BBI*(BBI/BCI*(EPCKE/(EAAEI/EXP(GI*TIME))))**(TI-1))**(-1))/BBI)**(TI/(TI-1))

18:    LSTARI = LQSTAR*QSTARI
```

Actual labour inputs (LI) are a dynamic function (ECM) of optimal inputs (LSTARI) and of the rate of capacity utilisation (CURH).

```
19:    DEL( LOG(LI)) = A041I+A042I*DEL( LOG(LSTARI))+A043I*LOG(LSTARI(-1)/LI(-1))+A044I*LOG(CURH)+RHO04I*R04I(-1)+LOG(
       FLI)

    DEL(1 : LOG(LI)) = A041I+A042I*DEL(1 : LOG(LSTARI))+A043I*LOG(LSTARI(-1)/LI(-1))+A044I*LOG(CURH)

NOB = 20                  NOVAR = 5                     RANGE:  1964  TO  1984
RSQ =          0.967705 CRSQ =           0.959093  F(3/15) =       112.368      PROB>F =        0.
SER =          0.007269 SSR =            0.000793  DW(0) =           2.18763    COND =          6.57145
MAX:HAT =      0.453005 RSTUDENT =      -2.76899   DFFITS =         -1.19905
```

COEF	ESTIMATE	STER	TSTAT
A041I	0.011373	0.00326	3.48883
A042I	1.30112	0.066857	19.461
A043I	0.317081	0.057978	5.46898
A044I	0.229059	0.028853	7.93893
RHO1	-0.196385	0.209137	-0.939027

"Normal" industrial output (QVIN), i.e., the output which could be produced with existing factor inputs at normal rates of utilisation, is a CES function of LI and KEVIN.

```
20:    QVIN = (BBI*(EXP(GI*TIME)*LI)**((TI-1)/TI)+BCI*KEVIN**((TI-1)/TI))**(TI/(TI-1))
```

Actual industrial output (QHI) is a dynamic (ECM) function of normal output (QVIN), modified by deviations of domestic industrial demand from trend and deviations of world output from trend.

```
21:    DEL( LOG(QHI)) = A061I*DEL( LOG(QVIN))+A062I*LOG(QVIN(-1)/QHI(-1))+A063I*DEL( LOG(GSOID/QVIN))+A064I*DEL(1 :
       LOG(YWDIS))+LOG(FQHI)

      DEL(1 : LOG(QHI)) = A061I*DEL(1 : LOG(QVIN))+A062I*LOG(QVIN(-1)/QHI(-1))+A063I*DEL(1 : LOG(GSOID/QVIN))+A064I*DEL(1 : LOG(
YWDIS))

NOB = 21                  NOVAR = 4                     RANGE:  1964  TO  1984
RSQ =          0.860978 CRSQ =           0.836444  F(4/17) =       NA           PROB>F =        NA
SER =          0.023447 SSR =            0.009346  DW(0) =         1.44206      COND =          2.32511
MAX:HAT =      0.408757 RSTUDENT =       2.36828   DFFITS =        1.31812
```

COEF	ESTIMATE	STER	TSTAT
A061I	0.902602	0.096237	9.37891
A062I	0.090528	0.078484	1.15347
A063I	0.343331	0.190832	1.79912
A064I	0.368094	0.192488	1.9123

The rate of capacity utilisation (CURH) is a suitably scaled ratio of QHI to QVIN.

```
22:    CURH = 1/KCURH*(QHI/QVIN)
```

Equations 23-26 determine added-value in industry in constant (OI) and current (OIV) prices.

```
23:    OI = QHI-EI

24:    QHIV = PQHI*QHI

25:    EIV = PE*EI

26:    OIV = QHIV-EIV
```

Equations 27-31 determine the industrial sector wage bill (YWI), profits (YCI), profit repatriation (YCIREP),profits in constant prices (YCIR) and profits per unit of capital stock (RYCI). Note that the average propensity to repatriate profits made by multinationals (KYCI) is an exogenous variable.

```
27:    YWI = LI*AAEI

28:    YCI = OIV-YWI

29:    YCIREP = KYCI*YCI

30:    YCIR = YCI/PII

31:    RYCI = YCIR/KI
```

The key measure of competitiveness used in the model to determine Irelands share of world capacity output is profit per unit of added-value (PRIRL) and a three-year moving average of this (PRIRLS).

```
32:    PRIRL = (OIV-YWI)/OIV

33:    PRIRLS = (PRIRL+PRIRL(-1)+PRIRL(-2))/3.
```

Equations 34-36 determine labour productivity (OPRI), unit labour costs (UCLI) and the trend of productivity (EOPRI).

```
34:    OPRI = OI/LI

35:    UCLI = AAEI/OPRI

36:    LOG(EOPRI) = A101+A102*(T-ZT2)+LOG(FEOPRI)

    LOG(OPRI) = A101+A102*T

NOB = 21                  NOVAR = 2                     RANGE:  1964  TO  1984
RSQ =          0.970727 CRSQ =           0.969186  F(1/19) =      630.06        PROB>F =        0.
SER =          0.038853 SSR =            0.028681  DW(0) =          1.01473     COND =          9.02857
MAX:HAT =      0.177489 RSTUDENT =       3.0942    DFFITS =         1.43735
```

COEF	ESTIMATE	STER	TSTAT
A101	1.02537	0.038743	26.4657
A102	0.035145	0.0014	25.101

Equations 37-45 determine certain price, wage and cost measures used in the industrial sector model: the price of the optimal capital-energy bundle (PCKE) and the optimal capital-energy-labour bundle (PCKEL); unit costs of production (UCOSTI) and its trens (UCOSTIMA); the user-cost of capital (UCCI) and its trend (EUCCI) and the trend energy price (EPE), labour price (EAAEI) and the trend in PCKE (EPCKE).

37: PCKE = (BI**SI*UCCI**(1-SI)+CI**SI*PE**(1-SI))**(1/(1-SI))

38: PCKEL = (BBI**TI*(AAEI/EXP(GI*TIME))**(1-TI)+BCI**TI*PCKE**(1-TI))**(1/(1-TI))

39: UCOSTI = (AAEI*LI+PE*EI+PII*KI(-1)*(RSCRI+RES/100+DFR*RRPL/100))/(PQHI*QHI)

40: UCOSTIMA = (UCOSTI+UCOSTI(-1)+UCOSTI(-2))/3.

41: UCCI = PII*(RSCRI+RHORI/100)*(1-RGKTI)/(1-RGTYC)

42: EUCCI = (UCCI+UCCI(-1)+UCCI(-2))/3

43: EPE = (PE+PE(-1)+PE(-2))/3

44: EAAEI = (AAEI+AAEI(-1)+AAEI(-2))/3

45: EPCKE = (PCKE+PCKE(-1)+PCKE(-2))/3

Finally, national accounting depreciation (DEPI) is a function of the lagged value of the capital stock.

46: LOG(DEPI) = A581+A582*LOG(PII(-1)*KI(-1))+RHO58*R58(-1)+LOG(FDEPI)

LOG(DEPI) = A581+A582*LOG(PII(-1)*KI(-1))

NOB = 20		NOVAR = 3		RANGE: 1964 TO 1984			
RSQ =	0.986121	CRSQ =	0.984489	F(1/17) =	603.953	PROB>F =	0.
SER =	0.102076	SSR =	0.177133	DW(0) =	1.68429	COND =	14.0601
MAX:HAT =	0.148506	RSTUDENT =	2.95887	DFFITS =	1.01867		

COEF	ESTIMATE	STER	TSTAT
A581	-0.50475	0.516912	-0.976471
A582	0.685513	0.065565	10.4555
RHO1	0.696798	0.137353	5.07303

(2) : THE AGRICULTURAL SECTOR

Capacity output in agriculture (QGCA) is simply a five-year moving-average of actual output, QGA.

47: QGCA = KQGCA*(QGA(-1)+QGA(-2)+QGA(-3)+QGA(-4)+QGA(-5))

Actual agricultural output, QGA, is a function of the relative price of output to material inputs, lagged one period, and of a measure of how favourable the growing season was (WEATH3).

48: QGA = A051+(A052*WEATH3+A053*PQGA(-1)/PQMA(-1))*QGCA+FQGA

QGA = A051+(A052*WEATH3+A053*PQGA(-1)/PQMA(-1))*QGCA

NOB = 20		NOVAR = 3		RANGE: 1965 TO 1984			
RSQ =	0.890215	CRSQ =	0.877299	F(2/17) =	68.9242	PROB>F =	0.
SER =	79.2629	SSR =	106804.	DW(0) =	1.67033	COND =	22.5495
MAX:HAT =	0.425601	RSTUDENT =	2.26273	DFFITS =	1.19793		

COEF	ESTIMATE	STER	TSTAT
A051	99.1993	132.488	0.748742
A052	0.000372	5.805568E-05	6.40584
A053	0.232995	0.102119	2.2816

The ratio of material inputs to output is a simple time trend.

49: LOG(QMA/QGA) = A061+A062*(T-ZT3)+LOG(FQMA)

LOG(QMA/QGA) = A061+A062*T

NOB = 21		NOVAR = 2		RANGE: 1964 TO 1984			
RSQ =	0.784969	CRSQ =	0.773652	F(1/19) =	69.3594	PROB>F =	0.
SER =	0.066784	SSR =	0.084743	DW(0) =	1.24599	COND =	9.02857
MAX:HAT =	0.177489	RSTUDENT =	2.7597	DFFITS =	-1.03375		

COEF	ESTIMATE	STER	TSTAT
A061	-1.50107	0.066596	-22.5398
A062	0.020044	0.002407	8.32823

Gross agricultural output (QGA) is allocated over domestic absorption (QDA), stock changes (STADL and STIVDL) and exports (XA). Domestic absorption relative to output is a simple function of time. Stock changes are exogenous. Exports are derived residually.

50: QDA/QGA = A091+A092*(T-ZT5)+FQDA/QGA

QDA/QGA = A091+A092*T

NOB = 21		NOVAR = 2		RANGE: 1964 TO 1984			
RSQ =	0.477848	CRSQ =	0.450366	F(1/19) =	17.3879	PROB>F =	0.00052
SER =	0.029067	SSR =	0.016053	DW(0) =	1.24689	COND =	9.02857
MAX:HAT =	0.177489	RSTUDENT =	-2.92165	DFFITS =	-0.662601		

COEF	ESTIMATE	STER	TSTAT
A091	0.5142	0.028985	17.7399
A092	-0.004368	0.001048	-4.16988

51: XA = QGA-QDA-STADL-STIVDL

Equations 52-59 determine added-value in agriculture, forestry and fishing. Added-value in agriculture (OA and OAV) is determined by gross output net of material inputs and adjusted for agricultural subsidies not related to sales and by indirect taxes. Added-value in forestry and fishing (OAFF and OAFFV) is exogenous.

```
52:    OA = QGA-QMA+GCSANS/PSUB-GTEARL/PTE
53:    OAFF = IF Z2 EQ 1 THEN OAFFH ELSE (IF Z2 EQ 2 THEN OAFF(-1)*OA/OA(-1) ELSE OAFFH*OA/OAH)
54:    OAG = OA+OAFF
55:    QGAV = PQGA*QGA
56:    QMAV = PQMA*QMA
57:    OAV = QGAV-QMAV+GCSANS-GTEARL
58:    OAFFV = IF Z2 EQ 1 THEN OAFFVH ELSE (IF Z2 EQ 2 THEN OAFFV(-1)*OAV/OAV(-1) ELSE OAFFVH*OAV/OAVH)
59:    OAGV = OAV+OAFFV
```

Equations 60-62 determine income in AFF (YAG) as added-value less depreciation, income from self-employment (YSEAG) as an exogenous fraction of YAG, and wage income (YWAG) residually.

```
60:    YAG = OAGV-DEPAG
61:    YSEAG = KYSEAG*YAG
62:    YWAG = YAG-YSEAG
```

Employment in agriculture (LAG) is declining exponentially with time.

```
63:    LOG(LAG) = A071+A072*(T-ZT4)+RHO07*R07(-1)+LOG(FLAG)

       LOG(LAG) = A071+A072*T

NOB = 20              NOVAR = 3                 RANGE:  1964  TO  1984
RSQ =       0.993347  CRSQ =         0.992564   F(1/17) =     1269.05    PROB>F =       0.
SER =       0.014762  SSR =          0.003704   DW(0) =          1.3339  COND =         10.5554
MAX:HAT =   0.185714  RSTUDENT =    -2.6192     DFFITS =      -0.937346
```

COEF	ESTIMATE	STER	TSTAT
A071	6.25787	0.06251	100.11
A072	-0.028317	0.002036	-13.9099
RHO1	0.726733	0.136421	5.32712

The capital stock (of buildings and machinery only) is a function of added-value and the real cost of capital. This equation displays great inertia due to the large coefficient A084. Actual investment (IAG) is derived by reversing the perpetual inventory equation used originally to derive KAG.

```
64:    LOG(KAG) = A081+A082*LOG((OAG(-1)+OAG(-2))/2)+A083*LOG(PKAG/POAG)+A084*LOG(KAG(-1))+RHO08*R08(-1)+LOG(FKAG)

       LOG(KAG) = A081+A082*LOG((OAG(-1)+OAG(-2))/2.)+A083*LOG(PKAG/POAG)+A084*LOG(KAG(-1))

NOB = 20              NOVAR = 5                 RANGE:  1964  TO  1984
RSQ =       0.998506  CRSQ =         0.998107   F(3/15) =     2506.2     PROB>F =       0.
SER =       0.007646  SSR =          0.000877   DW(0) =          1.33589 COND =         138.221
MAX:HAT =   0.552502  RSTUDENT =    -2.25042    DFFITS =      -0.907768
```

COEF	ESTIMATE	STER	TSTAT
A081	-0.016615	0.428941	-0.038736
A082	0.072135	0.051087	1.41201
A083	-0.045926	0.018469	-2.4866
A084	0.928187	0.058917	15.7542
RHO1	0.812116	0.138283	5.87283

```
65:    IAG = KAG-(1-RSCRS)*KAG(-1)
```

Equations 66-69 determine certain price measures: AAEAGIMP is an implicit average annual earnings measure; RAW is a measure of earnings in AFF relative to the non-agricultural sector; PKAG is the user-cost of capital in AFF.

```
66:    AAEAGIMP = YAG/LAG
67:    RAW = AAEAGIMP/AAENA
68:    ERAW = (RAW(-1)+RAW(-2))/2.
69:    PKAG = PIAG*(RRRETA+RSCRA)
```

Finally, national accounting depreciation (DEPAG) is a function of the lagged value of the capital stock.

```
70:    LOG(DEPAG) = A591+A592*LOG(PIAG(-1)*KAG(-1))+RHO59*R59(-1)+LOG(FDEPAG)

       LOG(DEPAG) = A591+A592*LOG(PIAG(-1)*KAG(-1))

NOB = 20              NOVAR = 3                 RANGE:  1964  TO  1984
RSQ =       0.996741  CRSQ =         0.996358   F(1/17) =     2599.99    PROB>F =       0.
SER =       0.074999  SSR =          0.095622   DW(0) =          2.05812 COND =         12.6809
MAX:HAT =   0.176869  RSTUDENT =     6.37013    DFFITS =         1.82109
```

COEF	ESTIMATE	STER	TSTAT
A591	-3.49701	1.17399	-2.97875
A592	1.08867	0.136003	8.00475
RHO1	0.911432	0.033396	27.2918

(3) : THE SERVICES SECTOR

Capacity output in marketed services (OSTARSM) is a three-year moving average of actual output (OSM). Actual output in constant prices is derived as a function of final demand weighted by services output content (GSOSM) and a time trend to capture secular shifts in composition.

```
71:    OSTARSM = KOSM*(OSM+OSM(-1)+OSM(-2))
72:    LOG(OSM) = A011S+A012S*LOG(GSOSM)+A013S*(T-ZT6)+RHO01S*R01S(-1)+LOG(FOSM)

       LOG(OSM) = A011S+A012S*LOG(GSOSM)+A013S*T

NOB = 20              NOVAR = 4                 RANGE:  1964  TO  1984
RSQ =       0.997485  CRSQ =         0.997014   F(2/16) =     2115.62    PROB>F =       0.
SER =       0.012414  SSR =          0.002466   DW(0) =          2.46428 COND =         307.267
MAX:HAT =   0.289631  RSTUDENT =     1.88384    DFFITS =      -0.963606
```

COEF	ESTIMATE	STER	TSTAT
A011S	2.55171	0.415929	6.13497
A012S	0.670443	0.065837	10.1834
A013S	0.007776	0.003021	2.57436
RHO1	0.266811	0.140642	1.89709

The value of output in marketed services (OSMV) is derived residually from the current price identity of GDP on an output and expenditure basis.

73: OSMV = GDPEV-(OIV+OAGV+OSHEV+OPAV-YAFS+(TE-SUB))-STATDISV

The determination of factor inputs in marketed services is a hybrid version of the more rigorous methods used in the industrial sector above. The production function underlying marketed services is a two-factor (added-value) CES type. The optimal factor inputs are derived from a process of cost minimisation. Equations 74-77 determine the capital stock and investment. The optimal capital-output ratio (KQSTARSM) is a function of expected relative factor prices. The optimal capital stock (KSTARSM) is the product of KQSTARSM and the trend output (OSTARSM). The actual capital stock is a function of trend output and real factor prices. Investment (ISM) is recovered by inverting the perpetual inventory equation.

74: KQSTARSM = (BCS+BBS*(BBS/BCS*(EUCCS/(EAAESM/EXP(GS*TIME))))**(SS-1))**(SS/(1-SS))

75: KSTARSM = KQSTARSM*OSTARSM

76: LOG(KSM) = A021S+A022S*LOG(OSTARSM)+A023S*LOG(EUCCS/EPOSM)+A024S*LOG(EAAESM/EPOSM)+A025S*LOG(KSM(-1))+LOG(FKSM)

LOG(KSM) = A021S+A022S*LOG(OSTARSM)+A023S*LOG(EUCCS/EPOSM)+A024S*LOG(EAAESM/EPOSM)+A025S*LOG(KSM(-1))

NOB = 21		NOVAR = 5		RANGE: 1964 TO 1984			
RSQ =	0.9995	CRSQ =	0.999375	F(4/16) =	7994.04	PROB>F =	0.
SER =	0.009154	SSR =	0.001341	DW(0) =	1.79643	COND =	1127.66
MAX:HAT =	0.42952	RSTUDENT =	2.21299	DFFITS =	1.01188		

COEF	ESTIMATE	STER	TSTAT
A021S	-0.853842	0.280736	-3.04144
A022S	0.600623	0.096775	6.20641
A023S	-0.411329	0.084373	-4.87512
A024S	0.151407	0.054502	2.77799
A025S	0.448987	0.085134	5.27388

77: ISM = KSM-(1-RSCRS)*KSM(-1)

The optimal labour-output ratio and optimal labour inputs are similarly determined (compare eqns. 74-75 above). However, actual labour inputs (LSM) are derived from the underlying optimal factor proportions formula in equation 80.

78: LQSTARSM = ((1-BCS*(BCS+BBS*(BBS/BCS*(EUCCS/(EAAESM/EXP(GS*TIME))))**(SS-1))**(-1))/BBS)**(SS/(SS-1))*EXP((-GS)*TIME)

79: LSTARSM = LQSTARSM*OSM

80: LOG(LSM/KSM) = A031S+A032S*LOG(EAAESM/EUCCS)+A033S*T+RHO03S*R03S(-1)+LOG(FLSM)

LOG(LSM/KSM) = A031S+A032S*LOG(EAAESM/EUCCS)+A033S*T

NOB = 20		NOVAR = 4		RANGE: 1964 TO 1984			
RSQ =	0.998445	CRSQ =	0.998153	F(2/16) =	3424.12	PROB>F =	0.
SER =	0.011881	SSR =	0.002259	DW(0) =	1.9094	COND =	102.939
MAX:HAT =	0.284684	RSTUDENT =	-1.9442	DFFITS =	0.809323		

COEF	ESTIMATE	STER	TSTAT
A031S	-0.209963	0.120319	-1.74504
A032S	-0.638092	0.094199	-6.77385
A033S	-0.019815	0.00394	-5.02875
RHO1	0.451292	0.231331	1.95085

Equations 81-84 derive certain price measures: the cost of capital (UCCS) and its trend (EUCCS); the expected output price (EPOSM), and the expected wage rate (EAAESM).

81: UCCS = PIS*(RSCRS+RHORS/100)

82: EPOSM = (POSM+POSM(-1)+POSM(-2))/3

83: EUCCS = (UCCS+UCCS(-1)+UCCS(-2))/3

84: EAAESM = (AAESM+AAESM(-1)+AAESM(-2))/3

Equations 85-87 derive the wage bill in marketed services (YWSM), profits (YCSM) and a measure of profitability (RYCSM).

85: YWSM = LSM*AAESM

86: YCSM = OSMV-YWSM

87: RYCSM = POSM/UCLSM

Equations 88-90 determine labour productivity (OPRSM), trend productivity (EOPRSM) and unit labour costs (UCLSM).

88: OPRSM = OSM/LSM

89: LOG(EOPRSM) = A331+A332*(T-ZT2)+LOG(FEOPRSM)

LOG(OPRSM) = A331+A332*T

NOB = 21		NOVAR = 2		RANGE: 1964 TO 1984			
RSQ =	0.918722	CRSQ =	0.914445	F(1/19) =	214.767	PROB>F =	0.
SER =	0.047123	SSR =	0.04219	DW(0) =	0.433453	COND =	9.02857
MAX:HAT =	0.177489	RSTUDENT =	-1.91943	DFFITS =	-0.820003		

COEF	ESTIMATE	STER	TSTAT
A331	1.3026	0.04699	27.7209
A332	0.024887	0.001698	14.6549

90: UCLSM = AAESM/OPRSM

Equations 91-93 describe the Health and Education sector. Here, the volume of output (OSHE) is determined purely by labour inputs (LSHE) and the value of output (OSHEV) is measured by the adjusted wage bill.

91: OSHE/LSHE = KOPRSHE

92: OSHEV = YWSHE+YCSHE

93: YCSHE = KYCSHE*OSHEV

The volume of output in the Public Administration sector (OPA) is a function of employment (LPA), with a small adjustment for productivity. The value of output (OPAV) is determined by the wage bill (YWPA).

```
94:      LOG(OPA/LPA) = A131+A132*(T-ZT7)+LOG(FOPA)

     LOG(OPA/LPA) = A131+A132*T

NOB = 21                  NOVAR = 2                        RANGE:  1964  TO  1984
RSQ =          0.637482 CRSQ =            0.618402  F(1/19) =     33.4112    PROB>F =         0.
SER =          0.018052 SSR =             0.006192  DW(0) =        1.43627   COND =           9.02857
MAX:HAT =      0.177489 RSTUDENT =       -2.18328   DFFITS =      -0.644193
```

COEF	ESTIMATE	STER	TSTAT
A131	1.96392	0.018002	109.097
A132	0.00376	0.000651	5.78023

```
95:      OPAV = YWPA
```

Equations 96-98 define some aggregates for the total of marketed services plus health and education.

```
96:      OSO = OSM+OSHE

97:      OSOV = OSHEV+OSMV

98:      YWSO = YWSM+YWSHE
```

Finally, national accounting depreciation for total services (DEPS) is a function of the lagged value of the capital stock.

```
99:      LOG(DEPS) = A601+A602*LOG(PIS(-1)*KSM(-1))+RHO60*R60(-1)+LOG(FDEPS)

     LOG(DEPS) = A601+A602*LOG(PIS(-1)*KSM(-1))

NOB = 20                  NOVAR = 3                        RANGE:  1964  TO  1984
RSQ =          0.997661 CRSQ =            0.997386  F(1/17) =   3625.32      PROB>F =         0.
SER =          0.057688 SSR =             0.056575  DW(0) =        1.73286   COND =           13.9465
MAX:HAT =      0.155988 RSTUDENT =       -2.20711   DFFITS =      -0.776471
```

COEF	ESTIMATE	STER	TSTAT
A601	-2.39739	0.254055	-9.43648
A602	1.04232	0.03346	31.1509
RHO1	0.654143	0.149664	4.37074

(4) : IMPORTS AND THE BALANCE OF PAYMENTS

Imports of producers capital goods (MPCG) are a simple function of total investment in machinery and equipment (IME).

```
100:     LOG(MPCG/IME) = A111A+LOG(FMPCG)+RHO11A*R11A(-1)

     LOG(MPCG/IME) = A111A

NOB = 20                  NOVAR = 2                        RANGE:  1964  TO  1984
RSQ =          0.645933 CRSQ =            0.626263  F(0/18) =     32.8378    PROB>F =         0.
SER =          0.062103 SSR =             0.069423  DW(0) =        2.07535   COND =           1.
MAX:HAT =      0.05     RSTUDENT =        2.20721   DFFITS =       0.506369
```

COEF	ESTIMATE	STER	TSTAT
A111A	-0.539076	0.058198	-9.26281
RHO1	0.767752	0.117873	6.51336

Consumption imports (MC) are determined by the volume of consumption (C) and by import prices (PMG) relative to the price of domestic transportable goods prices (PQTI). Two variants are provided: the default version has a imposed unitary elasticity on consumption and a time trend (eqn. 101); the second does not impose the unitary elsticity and drops the time trend.

```
101:     LOG(DV12A/C) = A121A+A122A*(T-ZT8)+A123A*LOG(PMG/PQTI)+A124A*DUM73+A125A*DUM74+A126A*DUM75+RHO12A*R12A(-1)+LOG(FMCA)

     LOG(MC/C) = A121A+A122A*T+A123A*LOG(PMG/PQTI)+A124A*DUM73+A125A*DUM74+A126A*DUM75

NOB = 20                  NOVAR = 7                        RANGE:  1964  TO  1984
RSQ =          0.970582 CRSQ =            0.957005  F(5/13) =     71.4847    PROB>F =         0.
SER =          0.051084 SSR =             0.033924  DW(0) =        1.47472   COND =           12.1723
MAX:HAT =      0.962071 RSTUDENT =       -3.81323   DFFITS =     -19.2047
```

COEF	ESTIMATE	STER	TSTAT
A121A	-2.78811	0.185533	-15.0276
A122A	0.03842	0.006005	6.39834
A123A	-0.328896	0.323109	-1.01791
A124A	-0.150426	0.052873	-2.84507
A125A	-0.207238	0.05772	-3.59043
A126A	-0.171071	0.048665	-3.51526
RHO1	0.659672	0.16076	4.10346

```
102:     LOG(DV12B) = A121B+A122B*LOG(C)+A123B*LOG(PMG/PQTI)+A124B*DUM73+A125B*DUM74+A126B*DUM75+RHO12B*R12B(-1)+LOG(FMCB)

     LOG(MC) = A121B+A122B*LOG(C)+A123B*LOG(PMG/PQTI)+A124B*DUM73+A125B*DUM74+A126B*DUM75

NOB = 20                  NOVAR = 7                        RANGE:  1964  TO  1984
RSQ =          0.991694 CRSQ =            0.98786   F(5/13) =    258.687     PROB>F =         0.
SER =          0.048747 SSR =             0.030892  DW(0) =        1.4166    COND =           18.2007
MAX:HAT =      0.846605 RSTUDENT =       -4.15486   DFFITS =      -9.76093
```

COEF	ESTIMATE	STER	TSTAT
A121B	-6.4367	2.9644	-2.17134
A122B	1.65252	0.317425	5.20603
A123B	-0.401649	0.272283	-1.47512
A124B	-0.186728	0.047472	-3.93342
A125B	-0.224872	0.05169	-4.35042
A126B	-0.159291	0.041364	-3.85098
RHO1	0.969505	0.010247	94.6141

```
103:     MC = IF VE12 EQ 1 THEN DV12A ELSE DV12B
```

Imports of materials for further production in agriculture (MMFPA) are determined by the volume of agricultural output (QGA). As for MC above, two variants are provided, eqn. 104 being the default option.

104: LOG(DV14A/QGA) = A141A+A142A*(T-ZT9)+LOG(FMMFPAA)

LOG(MMFPA/QGA) = A141A+A142A*T

```
NOB = 21               NOVAR = 2              RANGE:  1964  TO  1984
RSQ =       0.660665 CRSQ =        0.642806 F(1/19) =       36.9919   PROB>F =      0.
SER =       0.125877 SSR =         0.301054 DW(0) =          2.02913  COND =        9.02857
MAX:HAT =   0.177489 RSTUDENT =    3.00319  DFFITS =         0.856936
```

COEF	ESTIMATE	STER	TSTAT
A141A	-2.8785	0.125522	-22.9322
A142A	0.02759	0.004536	6.0821

105: LOG(DV14B) = A141B+A142B*LOG(QGA)+LOG(FMMFPAB)

LOG(MMFPA) = A141B+A142B*LOG(QGA)

```
NOB = 21               NOVAR = 2              RANGE:  1964  TO  1984
RSQ =       0.880325 CRSQ =        0.874026 F(1/19) =      139.763    PROB>F =      0.
SER =       0.122789 SSR =         0.286466 DW(0) =          2.2109   COND =        99.2162
MAX:HAT =   0.234891 RSTUDENT =    3.04958  DFFITS =        -0.893755
```

COEF	ESTIMATE	STER	TSTAT
A141B	-10.5231	1.32937	-7.91581
A142B	2.14558	0.181488	11.8222

106: MMFPA = IF VE14 EQ 1 THEN DV14A ELSE DV14B

Energy imports (M3) are derived by subtracting domestic production (QE) from total industrial energy demand (EI), and adjusting for re-exports of energy (X3RES).

107: M3 = EI-QE+X3RES

108: M3V = PM3*M3

The largest import category consists of non-energy imports of materials for further production in industry (MMFPNE). This is derived residually from the constant price identity between GDP on an expenditure and output basis, suitably adjusted for the statistical discrepancy (STATDIS).

109: MMFPNE = GFD-GDPM-STATDIS-(M3+MPCG+MC+MMFPA+MS)

Imports of services (MS) are determined as a function of the volume of consumption (C). Equations 111 and 112 split this between imports of tourism (MTO) and imports of other services (MSO).

110: LOG(MS) = A631+A632*LOG(C)+A633*LOG(MS(-1))+LOG(FMS)

LOG(MS) = A631+A632*LOG(C)+A633*LOG(MS(-1))

```
NOB = 21               NOVAR = 3              RANGE:  1964  TO  1984
RSQ =       0.951456 CRSQ =        0.946062 F(2/18) =      176.399    PROB>F =      0.
SER =       0.096786 SSR =         0.168617 DW(0) =          1.83626  COND =        256.45
MAX:HAT =   0.309913 RSTUDENT =    2.41549  DFFITS =         0.929419
```

COEF	ESTIMATE	STER	TSTAT
A631	-2.03722	1.77679	-1.14658
A632	0.409564	0.293042	1.39763
A633	0.758962	0.137375	5.52476

111 MTO = KMTO*MS

112: MSO = MS-MTO

Equations 113-118 are identities defining total imports of goods (MG, MGV) and total imports of goods and services (MGS, MGSV).

113: MG = MPCG+MC+MMFPA+MMFPNE+M3

114: MGV = M3V+PMGNE*(MMFPA+MPCG+MC+MMFPNE)

115: PMG = MGV/MG

116: MGS = MG+MS

117: MGSV = PMG*MG+PMS*MS

118: PMGS = MGSV/MGS

The terms of trade (TOTRADE) are defined as the ratio of export to import prices.

119: TOTRADE = PXGS/PMGS

Equations 120-121 define the balance of trade and express it as a percentage of GNP (BPTR).

120: BPT = XGSV-MGSV

121: BPTR = 100*(BPT/GNPV)

The private net capital outflows (-BPPK) are cumulated as KBPPK, and added to the net foreign liabilities of the commercial banks (NFLB) to form total net foreign liabilities of the private sector (NFLP).

122: KBPPK = KBPPK(-1)-BPPK

123: NFLP = KBPPK+NFLB

The residual component of net factor income (YFNPO) (i.e. excluding national debt interest and profit repatriation), can, as an option, be related to NFLP by means of an exogenous propensity term (KYFNPO).

124: YFNPO = IF Z24 EQ 1 THEN YFNPOH ELSE KYFNPO*NFLP(-1)

Identities 125-130 define the balance of payments. Options are available to index certain items to movements in world prices.

```
125:    YFN = YFNPO-GCTNDIF-YCIREP

126:    YRFN = IF TYEAR LE 1975 THEN KYFNM*YFN/PMGS ELSE KYFNX*YFN/PXGS

127:    BPTCK = IF Z22 EQ 1 THEN BPTCKH ELSE (IF Z22 EQ 2 THEN PWORLD/PWORLD(-1)*BPTCK(-1) ELSE PWORLD/PWORLDH*BPTCKH)

128:    BPTPRNE = IF Z22 EQ 1 THEN BPTPRNEH ELSE (IF Z22 EQ 2 THEN PWORLD/PWORLD(-1)*BPTPRNE(-1) ELSE PWORLD/PWORLDH*BPTPRNEH)

129:    BP = BPT+YFN+BPTPRNE+(GTTABR-GCTABR)+(EECS-EECTE)+BPTCK

130:    BPR = 100*(BP/GNPV)
```

(5) : DEMOGRAPHICS, LABOUR SUPPLY AND MIGRATION

Simple equations are provided from 131-137 to project the total population (NT), population aged under 15 (NLE14) and of working age (N1564). The default option exogenises population.

```
131:    DEL( DV15)+NMA = A151*NT(-1)+FNT

        DEL(1 : NT)+NMA = A151*NT(-1)

NOB = 21            NOVAR = 1                   RANGE:  1964  TO  1984
RSQ =       0.973614 CRSQ =        0.973614  F(1/20) =      NA        PROB>F =      NA
SER =       5.59434  SSR =       625.934     DW(0) =        1.80469   COND =        1.
MAX:HAT =   0.059843 RSTUDENT =   -3.02652   DFFITS =      -0.636213
```

COEF	ESTIMATE	STER	TSTAT
A151	0.010598	0.00039	27.1658

```
132:    NT = IF Z15 EQ 1 THEN NTH ELSE DV15

133:    DEL(DV16) = A161*NLE14(-1)+A162*NMA+FNLE14

        DEL(1 : NLE14) = A161*NLE14(-1)+A162*NMA

NOB = 21            NOVAR = 2                   RANGE:  1964  TO  1984
RSQ =       0.929607 CRSQ =        0.925902  F(2/19) =      NA        PROB>F =      NA
SER =       2.44514  SSR =       113.595     DW(0) =        0.799525  COND =        1.0058
MAX:HAT =   0.158584 RSTUDENT =   -2.59602   DFFITS =      -0.756884
```

COEF	ESTIMATE	STER	TSTAT
A161 A162	0.007904 -0.282234	0.000553 0.040881	14.2963 -6.90383

```
134:    NLE14 = IF Z15 EQ 1 THEN NLE14H ELSE DV16

135:    DEL(DV17) = A171*N1564(-1)+A172*NMA+FN1564

        DEL(1 : N1564) = A171*N1564(-1)+A172*NMA

NOB = 21            NOVAR = 2                   RANGE:  1964  TO  1984
RSQ =       0.958185 CRSQ =        0.955984  F(2/19) =      NA        PROB>F =      NA
SER =       5.31504  SSR =       536.744     DW(0) =        1.19001   COND =        1.00707
MAX:HAT =   0.156762 RSTUDENT =   -2.76927   DFFITS =       0.994337
```

COEF	ESTIMATE	STER	TSTAT
A171 A172	0.012465 -0.652588	0.000637 0.088864	19.5821 -7.34367

```
136:    N1564 = IF Z15 EQ 1 THEN N1564H ELSE DV17

137:    NGE65 = NT-(NLE14+N1564)
```

An option is available to calculate the participation rate in full time education by those of working age. The default option is to exogenise NEDPR.

```
138:    LOG(DV18) = A181+A182*DUMED+A183*(T-ZT11)+LOG(FNEDPR)

        LOG(NEDPR) = A181+A182*DUMED+A183*T

NOB = 21            NOVAR = 3                   RANGE:  1964  TO  1984
RSQ =       0.984514 CRSQ =        0.982793  F(2/18) =    572.165     PROB>F =      0.
SER =       0.029659 SSR =         0.015834  DW(0) =        0.909987  COND =       18.3211
MAX:HAT =   0.261523 RSTUDENT =   -2.33139   DFFITS =      -1.16022
```

COEF	ESTIMATE	STER	TSTAT
A181 A182 A183	1.21716 0.184676 0.025003	0.038683 0.030092 0.002025	31.4651 6.13707 12.3495

```
139:    NEDPR = IF Z16 EQ 1 THEN NEDPRH ELSE DV18
```

An adjusted population of working age (N1564A) is derived by subtracting the numbers of working age in full-time education from N1564.

```
140:    NLFED = NEDPR*N1564/100

141:    N1564A = N1564-NLFED
```

The dependancy ratio (RDEPEND) is defined as follows.

```
142:    RDEPEND = 100*(NLE14+NGE65+NLFED)/N1564A
```

An option is provided to calculate the aggregate labour force participation rate (LFPR). The default option is to exogenise it.

```
143:    LOG(DV19) = A191+A192*(T-ZT12)+RHO19*R19(-1)+LOG(FLFPR)

        LOG(LFPR) = A191+A192*T

NOB = 20            NOVAR = 3                   RANGE:  1964  TO  1984
RSQ =       0.744327 CRSQ =        0.714248  F(1/17) =     24.7456    PROB>F =      0.
SER =       0.005847 SSR =         0.000581  DW(0) =        1.12114   COND =       11.3956
MAX:HAT =   0.185714 RSTUDENT =   -3.09206   DFFITS =      -1.47667
```

COEF	ESTIMATE	STER	TSTAT
A191	4.18342	0.044521	93.9653
A192	0.001282	0.001345	0.9535
RHO1	0.836126	0.102403	8.16504

144: LFPR = IF Z17 EQ 1 THEN LFPRH ELSE DV19

The total labour force (LF) is defined as the product of the participation rate and the adjusted working-age population.

145: LF = LFPR*N1564A/100

The following identity defines the numbers not in the labour force.

146: NLF = N1564-LF

Equations 147-153 define various employment aggregates: total services employment (LS), total employment (LTOT), non-agricultural employment (LNA), employment in the market sector (LM), employment in the non-agricultural market sector (LMNA), employment in the non-market sector (LNM), and employment in marketed services plus health and education.

147: LS = LSM+LSHE+LPA

148: LTOT = LI+LAG+LS

149: LNA = LI+LS

150: LM = LAG+LI+LSM

151: LMNA = LI+LSM

152: LNM = LPA+LSHE

153: LSO = LSM+LSHE

The numbers unemployed are defined as the difference between the numbers in the labour force (LF) and total employment (LTOT).

154: U = LF-LTOT

Equations 155-156 define the unemployment rate (UR) and a four-year moving average (URNAT).

155: UR = 100*(U/LF)

156: URNAT = (UR+UR(-1)+UR(-2)+UR(-3))/4.

An option is provided to endogenise net outward migration (NMA), as a function of relative earnings (RW) and employment (RE) possibilities between Ireland and the Great Britain.

157: DV20 = A201+A202*RE*RWN+A203*NMA(-1)+FNMA

NMA = A201+A202*RE*RWN+A203*NMA(-1)

```
NOB = 21                NOVAR = 3                   RANGE:  1964  TO  1984
RSQ =          0.659576 CRSQ =          0.621751  F(2/18) =       17.4376   PROB>F =        0.
SER =          8.22352  SSR =        1217.27      DW(0) =          2.33577  COND =         40.5694
MAX:HAT =      0.258062 RSTUDENT =      3.96615   DFFITS =         2.06662
```

COEF	ESTIMATE	STER	TSTAT
A201	19.2832	36.4177	0.529502
A202	-27.4688	51.219	-0.536302
A203	0.743309	0.158232	4.69758

158: NMA = IF Z21 EQ 1 THEN NMAH ELSE DV20

159: RE = (1.-UR/100)/(1.-URUK/100)

160: RW = AAEIR/AAEIR80/WIRUK

161: RWN = RW*RETRAT

THE ABSORPTION BLOCK

Two variants of the consumption function are provided: the first has an aggregate real personal disposable income measure (YRPERD); the second constrains the marginal propensity to consume out of transfer income to be unity. The default choice is the first.

162: DV21A/NT = A211A+A212A*YRPERD/NT+A213A*DUM75+FCA/NT+RHO21A*R21A(-1)

C/NT = A211A+A212A*YRPERD/NT+A213A*DUM75

```
NOB = 20                NOVAR = 4                   RANGE:  1964  TO  1984
RSQ =          0.978988 CRSQ =          0.975048  F(2/16) =      248.487    PROB>F =        0.
SER =          0.030287 SSR =           0.014677  DW(0) =          1.53158  COND =         13.3711
MAX:HAT =      0.743546 RSTUDENT =     -2.94655   DFFITS =        -2.20963
```

COEF	ESTIMATE	STER	TSTAT
A211A	0.32611	0.118578	2.75017
A212A	0.657001	0.061048	10.762
A213A	-0.09479	0.025408	-3.73071
RHO1	0.629286	0.182619	3.44589

163: DV21B/NT = A211B+A212B*((YPERD-(GCTPER-GCTW))/(PC*NT))+A213B*DUM75+1.*(GCTPER-GCTW)/(PC*NT)+FCB/NT+RHO21B*R21B(-1)

C/NT = A211B+A212B*(YPERD-(GCTPER-GCTW))/(PC*NT)+A213B*DUM75+1.*(GCTPER-GCTW)/(PC*NT)

```
NOB = 20                NOVAR = 4                   RANGE:  1964  TO  1984
RSQ =          0.946477 CRSQ =          0.936442  F(2/16) =       94.3128   PROB>F =        0.
SER =          0.034328 SSR =           0.018854  DW(0) =          1.7605   COND =          5.02038
MAX:HAT =      0.611178 RSTUDENT =     -3.82787   DFFITS =        -2.13135
```

COEF	ESTIMATE	STER	TSTAT
A211B	-0.038628	0.194655	-0.198442
A212B	0.786456	0.101073	7.78104
A213B	-0.104098	0.025382	-4.1012
RHO1	0.900685	0.066631	13.5174

164: C = IF VE21 EQ 1 THEN DV21A ELSE DV21B

165: CV = PC*C

Equations 166-171 define consumption by the public authorities. Total public consumption (GCGV) is the sum of wage payments in public administration (OPAV), in Health and Education net of certain wages paid as transfers (GCGOWV), plus non-wage consumption (GCGNPV). Equation 166 defines the constant price consumption (GCG). The deflator of GCGOWV is tied directly to wage rates in Health and Education (PGCGOW).

166: GCGV = OPAV+GCGOWV+GCGNPV

167: GCGNP = GCGNPV/PGCGNP

168: GCG = OPA+GCGOW+GCGNP

169: GCGOWV = YWSHE-GCTW

170: GCGOW = GCGOWV/PGCGOW

171: PGCGOW = PGCGOW(-1)*(AAESHE/AAESHE(-1))

Private housing investment (IHP) is a function of real personal disposable income (YRPERD), the rate of housing transfers (RGKTH) and to a real interest rate (RPL deflated by PIH, the deflator of IHPV).

172: LOG(IHP/NT) = A221+A222*LOG(YRPERD/NT)+A223*LOG(RGKTH)+A224*LOG(RPL/100)-A224*LOG(PIH/PIH(-1))+LOG(FIHP)

LOG(IHP/NT) = A221+A222*LOG(YRPERD/NT)+A223*LOG(RGKTH)+A224*LOG(RPL/100)-A224*LOG(PIH/PIH(-1))

```
NOB = 21                  NOVAR = 4                     RANGE:  1964  TO  1984
RSQ =           0.942987  CRSQ =          0.932926      F(3/17) =       93.7261    PROB>F =        0.
SER =           0.0944    SSR =           0.151492      DW(0) =          1.73308   COND =         55.6567
MAX:HAT =       0.341234  RSTUDENT =      2.45026       DFFITS =         1.26451
```

COEF	ESTIMATE	STER	TSTAT
A221	-4.08769	0.470803	-8.68237
A222	2.31648	0.259944	8.91147
A223	0.038799	0.088954	0.436169
A224	-0.196321	0.142461	-1.37806

173: IHPV = PIH*IHP

Equations 174-175 define the volume of public housing investment (IHG) and total housing investment (IH).

174: IHG = IHGV/PIH

175: IH = IHP+IHG

176: IHV = IHPV+IHGV

Equations 177-189 define various aggregates of investment in current and constant prices. The split of total non-housing investment (ITOT-IH) into machinery and construction (IME) and building and construction (IBC) is by means of an exogenous weighing variable WTIME which is defined so as to reproduce the historical split.

177: IIV = PII*II

178: IAGV = PIAG*IAG

179: IS = ISM+ISHE+IPA

180: ISV = PIS*IS

181: ISMV = ISV-IPAV-ISHEV

182: ITNG = II+IAG+ISM

183: IPA = IPAV/PIPA

184: ISHE = ISHEV/PISHE

185: IGIN = IPA+ISHE

186: ITOT = II+IAG+IS+IH+DISI

187: IME = WTIME*(ITOT-IH)

188: IBC = ITOT-IME-IH

189: ITOTV = IIV+IAGV+ISV+IHV+DISIV

Equations 190-195 define stock changes. Non-agricultural stock changes (STNADL) are a function of the level of industrial output (a simple stock adjustment model), and are accumulated in the variable STNA. Total stock changes (STDL and STVDL) are the sum of agricultural, non-agricultural and intervention stocks.

190: STNADL = A621+A622*OI+A623*STNA(-1)+FSTNADL

STNADL = A621+A622*OI+A623*STNA(-1)

```
NOB = 21                  NOVAR = 3                     RANGE:  1964  TO  1984
RSQ =           0.33879   CRSQ =          0.265322      F(2/18) =        4.6114    PROB>F =        0.024158
SER =          61.8944    SSR =       68956.4           DW(0) =          1.23216   COND =         41.6573
MAX:HAT =       0.328743  RSTUDENT =      2.73105       DFFITS =        -0.967395
```

COEF	ESTIMATE	STER	TSTAT
A621	-324.028	132.474	-2.44597
A622	0.322721	0.106285	3.03637
A623	-0.408398	0.137556	-2.96896

191: STNAVDL = PSTNADL*STNADL

192: STNA = STNADL+STNA(-1)

193: STNAV = PSTNA*STNA

194: STDL = STADL+STNADL+STIVDL

195: STVDL = STAVDL+STIVVDL+STNAVDL

Industrial exports (XI) as a fraction of industrial output (QHI) is modelled as a time trend. Tourism exports (XTO) are driven by world output (QIW), with a Northern Ireland dummy variable. Exports of other services (XSO) are driven by GNP.

196: LOG(XI/QHI) = A231+A232*(T-ZT10)+RHO23*R23(-1)+LOG(FXI)

LOG(XI/QHI) = A231+A232*T

```
NOB = 20                  NOVAR = 3               RANGE:  1964  TO  1984
RSQ =         0.988044 CRSQ =           0.986637  F(1/17) =      702.43     PROB>F =        0.
SER =         0.043241 SSR =            0.031787  DW(0) =         1.48171   COND =          11.263
MAX:HAT =     0.185714 RSTUDENT =      -2.48816   DFFITS =       -0.674316
```

COEF	ESTIMATE	STER	TSTAT
A231	-2.63876	0.304904	-8.65439
A232	0.070591	0.009316	7.57737
RHO1	0.825079	0.128657	6.413

197: LOG(XTO/QIW) = A641+A642*DUMNI+A643*LOG(XTO(-1)/QIW(-1))+LOG(FXTO)

LOG(XTO/QIW) = A641+A642*DUMNI+A643*LOG(XTO(-1)/QIW(-1))

```
NOB = 21                  NOVAR = 3               RANGE:  1964  TO  1984
RSQ =         0.879864 CRSQ =           0.866516  F(2/18) =      65.9154    PROB>F =        0.
SER =         0.067508 SSR =            0.082033  DW(0) =         1.81616   COND =          148.216
MAX:HAT =     0.407878 RSTUDENT =      -3.35191   DFFITS =       -1.22033
```

COEF	ESTIMATE	STER	TSTAT
A641	2.84243	0.944229	3.01031
A642	-0.177139	0.064498	-2.74643
A643	0.519036	0.15887	3.26704

198: LOG(XSO/GNP) = A431+A432*LOG(XSO(-1)/GNP(-1))+LOG(FXSO)

LOG(XSO/GNP) = A431+A432*LOG(XSO(-1)/GNP(-1))

```
NOB = 21                  NOVAR = 2               RANGE:  1964  TO  1984
RSQ =         0.524287 CRSQ =           0.499249  F(1/19) =      20.94      PROB>F =        0.000206
SER =         0.101772 SSR =            0.196794  DW(0) =         2.58364   COND =          48.2178
MAX:HAT =     0.300767 RSTUDENT =       3.29398   DFFITS =        2.16036
```

COEF	ESTIMATE	STER	TSTAT
A431	-0.853113	0.535653	-1.59266
A432	0.736606	0.160971	4.57602

Equations 199-203 define various aggregates of exports: services (XS); non-agricultural (XNA) and total goods and services (XGS).

199: XS = XTO+XSO

200: XNA = XI+XS

201: XNAV = PXI*XI+PXS*XS

202: XGS = XNA+XA

203: XGSV = XNAV+PXA*XA

Equations 204-208 define personal savings (SAV), company savings (SAVC), total savings (SAVTOT), net savings (SAVNET), and gross savings (SAVG).

204: SAV = YPERD-CV

205: SAVC = YCU-GTYC

206: SAVTOT = SAV+SAVC+GBRC

207: SAVNET = SAVTOT-YASA

208: SAVG = SAVNET+DEP+BPTCK-BP

Equations 209-210 define gross domestic absorption (GDA, GDAV).

209: GDA = C+GCG+ITOT+STDL

210: GDAV = CV+GCGV+ITOTV+STVDL

Equations 211-212 define gross final demand (GFD, GFDV).

211: GFD = GDA+XGS

212: GFDV = GDAV+XGSV

Equations 213-215 define gross domestic product on an expenditure basis (GDPE, GDPEV) and its deflator (PGDPE).

213: GDPE = GDA+XGS-MGS

214: GDPEV = GDAV+XGSV-MGSV

215: PGDPE = GDPEV/GDPE

Equations 216-219 define four weighted final demand measures, using the 1975 input-output table weights. GSOIMMUD is final demand weighted by its output content of the mining, manufacturing and utilities sectors. GSOIBD uses weights from the building and construction output content. GSOSM uses weights from the services sector output content.

216: GSOIMMUD = 0.125109*(C+XTO)+0.032366*GCGNP*(703.3/206.108)+0.098706*(IH+IBC)+0.089649*IME+0.165475*STNADL+0.205043*STIVDL+0.062342*STADL+0.09053*XSO+0.171588*XA

217: GSOIBD = 0.009114*(C+XTO)+0.038731*GCGNP*(703.3/206.108)+0.461787*(IH+IBC)+0.001913*IME+0.001517*STNADL+0.005529*STIVDL+0.004809*STADL+0.010449*XSO+0.005861*XA

218: GSOID = GSOIMMUD+GSOIBD

219: GSOSM = 0.218757*(C+XTO)+0.073176*GCGNP*(703.3/206.108)+0.142381*(IH+IBC)+0.125736*IME+0.040762*STNADL+0.097216*STIVDL+0.065537*STADL+0.133103*XI+0.435114*XSO+0.095004*XA

Equation 220 defines a moving average of GSOSM.

220: EGSOSM = EW1*GSOSM+EW2*GSOSM(-1)+EW3*GSOSM(-2)+(1-EW1-EW2-EW3)*GSOSM(-3)

THE INCOME DISTRIBUTION BLOCK

(1) : Price Determination : External Prices

Equations 221-225 refer to the three main import price indices: energy (PM3), non-energy goods (PMGNE) and services (PMS). In each case the domestic price (i.e., the price in £IR) is determined by dividing the foreign currency price by the effective exchange rate, FXAEFF.

```
221:        PM3 = PM3F/FXAEFF
222:        PE = FPE*PM3
223:        PEDOT = 100*DEL(PE)/PE(-1)
224:        PMGNE = PMGNEF/FXAEFF
225:        PMS = PMSF/FXAEFF
```

Two choices are available for the world price of industrial output (PWORLD): in the first (DVPW) it is a weighted average of energy and non-energy import prices, while in the second it is simply exogenous.

```
226:        LOG(DVPW) = WTEMV*LOG(PM3)+(1-WTEMV)*LOG(PMGNE)+LOG(FPWORLD)
227:        PWORLD = IF Z4 EQ 1 THEN PWORLDF/FXA ELSE DVPW
228:        PWORLDDT = 100*(PWORLD/PWORLD(-1)-1.)
```

The price of gross agricultural output (PQGA) is also exogenous.

```
229:        PQGA = PQGAF/FXAEFF+ZCAP*(GCSAS-GCSASH+(EECS-EECSH))/QGA
```

(2) : Price Determination : Domestic Output Prices

The domestic industrial prices are determined in three stages. First, the price of gross output of transportable goods industries (PQTI) is a function of world industrial output prices (PWORLD) and of agricultural prices (PQGA). The deflator of added-value plus energy (PQHI) is a function of PQTI and the price of imports of materials. Using these prices, the deflator of industrial added-value is simply the value over the volume of added value in industry.

```
230:        LOG(PQTI) = A241+A242*LOG(PWORLD)+(1-A242)*LOG(PQGA)+LOG(FPQTI)

      LOG(PQTI) = A241+A242*LOG(PWORLD)+(1-A242)*LOG(PQGA)

NOB = 21                  NOVAR = 2                  RANGE:  1964  TO  1984
RSQ =          0.837057  CRSQ =          0.828481   F(1/19) =      97.6054    PROB>F =     0.
SER =          0.027075  SSR =           0.013928   DW(0) =         2.17437   COND =       1.28196
MAX:HAT =      0.253656  RSTUDENT =      1.95236    DFFITS =       -0.643253
```

COEF	ESTIMATE	STER	TSTAT
A241	-0.037113	0.006091	-6.09265
A242	0.710477	0.071914	9.87954

```
231:        LOG(PQHI) = 1/A532*LOG(PQTI)-A531/A532-(1-A532)/A532*LOG(PMG)-1/A532*RHO53*R53(-1)+LOG(FPQHI)

      LOG(PQTI) = A531+A532*LOG(PQHI)+(1-A532)*LOG(PMG)

NOB = 20                  NOVAR = 3                  RANGE:  1964  TO  1984
RSQ =          0.692098  CRSQ =          0.655874   F(1/17) =      19.1062    PROB>F =     0.
SER =          0.031971  SSR =           0.017377   DW(0) =         1.57972   COND =       1.11814
MAX:HAT =      0.41019   RSTUDENT =     -2.46678    DFFITS =       -1.1807
```

COEF	ESTIMATE	STER	TSTAT
A531	-0.05251	0.106325	-0.493861
A532	0.80515	0.137653	5.84913
RHO1	0.934249	0.03742	24.9665

```
232:        POI = OIV/OI
```

The deflator of added-value in marketed services (POSM) is determined similarly. Remember that added value in current prices in marketed services (OSMV) is residually determined in the model in the current price expenditure-output identity. Hence, POSM is also essentially residually determined.

```
233:        POSM = OSMV/OSM
234:        POSO = (OSHEV+POSM*OSM)/(OSHE+OSM)
```

The deflator of material inputs in agriculture (PQMA) is a function of prices in industry (PQTI) and lagged agricultural prices. The added value deflator in agriculture, forestry and fishing (POAG) is determined as for POI and POSM.

```
235:        LOG(PQMA) = A271+A272*LOG(PQTI)+(1-A272)*LOG(PQGA(-1))+LOG(FPQMA)+RHO27*R27(-1)

      LOG(PQMA) = A271+A272*LOG(PQTI)+(1-A272)*LOG(PQGA(-1))

NOB = 20                  NOVAR = 3                  RANGE:  1964  TO  1984
RSQ =          0.791889  CRSQ =          0.767406   F(1/17) =      32.3437    PROB>F =     0.
SER =          0.038808  SSR =           0.025603   DW(0) =         1.76872   COND =       1.20874
MAX:HAT =      0.463103  RSTUDENT =     -3.40161    DFFITS =       -1.16092
```

COEF	ESTIMATE	STER	TSTAT
A271	0.000204	0.027646	0.007365
A272	0.841704	0.125152	6.72544
RHO1	0.689453	0.166725	4.13526

```
236:        POAG = OAGV/OAG
```

Equations 237-238 determine the deflator of GDP at factor cost (PGDPFC) and its inflation rate.

```
237:        PGDPFC = GDPFCV/GDPFC
238:        PGDPFCDT = 100*(PGDPFC/PGDPFC(-1)-1.)
```

(3) : Price Determination : Expenditure Prices

The personal consumption deflator (PC) is a function of industrial output prices (PQTI) and unit labour costs in marketed services, using "trend" labour productivity.

239: LOG(PC) = A281+A282*LOG(PQTI)+(1-A282)*LOG(AAESM/EOPRSM)+A283*TINC+RHO28*R28(-1)+LOG(FPC)

LOG(PC) = A281+A282*LOG(PQTI)+(1-A282)*LOG(AAESM/OPRSM)+A283*TINC

NOB = 20		NOVAR = 4		RANGE: 1964 TO 1984			
RSQ =	0.945239	CRSQ =	0.934971	F(2/16) =	92.0588	PROB>F =	0.
SER =	0.023274	SSR =	0.008667	DW(0) =	1.75617	COND =	5.93732
MAX:HAT =	0.427775	RSTUDENT =	-2.4876	DFFITS =	-1.15546		

COEF	ESTIMATE	STER	TSTAT
A281	0.171541	0.129458	1.32507
A282	0.429446	0.119698	3.58773
A283	0.735234	0.335646	2.19051
RHO1	0.885639	0.053177	16.6544

240: PCDOT = 100*(PC/PC(-1)-1.)

Equation 241 simply links the deflator of non-wage public consumption (PGCGNP) to PC, while equation 241 determines the overall deflator of public consumption (PGCG).

241: PGCGNP = FPGCGNP*PC

242: PGCG = GCGV/GCG

The deflators of housing investment (PIH), investment in machinery and equipment (PIME) and in building and construction (PIBC) are all determined by unit labour costs in industry (AAEI/EOPRI) and the price of imports of goods (PMG).

243: LOG(PIH) = A341+A342*LOG(AAEI/EOPRI)+(1-A342)*LOG(PMG)+RHO34*R34(-1)+LOG(FPIH)

LOG(PIH) = A341+A342*LOG(AAEI/OPRI)+(1-A342)*LOG(PMG)

NOB = 20		NOVAR = 3		RANGE: 1964 TO 1984			
RSQ =	0.78036	CRSQ =	0.75452	F(1/17) =	30.1997	PROB>F =	0.
SER =	0.039811	SSR =	0.026943	DW(0) =	2.09772	COND =	1.62479
MAX:HAT =	0.498081	RSTUDENT =	-2.01887	DFFITS =	-1.71424		

COEF	ESTIMATE	STER	TSTAT
A341	0.27692	0.10279	2.69402
A342	0.657064	0.129754	5.06391
RHO1	0.905727	0.066406	13.6393

244: LOG(PIBC) = A511+A512*LOG(AAEI/EOPRI)+(1-A512)*LOG(PMG)+RHO51*R51(-1)+LOG(FPIBC)

LOG(PIBC) = A511+A512*LOG(AAEI/OPRI)+(1-A512)*LOG(PMG)

NOB = 20		NOVAR = 3		RANGE: 1964 TO 1984			
RSQ =	0.921242	CRSQ =	0.911976	F(1/17) =	99.4256	PROB>F =	0.
SER =	0.019758	SSR =	0.006637	DW(0) =	1.96485	COND =	1.36279
MAX:HAT =	0.515932	RSTUDENT =	-3.23895	DFFITS =	-1.06939		

COEF	ESTIMATE	STER	TSTAT
A511	0.29422	0.080642	3.64845
A512	0.484605	0.063512	7.63012
RHO1	0.944186	0.01973	47.8546

245: LOG(PIME) = A251+A252*LOG(AAEI/EOPRI)+A253*LOG(PMG)+(1-A252-A253)*LOG(PMG(-1))+RHO25*R25(-1)+LOG(FPIME)

LOG(PIME) = A251+A252*LOG(AAEI/OPRI)+A253*LOG(PMG)+(1-A252-A253)*LOG(PMG(-1))

NOB = 20		NOVAR = 4		RANGE: 1964 TO 1984			
RSQ =	0.913949	CRSQ =	0.897814	F(2/16) =	56.6454	PROB>F =	0.
SER =	0.030924	SSR =	0.015301	DW(0) =	1.5361	COND =	2.11609
MAX:HAT =	0.577338	RSTUDENT =	-3.50084	DFFITS =	-2.62818		

COEF	ESTIMATE	STER	TSTAT
A251	0.104085	0.116264	0.895248
A252	0.323357	0.13984	2.31234
A253	0.390419	0.100417	3.88798
RHO1	0.938201	0.044893	20.8985

Equations 246-252 deal with sectoral and total investment prices. The deflators of investment by the industrial sector (PII), the service sector (PIS) and by agriculture (PIAG) are linked to the above PIME and PIBC deflators, where the coefficients capture the sectoral composition of investment. The deflators of investment in the health and education sector (PISHE) and in public administration (PIPA) are simply linked to the overall deflator of services investment (PIS). Finally, two identities determine the deflators of investment in marketed services (PISM) and total investment (PITOT).

246: LOG(PII) = A301+A302*LOG(PIBC)+(1-A302)*LOG(PIME)+RHO30*R30(-1)+LOG(FPII)

LOG(PII) = A301+A302*LOG(PIBC)+(1-A302)*LOG(PIME)

NOB = 20		NOVAR = 3		RANGE: 1964 TO 1984			
RSQ =	0.958163	CRSQ =	0.953242	F(1/17) =	194.672	PROB>F =	0.
SER =	0.009463	SSR =	0.001522	DW(0) =	1.41469	COND =	1.87522
MAX:HAT =	0.200595	RSTUDENT =	2.70809	DFFITS =	0.624023		

COEF	ESTIMATE	STER	TSTAT
A301	-0.007834	0.008009	-0.978075
A302	0.315096	0.046092	6.83616
RHO1	0.690824	0.166221	4.15605

247: LOG(PIS) = A311+A312*LOG(PIBC)+(1-A312)*LOG(PIME)+RHO31*R31(-1)+LOG(FPIS)

LOG(PIS) = A311+A312*LOG(PIBC)+(1-A312)*LOG(PIME)

NOB = 20		NOVAR = 3		RANGE: 1964 TO 1984			
RSQ =	0.991054	CRSQ =	0.990001	F(1/17) =	941.621	PROB>F =	0.
SER =	0.006143	SSR =	0.000642	DW(0) =	1.79664	COND =	2.07536
MAX:HAT =	0.201799	RSTUDENT =	2.79316	DFFITS =	0.768584		

COEF	ESTIMATE	STER	TSTAT
A311	0.007202	0.004431	1.62546
A312	0.438919	0.025254	17.3804
RHO1	0.614789	0.144986	4.24032

```
248:    LOG(PISHE) = LOG(PIS)+LOG(FPISHE)

249:    LOG(PIPA) = LOG(PIS)+LOG(FPIPA)

250:    PISM = ISMV/ISM

251:    LOG(PIAG) = A321+0.5*LOG(PIBC)+(1-0.5)*LOG(PIME)+RHO32*R32(-1)+LOG(FPIAG)

     LOG(PIAG) = A321+0.5*LOG(PIBC)+(1-0.5)*LOG(PIME)

NOB = 20                 NOVAR = 2                 RANGE:  1964  TO  1984
RSQ =          0.499817  CRSQ =         0.472029   F(0/18) =      17.9868   PROB>F =    0.000491
SER =          0.031867  SSR =          0.01828    DW(0) =         1.49468  COND =      1.
MAX:HAT =      0.05      RSTUDENT =    -2.6852     DFFITS =       -0.616028
```

COEF	ESTIMATE	STER	TSTAT
A321	0.00291	0.02403	0.121091
RHO1	0.711371	0.162951	4.36556

```
252:    PITOT = ITOTV/ITOT
```

Equations 253-258 concern export prices. Agricultural export prices are exogenous. Industrial export prices are determined by world industrial output prices (PWORLD), i.e. the SOE price-taking assumption. Services export prices (PXS) are simply linked to consumption prices. Identities determine non-agricultural export prices (PXNA), total export prices (PXGS) and export profitability (PRXI).

```
253:    PXA = PXAF/FXAEFF+ZCAP*(GCSAS-GCSASH-(EECS-EECSH))/XA

254:    LOG(PXI) = A351+A352*LOG(PWORLD)+(1-A352)*LOG(PWORLD(-1))+RHO35*R35(-1)+LOG(FPXI)

     LOG(PXI) = A351+A352*LOG(PWORLD)+(1-A352)*LOG(PWORLD(-1))

NOB = 20                 NOVAR = 3                 RANGE:  1964  TO  1984
RSQ =          0.903219  CRSQ =         0.891833   F(1/17) =      79.3274   PROB>F =    0.
SER =          0.021997  SSR =          0.008226   DW(0) =         1.79243  COND =      2.41584
MAX:HAT =      0.219988  RSTUDENT =     3.19429    DFFITS =        1.62031
```

COEF	ESTIMATE	STER	TSTAT
A351	0.020357	0.014801	1.37535
A352	0.886503	0.097102	9.12959
RHO1	0.543054	0.164087	3.30954

```
255:    LOG(PXS) = LOG(PC)+LOG(FPXS)

256:    PXNA = XNAV/XNA

257:    PXGS = XGSV/XGS

258:    PRXI = PXI/UCLI
```

Non-agricultural stock change prices (PSTNADL) are linked to industrial and import prices. The deflator of non-agricultural stock levels (PSTNA) proved difficult to model in this aggregate form and is simply linked to PSTNADL. Total stock change prices (PSTDL) are determined in an identity.

```
259:    LOG(PSTNADL) = A361+A362*LOG(PQTI)+(1-A362)*LOG(PMG)+LOG(FPSTNADL)

     LOG(PSTNADL) = A361+A362*LOG(PQTI)+(1-A362)*LOG(PMG)

NOB = 21                 NOVAR = 2                 RANGE:  1964  TO  1984
RSQ =          0.23086   CRSQ =         0.190378   F(1/19) =       5.7029   PROB>F =    0.027478
SER =          0.076686  SSR =          0.111735   DW(0) =         2.03213  COND =      2.30933
MAX:HAT =      0.349144  RSTUDENT =     4.48846    DFFITS =        2.77974
```

COEF	ESTIMATE	STER	TSTAT
A361	0.053991	0.022946	2.353
A362	0.773461	0.323885	2.38807

```
260:    LOG(PSTNA) = A371+1.*LOG(PSTNADL)+LOG(FPSTNA)

     LOG(PSTNA) = A371+1.*LOG(PSTNADL)

NOB = 21                 NOVAR = 1                 RANGE:  1964  TO  1984
RSQ =          0.742358  CRSQ =         0.742358   F(0/20) =       0.       PROB>F =    1.
SER =          0.075701  SSR =          0.114612   DW(0) =         2.10634  COND =      1.
MAX:HAT =      0.047619  RSTUDENT =    -4.30738    DFFITS =       -0.96316
```

COEF	ESTIMATE	STER	TSTAT
A371	-0.04301	0.016519	-2.60366

```
261:    PSTDL = STVDL/STDL
```

Given the explicit modelling of output at factor and market prices, we need to endogenise the "deflators" of indirect taxes (PTE) and of subsidies (PSUB). Both are determined by identities. *Real* indirect taxes and subsidies are determined later.

```
262:    PTE = TE/TRE

263:    PSUB = SUB/SRUB
```

Finally, the deflator of the adjustment for financial services (PYAFS) is determined by the deflator of GDP at factor cost (PGDPFC).

264: LOG(PYAFS) = A381+1.*LOG(PGDPFC)+RHO38*R38(-1)+LOG(FPYAFS)

LOG(PYAFS) = A381+1.*LOG(PGDPFC)

```
NOB = 20              NOVAR = 2            RANGE:  1964  TO  1984
RSQ =      0.940532 CRSQ =      0.937228 F(0/18) =    284.684   PROB>F =     0.
SER =      0.097647 SSR =       0.171631 DW(0) =      2.47784   COND =       1.
MAX:HAT =  0.05     RSTUDENT =  2.17074  DFFITS =     0.498003
```

COEF	ESTIMATE	STER	TSTAT
A381	0.961073	0.514604	1.8676
RHO1	0.958702	0.014085	68.0649

(4) : Wage Determination

The product wage in industry (AAEI/PQTI) is determined as a function of a tax "wedge" , the unemployment rate (UR) and labour productivity in a dynamic specification. The wedge (WEDGE) combines the effect of all direct and indirect taxes.

265: WEDGE = PC/PQTI*(1+RGTYSE)/(1-RTYPTOT)

Two variants are provided: the first uses a moving average of current and lagged unemployment in the Phillips curve term; the second uses only lagged unemployment. In actual use for model simulations a variant of each of the above two permits the use of actual labour productivity (OPRI) or trend productivity (EOPRI).

266: LOG(DV41A/PQTI) = A411A+A412A*LOG(WEDGE)+A413A*(UR+UR(-1))/2+A414A*LOG(OPRI)+(1-A414A)*LOG(AAEI(-1)/PQTI(-1))+LOG(FAAEIA)

LOG(AAEI/PQTI) = A411A+A412A*LOG(WEDGE)+A413A*(UR+UR(-1))/2+A414A*LOG(OPRI)+(1-A414A)*LOG(AAEI(-1)/PQTI(-1))

```
NOB = 21              NOVAR = 4            RANGE:  1964  TO  1984
RSQ =      0.770513 CRSQ =      0.730016 F(3/17) =    19.0261   PROB>F =     0.
SER =      0.023013 SSR =       0.009003 DW(0) =      1.97814   COND =       22.5059
MAX:HAT =  0.481857 RSTUDENT =  2.03792  DFFITS =     -1.21218
```

COEF	ESTIMATE	STER	TSTAT
A411A	-0.217392	0.037001	-5.87536
A412A	0.548073	0.109457	5.00722
A413A	-0.022605	0.004475	-5.05143
A414A	0.645947	0.088019	7.33874

267: LOG(DV41B/PQTI) = A411A+A412A*LOG(WEDGE)+A413A*(UR+UR(-1))/2+A414A*LOG(EOPRI)+(1-A414A)*LOG(AAEI(-1)/PQTI(-1))+LOG(FAAEIA)

268: LOG(DV41C/PQTI) = A411B+A412B*LOG(WEDGE)+A413B*UR(-1)+A414B*LOG(OPRI)+(1-A414B)*LOG(AAEI(-1)/PQTI(-1))+LOG(FAAEIB)

LOG(AAEI/PQTI) = A411B+A412B*LOG(WEDGE)+A413B*UR(-1)+A414B*LOG(OPRI)+(1-A414B)*LOG(AAEI(-1)/PQTI(-1))

```
NOB = 21              NOVAR = 4            RANGE:  1964  TO  1984
RSQ =      0.783752 CRSQ =      0.745591 F(3/17) =    20.5378   PROB>F =     0.
SER =      0.022339 SSR =       0.008483 DW(0) =      1.90457   COND =       21.5909
MAX:HAT =  0.496273 RSTUDENT =  -1.89131 DFFITS =     -1.23935
```

COEF	ESTIMATE	STER	TSTAT
A411B	-0.208782	0.035251	-5.92266
A412B	0.48828	0.094263	5.17996
A413B	-0.022681	0.004277	-5.30281
A414B	0.646852	0.085141	7.59742

269: LOG(DV41D/PQTI) = A411B+A412B*LOG(WEDGE)+A413B*UR(-1)+A414B*LOG(EOPRI)+(1-A414B)*LOG(AAEI(-1)/PQTI(-1))+LOG(FAAEIB)

270: AAEI = IF VE41 EQ 1 THEN DV41A ELSE (IF VE41 EQ 2 THEN DV41B ELSE (IF VE41 EQ 3 THEN DV41C ELSE DV41D))

The identities in equations 271-276 determine wage inflation (AAEIDOT), trend wage inflation (EAAEIDOT), real "consumption wages (AAEIR) and its inflation rate (AAEIRDOT), real "after tax" wages (RATAAEI) and labour's share of added value (LSVAI).

271: AAEIDOT = 100*(AAEI/AAEI(-1)-1.)

272: EAAEIDOT = (AAEIDOT(-1)+AAEIDOT(-2)+AAEIDOT(-3))/3.

273: AAEIR = AAEI/PC

274: AAEIRDOT = 100*(AAEIR/AAEIR(-1)-1.)

275: RATAAEI = AAEI*RETRAT/PC

276: LSVAI = AAEI*LI/(POI*OI)

The wage rate in marketed services (AAESM) is determined as a relativity relation with industry.

277: LOG(AAESM/AAEI) = A421+A422*(T-ZT13)+RHO42*R42(-1)+LOG(FAAESM)

LOG(AAESM/AAEI) = A421+A422*T

```
NOB = 20              NOVAR = 3            RANGE:  1964  TO  1984
RSQ =      0.757185 CRSQ =      0.728619 F(1/17) =    26.5061   PROB>F =     0.
SER =      0.027359 SSR =       0.012725 DW(0) =      1.47833   COND =       9.85576
MAX:HAT =  0.185714 RSTUDENT =  2.8473   DFFITS =     0.655796
```

COEF	ESTIMATE	STER	TSTAT
A421	-0.530795	0.048041	-11.0488
A422	0.007766	0.001673	4.64061
RHO1	0.383866	0.187713	2.04496

Identities 278-279 determine real "after tax" wages in marketed services (RATAAESM) and the wage inflation rate (AAESMDOT).

278: RATAAESM = AAESM*RETRAT/PC

279: AAESMDOT = 100*(AAESM/AAESM(-1)-1.)

Wage levels in public administration and defence (AAEPA) are determined as a relativity relation to industry, where the relativity variable (WRELPA) is exogenous.

280: AAEPA = WRELPA*AAEI

Wage levels in health and education (AAESHE) are similarly determined with respect to public administration.

```
281:    AAESHE = WRELSHE*AAEPA
```

Identities 282-284 determine wage levels in marketed services plus health and education (AAESO), non-agricultural wage levels (AAENA) and its inflation rate (AAENADOT).

```
282:    AAESO = YWSO/LSO

283:    AAENA = YWNA/LNA

284:    AAENADOT = 100*(AAENA/AAENA(-1)-1.)
```

Identities 285-295 determine certain competitiveness measures: world hourly earnings (HEW) and its inflation rate (HEWDOT); world unit labour costs (UCLW) and its inflation rate (UCLWDOT); the inflation rate of domestic industrial unit labour costs (UCLIDOT); relative competitiveness measured by hourly earnings (COMAAEI) and its trend (ECOMAAEI); relative competitiveness measured by unit labour costs (COMUCLI) and its trend (ECOMUCLI); and relative competitiveness measured by total costs in industry (COMTCI) and its trend (ECOMTCI).

```
285:    HEW = HEWF/FXA

286:    HEWDOT = 100*(HEW/HEW(-1)-1.)

287:    UCLW = UCLWF/FXA

288:    UCLWDOT = 100*(UCLW/UCLW(-1)-1)

289:    UCLIDOT = 100*(UCLI/UCLI(-1)-1.)

290:    COMAAEI = HEW/AAEI

291:    ECOMAAEI = (COMAAEI+COMAAEI(-1)+COMAAEI(-2))/3.

292:    COMUCLI = UCLW/UCLI

293:    ECOMUCLI = (COMUCLI+COMUCLI(-1)+COMUCLI(-2))/3.

294:    COMTCI = PWORLD/PCKEL

295:    ECOMTCI = (COMTCI+COMTCI(-1)+COMTCI(-2))/3.
```

(5) : Indexation Rules for Fiscal Instruments

Equations 296-299 handle public sector employment and wage expenditures. For both employment in health and education (LSHE) and in public administration (LPA), the choice lies between setting to an (exogenous) value (tagged with a trailing "H", deriving as the ratio of the total wage bill to the wage rate, or leaving unchanged at the previous years level. Correspondingly, the respective wage bills (YWSHE and YWPA) can be exogenised, set to the product of employment and wage rates, or indexed in two possible ways. The first type of indexation (henceforth Type 1) links the wage bill to movements in the consumption inflation rate or the value of consumption in the previous year; the second type of indexation (henceforth Type 2) links to movements of PC or CV relative to values from some benchmark simulation (tagged with a trailing "H").

```
296:    LSHE = IF Z5 EQ 1 THEN LSHEH ELSE (IF Z5 EQ 2 THEN YWSHE/AAESHE ELSE LSHE(-1))

297:    YWSHE = IF Z6 EQ 1 THEN YWSHEH ELSE (IF Z6 EQ 2 THEN LSHE*AAESHE ELSE (IF Z6 EQ 3 THEN YWSHE(-1)*(T1*PC/PC(-1)+T2*CV/
        CV(-1)) ELSE CPC*YWSHEH*(T1*PC/PCH+T2*CV/CVH)))

298:    LPA = IF Z7 EQ 1 THEN LPAH ELSE (IF Z7 EQ 2 THEN YWPA/AAEPA ELSE LPA(-1))

299:    YWPA = IF Z6 EQ 1 THEN YWPAH ELSE (IF Z6 EQ 2 THEN LPA*AAEPA ELSE (IF Z6 EQ 3 THEN CPC*YWPA(-1)*(T1*PC/PC(-1)+T2*CV/CV
        (-1)) ELSE CPC*YWPAH*(T1*PC/PCH+T2*CV/CVH)))
```

The non-pay element of public consumption (GCGNPV) can be either exogenised or indexed using Type 1 or Type 2.

```
300:    GCGNPV = IF Z3 EQ 1 THEN GCGNPVH ELSE (IF Z3 EQ 2 THEN CPC*GCGNPV(-1)*(PGCGNP/PGCGNP(-1)) ELSE CPC*GCGNPVH*(PGCGNP/
        PGCGNPH))
```

Equations 301-321 deal with the indexation of fiscal policy instruments which are defined in nominal (or value) terms. In every case the choice is between exogenisation, indexation of Type 1 or indexation of Type 2. The price index used varies depending on the nature of the instrument. For consumption or personal transfer items we use the consumption deflator. For agricultural items we use agricultural output. For a range of capital and other items we use the GDP deflator. In the case of the broad residual category of social welfare transfers, population growth further modifies the price indexation. For complete definitions of all the instruments, refer to Appendix 1.

```
301:    RGCSC = IF Z28 EQ 1 THEN RGCSCH ELSE (IF Z28 EQ 2 THEN CPC*(PC/PC(-1))*RGCSC(-1) ELSE CPC*(PC/PCH)*RGCSCH)

302:    GCSAS = IF Z26 EQ 1 THEN GCSASH ELSE (IF Z26 EQ 2 THEN QGAV/QGAV(-1)*GCSAS(-1) ELSE QGAV/QGAVH*GCSASH)

303:    GCSANS = IF Z26 EQ 1 THEN GCSANSH ELSE (IF Z26 EQ 2 THEN QGAV/QGAV(-1)*GCSANS(-1) ELSE QGAV/QGAVH*GCSANSH)

304:    GCSONA = IF Z27 EQ 1 THEN GCSONAH ELSE (IF Z27 EQ 2 THEN OIV/OIV(-1)*GCSONA(-1) ELSE OIV/OIVH*GCSONAH)

305:    RUP = IF Z8 EQ 1 THEN RUPH ELSE (IF Z8 EQ 2 THEN CPC*RUP(-1)*PC/PC(-1) ELSE CPC*RUPH*PC/PCH)

306:    GCTREST = IF Z8 EQ 1 THEN GCTRESTH ELSE (IF Z8 EQ 2 THEN CPC*(NT/NT(-1))*GCTREST(-1)*(T1*PC/PC(-1)+T2*CV/CV(-1)) ELSE
        CPC*(NT/NTH)*GCTRESTH*(T1*PC/PCH+T2*CV/CVH))

307:    IPAV = IF Z8 EQ 1 THEN IPAVH ELSE (IF Z8 EQ 2 THEN KPGNP*IPAV(-1)*(T1*PGDPM/PGDPM(-1)+T2*GDPMV/GDPMV(-1)) ELSE KPGNP*
        IPAVH*(T1*PGDPM/PGDPMH+T2*GDPMV/GDPMVH))

308:    ISHEV = IF Z8 EQ 1 THEN ISHEVH ELSE (IF Z8 EQ 2 THEN KPGNP*ISHEV(-1)*(T1*PGDPM/PGDPM(-1)+T2*GDPMV/GDPMV(-1)) ELSE
        KPGNP*ISHEVH*(T1*PGDPM/PGDPMH+T2*GDPMV/GDPMVH))

309:    IHGV = IF Z8 EQ 1 THEN IHGVH ELSE (IF Z8 EQ 2 THEN KPGNP*IHGV(-1)*(T1*PGDPM/PGDPM(-1)+T2*GDPMV/GDPMV(-1)) ELSE KPGNP*
        IHGVH*(T1*PGDPM/PGDPMH+T2*GDPMV/GDPMVH))

310:    GKREST = IF Z8 EQ 1 THEN GKRESTH ELSE (IF Z8 EQ 2 THEN KPGNP*GKREST(-1)*(T1*PGDPM/PGDPM(-1)+T2*GDPMV/GDPMV(-1)) ELSE
        KPGNP*GKRESTH*(T1*PGDPM/PGDPMH+T2*GDPMV/GDPMVH))

311:    REX = IF Z8 EQ 1 THEN REXH ELSE (IF Z8 EQ 2 THEN TPC*(PC/PC(-1))*REX(-1) ELSE TPC*(PC/PCH)*REXH)

312:    RCARS = IF Z8 EQ 1 THEN RCARSH ELSE (IF Z8 EQ 2 THEN TPC*(PC/PC(-1))*RCARS(-1) ELSE TPC*(PC/PCH)*RCARSH)

313:    RTEO = IF Z8 EQ 1 THEN RTEOH ELSE (IF Z8 EQ 2 THEN TPC*(PC/PC(-1))*RTEO(-1) ELSE TPC*(PC/PCH)*RTEOH)

314:    RTPYALL = IF Z8 EQ 1 THEN RTPYALLH ELSE (IF Z8 EQ 2 THEN TPC*(PC/PC(-1))*RTPYALL(-1) ELSE TPC*(PC/PCH)*RTPYALLH)

315:    GR = IF Z8 EQ 1 THEN GRH ELSE (IF Z8 EQ 2 THEN KPGNP*GR(-1)*(T1*PGDPM/PGDPM(-1)+T2*GDPMV/GDPMV(-1)) ELSE KPGNP*GRH*(T1
        *PGDPM/PGDPMH+T2*GDPMV/GDPMVH))

316:    GTAGLEV = IF Z8 EQ 1 THEN GTAGLEVH ELSE (IF Z8 EQ 2 THEN TPQGA*GTAGLEV(-1)*(T1*PQGA/PQGA(-1)+T2*QGAV/QGAV(-1)) ELSE
        TPQGA*GTAGLEVH*(T1*PQGA/PQGAH+T2*QGAV/QGAVH))

317:    GTEARL = IF Z8 EQ 1 THEN GTEARLH ELSE (IF Z8 EQ 2 THEN TPQGA*GTEARL(-1)*(T1*PQGA/PQGA(-1)+T2*QGAV/QGAV(-1)) ELSE TPQGA
        *GTEARLH*(T1*PQGA/PQGAH+T2*QGAV/QGAVH))

318:    GTERATE = IF Z8 EQ 1 THEN GTERATEH ELSE (IF Z8 EQ 2 THEN TPGNP*GTERATE(-1)*(T1*PGDPM/PGDPM(-1)+T2*GDPMV/GDPMV(-1))
         ELSE TPGNP*GTERATEH*(T1*PGDPM/PGDPMH+T2*GDPMV/GDPMVH))

319:    GTYA = IF Z8 EQ 1 THEN GTYAH ELSE (IF Z8 EQ 2 THEN TPQGA*GTYA(-1)*(T1*PQGA/PQGA(-1)+T2*QGAV/QGAV(-1)) ELSE TPQGA*GTYAH
```

```
*(T1*PQGA/PQGAH+T2*QGAV/QGAVH))

320:    GTW = IF Z8 EQ 1 THEN GTWH ELSE (IF Z8 EQ 2 THEN TPC*GTW(-1)*(T1*PC/PC(-1)+T2*CV/CV(-1)) ELSE TPC*GTWH*(T1*PC/PCH+T2*
        CV/CVH))

321:    GTTI = IF Z8 EQ 1 THEN GTTIH ELSE (IF Z8 EQ 2 THEN TPGNP*GTTI(-1)*(T1*PGDPM/PGDPM(-1)+T2*GDPMV/GDPMV(-1)) ELSE TPGNP*
        GTTIH*(T1*PGDPM/PGDPMH+T2*GDPMV/GDPMVH))
```

Equations 322-328 deal with the indexation of those fiscal instruments which are expressed in real terms. Here the choice lies between exogenisation or leaving them unchanged from a previous years setting. The instruments involved are the VAT rate (RVAT), the customs duty rate (RCUS), the employers aand employees rate of social insurance contributions (RGTYSE, RGTYSP), the implicit rate of corporation tax (RGTYC), and the implicit rate of capital grants to households for housing purposes (RGKTH) and to industry for investment purposes (RGKTI).

```
322:    RVAT = IF Z9 EQ 1 THEN RVATH ELSE RVAT(-1)

323:    RCUS = IF Z9 EQ 1 THEN RCUSH ELSE RCUS(-1)

324:    RGTYSE = IF Z9 EQ 1 THEN RGTYSEH ELSE RGTYSE(-1)

325:    RGTYSP = IF Z9 EQ 1 THEN RGTYSPH ELSE RGTYSP(-1)

326:    RGTYC = IF Z9 EQ 1 THEN RGTYCH ELSE RGTYC(-1)

327:    RGKTI = IF Z9 EQ 1 THEN RGKTIH ELSE RGKTI(-1)

328:    RGKTH = IF Z9 EQ 1 THEN RGKTHH ELSE RGKTH(-1)
```

(6) : Tax Revenue Equations : Indirect Taxes

Revenue from a broad class of excise taxes (oil, tobacco, alcohol) are determined by a representative rate instrument (REX), a tax base proxy (consumption plus tourism exports) and consumer prices.

```
329:    LOG(GTEXT) = A441+A442*LOG(REX)+A443*LOG(C+XTO)+A444*LOG(PC)+LOG(FGTEXT)

        LOG(GTEXT) = A441+A442*LOG(REX)+A443*LOG(C+XTO)+A444*LOG(PC)

NOB = 21              NOVAR = 4                RANGE:  1964  TO  1984
RSQ =        0.999452 CRSQ =         0.999356  F(3/17) =     10344.9     PROB>F =      0.
SER =        0.022508 SSR =          0.008613  DW(0) =       1.63087     COND =        374.911
MAX:HAT =    0.338749 RSTUDENT =     2.32079   DFFITS =      -0.986122
```

COEF	ESTIMATE	STER	TSTAT
A441	-3.89477	0.710681	-5.48034
A442	0.701072	0.050325	13.9308
A443	1.20924	0.081648	14.8104
A444	0.261322	0.059929	4.36053

Revenue from VAT is determined by a representative VAT rate (RVAT), a VAT base (GTEVAT) and consumer prices. The delay between collection and payment of VAT is reflected in the lag structure of the equation.

```
330:    LOG(GTEVAT) = A451+A452*LOG(0.75*RVAT+0.25*RVAT(-1))+A453*LOG(GTEVATB)+A454*LOG(0.75*PC+0.25*PC(-1))+LOG(FGTEVAT)

        LOG(GTEVAT) = A451+A452*LOG(0.75*RVAT+0.25*RVAT(-1))+A453*LOG(GTEVATB)+A454*LOG(0.75*PC+0.25*PC(-1))

NOB = 21              NOVAR = 4                RANGE:  1964  TO  1984
RSQ =        0.998574 CRSQ =         0.998323  F(3/17) =     3969.43     PROB>F =      0.
SER =        0.06223  SSR =          0.065834  DW(0) =       1.33578     COND =        383.618
MAX:HAT =    0.436562 RSTUDENT =     2.64932   DFFITS =      -0.985541
```

COEF	ESTIMATE	STER	TSTAT
A451	-3.35389	1.99144	-1.68415
A452	1.1354	0.063543	17.8682
A453	1.43621	0.21929	6.54936
A454	0.856422	0.051907	16.4992

```
331:    GTEVATB = 0.75*(C+XTO)+0.25*(C(-1)+XTO(-1))
```

Revenue from a residual heterogeneous group of indirect taxes (GTEO) is a function of a representative tax rate (RTEO), a consumption base and consumer prices.

```
332:    LOG(GTEO) = A461+A462*LOG(RTEO)+A463*LOG(C)+A464*LOG(PC)+LOG(FGTEO)

        LOG(GTEO) = A461+A462*LOG(RTEO)+A463*LOG(C)+A464*LOG(PC)

NOB = 21              NOVAR = 4                RANGE:  1964  TO  1984
RSQ =        0.993728 CRSQ =         0.992621  F(3/17) =     897.783     PROB>F =      0.
SER =        0.102618 SSR =          0.179017  DW(0) =       1.44419     COND =        373.963
MAX:HAT =    0.336861 RSTUDENT =     -1.75151  DFFITS =      -0.943577
```

COEF	ESTIMATE	STER	TSTAT
A461	-8.81063	3.31998	-2.65382
A462	1.01844	0.274518	3.70991
A463	1.49747	0.382228	3.91772
A464	0.907713	0.168624	5.38308

Total revenue from duty on motor vehicles (GTMVD) is determined by a representative rate (RCARS) and the volume of consumption.

```
333:    LOG(GTMVD) = A471+A472*LOG(RCARS)+A473*LOG(C)+RHO47*R47(-1)+LOG(FGTMVD)

        LOG(GTMVD) = A471+A472*LOG(RCARS)+A473*LOG(C)

NOB = 20              NOVAR = 4                RANGE:  1964  TO  1984
RSQ =        0.989858 CRSQ =         0.987956  F(2/16) =     520.53      PROB>F =      0.
SER =        0.076512 SSR =          0.093666  DW(0) =       2.05626     COND =        103.127
MAX:HAT =    0.477401 RSTUDENT =     2.10056   DFFITS =      1.10975
```

COEF	ESTIMATE	STER	TSTAT
A471	-10.2274	1.85637	-5.50933
A472	1.06808	0.055459	19.2587
A473	1.52229	0.218008	6.98273
RHO1	0.58662	0.180172	3.25589

Revenue from customs duties (GTECUSO) is determined as the product of an implicit rate (RCUS) and the value of imports of goods.

```
334:     GTECUSO = RCUS*MGV+FGTECUSO
```

In equation 335 we isolate that portion of total motor vehicle duties which is paid by the company sector as an indirect tax (GTEMVDC).

```
335:     GTEMVDC = GTMVD-GTYMVDP
```

Equations 336-337 determine the Irish budget contribution to the EEC and the contribution to the Current International Cooperation Fund. Simplistic indexation options are provided to the world price (PWORLD).

```
336:     EECBUD = IF Z11 EQ 1 THEN EECBUDH ELSE (IF Z11 EQ 2 THEN KECB*(PWORLD/PWORLD(-1))*EECBUD(-1) ELSE KECB*(PWORLD/PWORLDH
         )*EECBUDH)

337:     EECCIC = IF Z11 EQ 1 THEN EECCICH ELSE (IF Z11 EQ 2 THEN KECB*(PWORLD/PWORLD(-1))*EECCIC(-1) ELSE KECB*(PWORLD/PWORLDH
         )*EECCICH)
```

Identities 338-340 determines total domestic indirect taxes (GTE), EEC taxes on expenditure (EECTE) and total indirect taxes (i.e. including EEC taxes).

```
338:     GTE = GTEXT+GTEVAT+GTEO+GTEMVDC+GTECUSO+GTERATE+GTAGLEV-(EECBUD-EECCIC)

339:     EECTE = IF Z11 EQ 1 THEN EECTEH ELSE (IF Z11 EQ 2 THEN KECB*(PWORLD/PWORLD(-1))*EECTE(-1) ELSE KECB*(PWORLD/PWORLDH)*
         EECTEH)

340:     TE = GTE+EECTE
```

(7) : Tax Revenue Equations : Direct Taxes

Equation 341 defines the average direct tax rate RTYPER and equation 342 defines a marginal direct tax rate (RTYPERM).

```
341:     RTYPER = GTYPER/YPERT

342:     RTYPERM = RTYPER*A482
```

Revenue from direct personal taxation (GTYPER) is determined by average annual taxable income (AAITI), non-agricultural employment (LNA) and tax allowances claimable (RTPYALL). This equation provides for a progressive tax system since the coefficient A482 is considerably greater than unity.

```
343:     LOG(GTYPER) = A481+A482*LOG(AAITI)+1.*LOG(LNA)+A483*LOG(RTPYALL)+LOG(FGTYPER)+LOG(GTYSHOCK)

         LOG(GTYPER) = A481+A482*LOG(AAITI)+1.*LOG(LNA)+A483*LOG(RTPYALL)

NOB = 21               NOVAR = 3              RANGE:  1964  TO  1984
RSQ =         0.997985 CRSQ =        0.997761 F(2/18) =    4457.83   PROB>F =        0.
SER =         0.058079 SSR =         0.060717 DW(0) =        1.20896  COND =      102.201
MAX:HAT =     0.250392 RSTUDENT =   -2.37529  DFFITS =      -1.2789
```

COEF	ESTIMATE	STER	TSTAT
A481	0.016777	0.510522	0.032862
A482	1.74827	0.085595	20.4249
A483	-0.430741	0.088959	-4.842

Equations 344-347 relate to social insurance contributions. The total rate of contribution (RGTYSL) is the sum of the employers and employees rates. Total revenue (GTYSL) is obtained by multiplying the total rate by the wage bill in industry and marketed services (i.e. excluding the public sector and agriculture). The employers portion of the revenue (GTYSE) is a fraction (WK1) of total revenue. The employees portion is residually determined.

```
344:     RGTYSL = RGTYSE+RGTYSP

345:     GTYSL = RGTYSL*(YWSM+YWI)+FGTYSL

346:     GTYSE = WK1*GTYSL

347:     GTYSP = GTYSL-GTYSE
```

Identities 348-349 define the total personal direct tax rate (RTYPTOT) and the retentions rate (RETRAT).

```
348:     RTYPTOT = RTYPER+RGTYSP

349:     RETRAT = 1-RTYPTOT
```

Corporation tax is determined in a quasi-identity as the product of an implicit tax rate (RGTYC) and total profits, lagged one year.

```
350:     GTYC = RGTYC*YC(-1)+FGTYC
```

The amount of motor vehicle duties paid by the personal sector (GTYMVDP) is classed as an income tax.

```
351:     GTYMVDP = (1-WL1)*GTMVD
```

Revenue from the DIRT, first introduced in 1986, is exogenous, although a schema for endogenising it is provided.

```
352:     GTYDIRT = IF Z20 EQ 1 THEN GTYDIRTH ELSE KDIRT*GDPMV*RD**EDIRT
```

Total revenue from taxes on income (GTY) is the summation of the above four tax revenues, in addition to taxes on agricultural incomes (GTYA).

```
353:     GTY = GTYPER+GTYSL+GTYC+GTYMVDP+GTYA+GTYDIRT
```

(8) : Total Tax Revenue

GTTOT is the total of revenue from indirect and direct taxation, in addition to public authorities trading and investment income (GTTI), transfers from abroad (GTTABR) and wealth tax.

```
354:     GTTOT = GTE+GTY+GTTI+GTTABR+GTW
```

Identities 355-357 define direct and indirect tax revenue as percentages of total tax revenue, while RGTTAX is total tax revenue as a percentage of GNP.

```
355:     GTYRAT = 100*(GTY/GTTOT)

356:     GTERAT = 100*(GTE/GTTOT)

357:     RGTTAX = 100*(GTE+GTY+GTW)/GNPV
```

(9) : Subsidies

Consumer subsidies (GCSC) are determined as the product of the implicit rate of subsidy (RGCSC) and the volume of consumption.

358: GCSC = RGCSC*C+FGCSC

EEC subsidies (EECS) are essentially exogenous.

359: EECS = IF Z29 EQ 1 THEN EECSH ELSE (IF Z29 EQ 2 THEN QGAV/QGAV(-1)*EECS(-1) ELSE QGAV/QGAVH*EECSH)

Agricultural subsidies (GCSA) are of two kinds: subsidies not related to sales (GCSANS) and subsidies related to sales (GCSAS).

360: GCSA = GCSANS+GCSAS

361: GCSO = GCSA+GCSONA

Identity 362 defines total subsidies, while TINC measures total indirect taxes, net of non-agricultural subsidies, as a fraction of the value of consumption, a variable used in the consumption deflator above.

362: SUB = GCSC+GCSO+EECS

363: TINC = (TE-(SUB-GCSA-EECS))/CV

(10) : Current Transfers

Unemployment assistance and benefit is modelled as an aggregate (GCTUB) as a function of a representative rate of benefit/assistance (RUP) and the numbers unemployed (U).

364: LOG(GCTUP) = A521+A522*LOG(RUP)+A523*LOG(U)+LOG(FGCTUP)

LOG(GCTUP) = A521+A522*LOG(RUP)+A523*LOG(U)

NOB = 21	NOVAR = 3		RANGE: 1964 TO 1984		
RSQ =	0.998049 CRSQ =	0.997832	F(2/18) = 4604.64	PROB>F =	0.
SER =	0.065811 SSR =	0.07796	DW(0) = 1.23314	COND =	69.5708
MAX:HAT =	0.382815 RSTUDENT =	2.56971	DFFITS = -1.28628		

COEF	ESTIMATE	STER	TSTAT
A521	-2.30394	0.32596	-7.06816
A522	1.07306	0.058058	18.4826
A523	0.793475	0.108107	7.33973

Pay-related benefit (GCTPRB) is determined by numbers unemployed (U) and average annual non-agricultural earnings (AAENA) in a quasi-identity.

365: GCTPRB = K2*U*AAENA(-1)+FGCTPRB

Certain transfers paid as wages to teachers (GCTW) are related to the number of teachers and average annual earnings in health and education (AAESHE).

366: GCTW = LTEACH*AAESHE

Identity 367 defines total current transfers (GCTPER), where GCTREST is a residual (exogenous) category of social welfare transfers (pensions, disability benefit, etc.). Identity 368 defines EEC transfers as essentially exogenous.

367: GCTPER = GCTUP+GCTPRB+GCTREST+GCTW

368: TREEC = IF Z11 EQ 1 THEN TREECH ELSE (IF Z11 EQ 2 THEN KECT*TREEC(-1)*(PWORLD/PWORLD(-1)) ELSE TREECH*(PWORLD/PWORLDH)
)

(11) : National Debt Interest on Domestic Borrowings

Two variants of the equation defining national debt interest on domestic borrowings are provided: the first determines interest payments as the product of an interest rate (RGL) and national loans outstanding (GNL), with lags of one and two years; the second is a specially parametrised equation based on a separate very detailed model of debt servicing.

369: DV55A = A551+A552*RGL(-1)/100*GNL(-1)+A553*RGL(-2)/100*GNL(-2)+FGCTNDIA

GCTNDID = A551+A552*RGL(-1)/100*GNL(-1)+A553*RGL(-2)/100*GNL(-2)

NOB = 21	NOVAR = 3		RANGE: 1964 TO 1984		
RSQ =	0.995204 CRSQ =	0.994671	F(2/18) = 1867.6	PROB>F =	0.
SER =	19.8177 SSR =	7069.32	DW(0) = 1.65171	COND =	20.1696
MAX:HAT =	0.581462 RSTUDENT =	5.19697	DFFITS = 1.47015		

COEF	ESTIMATE	STER	TSTAT
A551	25.9217	5.80084	4.46861
A552	0.497779	0.104756	4.7518
A553	0.50055	0.120063	4.16905

370: DEL(DV55B) = RGL(-1)*(DEL(GNL(-1))+GNLREP(-1))-GCTNDRI+FGCTNDIB

371: GCTNDID = IF VE55 EQ 1 THEN DV55A ELSE DV55B

Interest paid on "small savings" is simply the product of an implicit interest rate (RGLSSI) and the stock of "small savings".

372: GCTNDISS = RGLSSI/100*GNSS

Total national debt interest (GCTNDI) is the summation of the above two interest payments plus interest on foreign debt (GCTNDIF).

373: GCTNDI = GCTNDID+GCTNDISS+GCTNDIF

(12) : Total Current Expenditure

Identity 374 defines total current expenditure as the summation of expenditures on current goods and services (GCGV), domestic subsidies (SUB-EECS), current transfers (GCTPER), national debt interest (GCTNDI), and current transfers paid abroad (GCTABR).

374: GC = GCGV+(SUB-EECS)+GCTPER+GCTNDI+GCTABR

Identity 375 defines total current expenditure as a percentage of GNP (RGC).

375: RGC = 100*GC/GNPV

(13) : Total Capital Expenditure

Capital transfers paid to industry as investment grants (GKTI) are determined as the product of an implicit rate of grant (RGKTI) and the value of industrial investment (IIV). Capital transfers paid to the personal sector for housing investment purposes (GKTH) are similarly determined in terms of the value of private housing investment.

376: GKTI = RGKTI*IIV

377: GKTH = RGKTH*IHPV

Total capital expenditure by the public authorities (GK) is the summation of fixed investment in housing, investment by the public administration sector (IPAV), by the health and education sector (ISHEV), the above two capital transfer items and a residual capital expenditure item (GKREST).

378: GK = IHGV+IPAV+ISHEV+GKTI+GKTH+GKREST

(14) : Public Authorities Borrowing and Debt Financing

Identities 379-382 relate to the borrowing requirement of the public authorities. The total borrowing requirement (GBR) is defined as total current and capital revenue (GTTOT, GR) minus total current and capital expenditure (GC, GK). Identity 380 defines the current borrowing requirement. Identities 381-382 define the total (GBRR) and current (GBRCR) borrowing requirements as a percentage of GNP.

379: GBR = GTTOT-GC+(GR-GK)

380: GBRC = GTTOT-GC

381: GBRR = 100*(GBR/GNPV)

382: GBRCR = 100*(GTTOT-GC)/GNPV

National loans outstanding (GNL) is either exogenous or is the summation of the various domestic financing components. The stock of small savings (GNSS) is determined as a proportion (exogenous) of net financial acquisitions of the personal sector (FFAQH).

383: GNL = IF Z12 EQ 1 THEN GNLH ELSE GNL(-1)+GNHGDL+DEL(GNBG)+DEL(GNCG)-DEL(GNSS)+KGNL

384: GNSS = IF Z23 EQ 1 THEN GNSSH ELSE GNSS(-1)+KGNSS*FFAQH

Identity 385 defines total domestic debt (GND) as the summation of the above two components.

385: GND = GNL+GNSS

The uptake of debt by the commercial banks (GNBG) is either exogenous or is a proportion (exogenous) of the broad money supply (MON).

386: GNBG = IF Z23 EQ 1 THEN GNBGH ELSE KGNB*MON

Lending to the public authorities by the Central Bank (GNCG) is exogenous.

387: GNCG = GNCGH

The change in the personal sectors holdings of government bonds (GNHGDL) is either exogenous or is a proportion (exogenous) of total financial acquisitions of the private sector (FFAQT).

388: GNHGDL = IF Z23 EQ 1 THEN GNHGDLH ELSE KGNH*FFAQT

Net foreign borrowing (FBOR) is residually determined as the borrowing requirement less domestic financing.

389: FBOR = -GBR-DEL(GN[illegible]DEL(GNBG)+DEL(GNCG)+GNHGDL)

Identities 390-393 relate to a simplified method of handling the derivation of interest paid on foreign debt. Net foreign borrowing in £IR (FBOR) is converted to a representative currency basket (FBORF) using an appropriate exchange rate basket of $US, DM, Yen and £Sterling.

390: FBORF = FBOR*FXAFB

The foreign currency denominated interest payments (FBORF) are accumulated into the variable GNFF. This stock of debt is revalued using the same exchange rate basket back to £IR (GNF).

391: GNFF = GNFF(-1)+FBORF

392: GNF = GNFF/FXAFB

Interest payments on the foreign debt (denominated in £IR) is calculated as the product of an implicit interest rate (RFI) and the stock of debt outstanding (GNF).

393: GCTNDIF = RFI/100*GNF+FGCTNDIF

Identity 394 defines the total national debt outstanding (domestic and foreign).

394: GNT = GND+GNF

Identities 395-404 define a range of useful measures of the debt burden: total debt interest as a percentage of GNP (RNDI): foreign debt interest as a percentage of GNP (RNDIF): total debt outstanding as a percentage of GNP RDEBT): foreign debt as a percentage of GNP (RDEBTF): total debt as a percentage of exports of goods and services (RDEBTX): foreign debt as a percentage of exports of goods and services (RDEBTFX): total and foreign debt as a percentage of total population (RDEBTNT, RDEBTFNT): and total and foreign debt as a percentage of numbers employed (RDEBTL, RDEBTFL).

395: RNDI = 100*GCTNDI/GNPV

396: RNDIF = 100*GCTNDIF/GNPV

397: RDEBT = 100*(GND+GNF)/GNPV

398: RDEBTF = 100*(GNF/GNPV)

399: RDEBTX = 100*(GNT/XGSV)

400: RDEBTFX = 100*(GNF/XGSV)

401: RDEBTNT = 1000*(GNT/NT)

402: RDEBTFNT = 1000*(GNF/NT)

403: RDEBTL = 1000*(GNT/LTOT)

404: RDEBTFL = 1000*(GNF/LTOT)

(15) : National Income Identities

GDP at factor cost, in current prices, is built up from the output side in identity 405, with the adjustment for financial services (YRAFS) and GDP (GDPFC) in constant prices being defined in identities 406-407.

405: GDPFCV = OIV+OAGV+OSOV+OPAV-YAFS

406: YRAFS = YAFS/PYAFS

407: GDPFC = OI+OAG+OSO+OPA-YRAFS

To translate to constant market prices requires the endogenisation of indirect tax revenue and subsidies in constant prices. In both cases these are related to the notional bases involved: consumption (C) plus exports of tourism (XTO) and total imports of goods and services (MGS) in the case of real indirect taxes (TRE): agricultural output (QGA), consumption (C) and added-value in industry (OI) in the case of real subsidies (SRUB).

408: LOG(TRE) = WTTC*LOG(C+XTO)+(1-WTTC)*LOG(MGS)+LOG(FTRE)

409: LOG(SRUB) = WTSA*LOG(QGA)+WTSC*LOG(C)+(1-WTSA-WTSC)*LOG(OI)+LOG(FSRUB)

Identities 410-413 define GDP at current market prices (GDPMV) and constant market prices (GDPM), and the growth rate of GDMP (GDPMDOT) and its price deflator (PGDPM).

410: GDPMV = GDPFCV+(TE-SUB)

411: GDPM = GDPFC+(TRE-SRUB)

412: GDPMDOT = 100*(GDPM/GDPM(-1)-1.)

413: PGDPM = GDPMV/GDPM

Identities 414-417 define GNP in current and constant prices, and the real GNP growth rate and price deflator.

414: GNPV = GDPMV+YFN

415: GNP = GDPM+YRFN

416: GNPDOT = 100*(GNP/GNP(-1)-1.)

417: PGNP = GNPV/GNP

Total depreciation (DEP) is simply the total of depreciation in industry (DEPI), agriculture (DEPAG) and services (DEPS).

418: DEP = DEPI+DEPAG+DEPS

Identities 419-426 concern definitions of various measures of income: net domestic product at factor cost (NDPFCV), net national product at factor cost (NNPFCV).

419: NDPFCV = GDPEV-STATDISV-DEP-(TE-SUB)

420: NNPFCV = NDPFCV+YFN+YASA

The adjustment for stock appreciation is endogenised in identity 421.

421: YASA = DEL(STNAV)-STNAVDL+YASAIV+FYASA

Identities 422-424 define, respectively, private income (YP), personal income (YPER), and personal disposable income (YPERD).

422: YP = NNPFCV-GTTI+GCTNDI+GCTPER+BPTPRNE

423: YPER = YP-YCU

424: YPERD = YPER-(GTYPER+GTYSL+GTYA+GTW+GTYMVDP+GTYDIRT)

Identities 425-426 define the savings ratio (SAVRAT), and real personal disposable income (YRPERD).

425: SAVRAT = 100*(1-CV/YPERD)

426: YRPERD = YPERD/PC

Identities 427-429 define total profits (YC), real profits (YCR) and undistributed profits (YCU).

427: YC = NDPFCV-YAG-YWNA+YASA+YAFS

428: YCR = YC/PITOT

429: YCU = A561+A562*YC+FYCU

YCU = A561+A562*YC

NOB = 21		NOVAR = 2		RANGE: 1964 TO 1984			
RSQ =	0.959195	CRSQ =	0.957047	F(1/19) =	446.625	PROB>F =	0.
SER =	42.156	SSR =	33765.5	DW(0) =	1.44339	COND =	2.51303
MAX:HAT =	0.280534	RSTUDENT =	3.47232	DFFITS =	-1.17424		

COEF	ESTIMATE	STER	TSTAT
A561	42.5945	13.3893	3.18125
A562	0.18972	0.008977	21.1335

In deriving revenue from income tax, a concept of "taxable" income is required, and is defined in equation 430, and average taxable income per non-agricultural employee is defined in equation 431 (AAITI).

430: YPERT = IF TYEAR LT 1961 THEN YWNA(-1)+YPO(-1)-GTYSE(-1) ELSE (IF TYEAR LT 1975 THEN YWNA-YWPA+YWPA(-1)+YPO(-1)-GTYSE ELSE YWNA+YPO(-1)-GTYSE)

431: AAITI = YPERT/LNA

Identities 432-433 define two subcategories of income: non-agricultural wage income (YWNA) and "other" private income (YPO).

432: YPO = YC-YCU-GTTI+GCTNDI+YFN-YAFS

433: YWNA = YWI+YWSO+YWPA

(16) : Sectoral Flow-of-Funds

In identities 434-442 an attempt is made to derive sectoral flow-of-funds data. Sources (FFSC) and uses (FFUC) of funds for the company sector are defined in equations 434-435, and FFAQC defines the net acquisitions of funds by the company sector.

434: FFSC = SAVC+DEPI+0.55*DEPS+GKTI+GKREST

435: FFUC = IIV+ISMV+STNAVDL+STIVVDL

436: FFAQC = FFSC-FFUC

Sources (FFSH) and uses (FFUH) of funds by the household sector are defined in equations 437-438, and FFAQH defines the net acquisitions of funds by the household sector.

437: FFSH = SAV+DEPAG+GKTH

438: FFUH = IHPV+IAGV+STAVDL

439: FFAQH = FFSH-FFUH

Total net acquisitions of funds by the private sector (households plus companies) are defined by FFAQT, and the percentage of net acquisitions in sources are defined by RFFAQH and RFFAQC.

440: FFAQT = FFAQC+FFAQH

441: RFFAQH = 100*(FFAQH/FFSH)

442: RFFAQC = 100*(FFAQC/FFSC)

(17) : Exchange Rates, Interest Rates and Monetary Developments

Three types of exchange rate are used in the model: the number of $US per £IR (FXA); the number of a weighted basket of other world currencies per $US, and a weighted average of the number of $US, £Sterling, DM and Yen per £IR, where the weights reflect the currency composition of the Irish foreign debt.

443: FXA = IF Z19 EQ 1 THEN FXAH ELSE FXAH

444: FXAWD = IF Z19 EQ 1 THEN FXAWDH ELSE FXAWDH

445: FXAFB = IF Z19 EQ 1 THEN FXAFBH ELSE FXAFBH

Equations 446-449 define the "effective" exchange rate (i.e. number of units of a weighted average of world currencies per £IR (FXAEFF)), the rate of change of FXAEFF (FXAEFFDT), the rate of change of FXA (FXADOT) and the rate of change of FXAWD (FXAWDDOT).

446: FXAEFF = FXA/FXAWD

447: FXAEFFDT = 100*DEL(FXAEFF)/FXAEFF(-1)

448: FXADOT = 100*DEL(FXA)/FXA(-1)

449: FXAWDDOT = 100*DEL(FXAWD)/FXAWD(-1)

Equations 450-456 define the different types of interest rates in the model. Options are available, ranging from being exogenous in domestic terms, a form of perfect interest rate parity, a margin over the prevailing world rate of inflation and a fixed "real" interest rate.

450: RF = IF Z1 EQ 1 THEN RFH ELSE (IF Z1 EQ 2 THEN RFF-FXAEFFDT ELSE RMF+RFI)

451: RFI = IF Z1 EQ 1 THEN RFIH ELSE (IF Z1 EQ 2 THEN RFIF-FXAEFFDT ELSE (IF Z1 EQ 3 THEN RMFI+PWB7FDOT ELSE RRWINT+ PWB7FDOT))

452: RGL = IF Z1 EQ 1 THEN RGLH ELSE (IF Z1 EQ 2 THEN RGLF-FXAEFFDT ELSE (IF Z1 EQ 3 THEN RMGL+100*DEL(PGDPE)/PGDPE(-1) ELSE RRINT+100*DEL(PGDPE)/PGDPE(-1)))

453: RGLI = IF Z1 EQ 1 THEN RGLIH ELSE (IF Z1 EQ 2 THEN RGLIF-FXAEFFDT ELSE RMGLI+RGL)

454: RGLSSI = IF Z1 EQ 1 THEN RGLSSIH ELSE RGLSSIH

455: RPL = IF Z1 EQ 1 THEN RPLH ELSE (IF Z1 EQ 2 THEN RPLF-FXAEFFDT ELSE RMPL+RGL)

456: RD = IF Z1 EQ 1 THEN RDH ELSE (IF Z1 EQ 2 THEN RDF-FXAEFFDT ELSE RMD+RGL)

457: ERPL = (RPL+RPL(-1)+RPL(-2))/3.

458: RRPL = RPL-PGDPFCDT

Equations 459-463 define various capital flow and other financial items: domestic credit (DC), net foreign liabilities of the banking system (NFLB), other net liabilities of the banking system (ONLB), public authorities current receipts from abroad (GTTABR) and current transfers abroad (GCTABR).

459: DC = IF Z14 EQ 1 THEN DCH ELSE (IF Z14 EQ 2 THEN KDC*(GDPMV/GDPMV(-1))*DC(-1) ELSE KDC*(GDPMV/GDPMVH)*DCH)

460: NFLB = IF Z14 EQ 1 THEN NFLBH ELSE (IF Z14 EQ 2 THEN KNFLB*(GDPMV/GDPMV(-1))*NFLB(-1) ELSE KNFLB*(GDPMV/GDPMVH)*NFLBH)

461: ONLB = IF Z14 EQ 1 THEN ONLBH ELSE (IF Z14 EQ 2 THEN KONLB*(GDPMV/GDPMV(-1))*ONLB(-1) ELSE KONLB*(GDPMV/GDPMVH)*ONLBH)

462: GTTABR = IF Z14 EQ 1 THEN GTTABRH ELSE (IF Z14 EQ 2 THEN KGTTABR*(PWORLD/PWORLD(-1))*GTTABR(-1) ELSE KGTTABR*(PWORLD/ PWORLDH)*GTTABRH)

463: GCTABR = IF Z14 EQ 1 THEN GCTABRH ELSE (IF Z14 EQ 2 THEN KGCTABR*(PC/PC(-1))*GCTABR(-1) ELSE KGCTABR*(PC/PCH)*GCTABRH)

The money demand function is expressed as the demand for the real broad money aggregate, and is determined by real GDP and the inflation rate.

464: LOG(MON/PGDPM) = A571+A572*LOG(GDPM)+A573*LOG(PGDPM/PGDPM(-1))+RHO57*R57(-1)+LOG(FMON)

LOG(MON/PGDPM) = A571+A572*LOG(GDPM)+A573*LOG(PGDPM/PGDPM(-1))

NOB = 20		NOVAR = 4		RANGE: 1964 TO 1984			
RSQ =	0.93729	CRSQ =	0.925532	F(2/16) =	79.7147	PROB>F =	0.
SER =	0.048873	SSR =	0.038218	DW(0) =	1.55165	COND =	98.0477
MAX:HAT =	0.547689	RSTUDENT =	-1.81689	DFFITS =	-0.940663		

COEF	ESTIMATE	STER	TSTAT
A571	1.77642	0.90698	1.95861
A572	0.755387	0.101854	7.41637
A573	-0.333647	0.251926	-1.32438
RHO1	0.509214	0.168692	3.0186

Identities 465-466 define the official external reserves (R) and reserves as a percentage of the value of total imports (RR).

465: DEL(R) = DEL(MON)+DEL(ONLB)-DEL(DC)

466: RR = 100*(R/MGSV)

BPTKNG is the public authorities net capital receipts from abroad and BPPK, the net capital inflow of the non-banking private sector, is defined residually.

467: BPTKNG = IF Z22 EQ 1 THEN BPTKNGH ELSE (IF Z22 EQ 2 THEN PWORLD/PWORLD(-1)*BPTKNG(-1) ELSE PWORLD/PWORLDH*BPTKNGH)

468: BPPK = DEL(R)-BP-DEL(NFLB)-BPTKNG-FBOR

Finally, the adjustment for financial services (YAFS) is a simple function of GDP at factor cost.

469: LOG(YAFS) = A611+A612*LOG(GDPFCV)+RHO61*R61(-1)+LOG(FYAFS)

LOG(YAFS) = A611+A612*LOG(GDPFCV)

NOB = 20	NOVAR = 3		RANGE: 1964 TO 1984		
RSQ = 0.995682	CRSQ = 0.995174		F(1/17) = 1959.9	PROB>F = 0.	
SER = 0.089825	SSR = 0.137166		DW(0) = 1.70804	COND = 16.8896	
MAX:HAT = 0.163817	RSTUDENT = -2.30408		DFFITS = 0.601037		

COEF	ESTIMATE	STER	TSTAT
A611	-5.93713	0.451393	-13.1529
A612	1.30708	0.053819	24.2866
RHO1	0.63354	0.172066	3.68195