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

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[1.1] : Introductory Remarks

If a macroeconomic 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). 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 macroeconomic 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. 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 macroeconomic 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)."\

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 macro models 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.

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 disaggregation 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.

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!
INTRODUCTION

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 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.

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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. 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.
THE HERMES MODEL SPECIFICATION

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 KLE 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 variants of the Putty-Clay approach 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. Finally, constant incomes to scale were assumed, and this permits the separate determination of capacity output and factor inputs in a two-stage process.

In summary, the HERMES blueprint proposed a four factor KLE 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 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 post-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:

- \( Q^e_t \) = New production capacity installed in year \( t \) (i.e., new capacity vintage or generation)
- \( L^e_t \) = Normal level of labour input required to operate the capacity vintage introduced in year \( t \)
- \( E^e_t \) = Normal level of energy input required to operate the capacity vintage introduced in year \( t \)
- \( M^e_t \) = 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 subscripts for simplicity:

\[
Q^* = f(L^n, E^n, M^n, I)
\]

The process of determining 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:

\[
\text{Minimize } C = C(L^n, E^n, M^n, I, P_L, P_E, P_M, P_I)
\]

where

\[
Q^* = f(L^n, E^n, M^n, I)
\]

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

\[
L^n = g_1(Q^*, P_L, P_E, P_M, P_I)
\]
\[
E^n = g_2(Q^*, P_L, P_E, P_M, P_I)
\]
\[
M^n = g_3(Q^*, P_L, P_E, P_M, P_I)
\]
\[
I = g_4(Q^*, P_L, P_E, P_M, P_I)
\]

Examples of these factor demand equations for particular choices of the production function \( f(\cdot) \) 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 output and all prices, including the output price.

\[
\Pi = \Pi(Q^*, P_Q, P_L, P_E, P_M, P_I)
\]

Hence, maximizing profit with respect to capacity output yields

\[
Q^* = g_5(P_Q, P_L, P_E, P_M, P_I)
\]

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. Three possible estimation strategies suggest themselves:

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

---

2 For example, the Mulerki isoquant function (Mulerki, 1963; Hanocho, 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 (Arits 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

\[
C = E \cdot c(p_1, \ldots, p_8)
\]

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 \(\alpha_i, \gamma_{ij}\).

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

\[
\alpha_{ij} = \frac{\gamma_{il} + S_i S_j}{S_i S_j}
\]

\[
\sigma_{ij} = \frac{\gamma_{il} + S_i (S_i - 1)}{S_i^2}
\]

where the own price and cross price elasticities are given by

\[
\eta_{ii} = \sigma_{ii} S_i
\]

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:

<table>
<thead>
<tr>
<th>Coal, Coke and Lignite</th>
<th>(E_1 + E_2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Oil</td>
<td>(E_3)</td>
</tr>
<tr>
<td>Petroleum Products</td>
<td>(E_4)</td>
</tr>
<tr>
<td>Gas (Natural and Manufactured)</td>
<td>(E_5 + E_6)</td>
</tr>
<tr>
<td>Electricity (Hydro and Thermal)</td>
<td>(E_7)</td>
</tr>
</tbody>
</table>

and for the following aggregated branches:

<table>
<thead>
<tr>
<th>Agriculture</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing Industry plus Building</td>
<td>Q + K + C + B</td>
</tr>
<tr>
<td>Transport Services</td>
<td>Z</td>
</tr>
<tr>
<td>Other Services (Marketed and Non-Marked)</td>
<td>L + N</td>
</tr>
</tbody>
</table>

---

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.
THE HERMES MODEL SPECIFICATION

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 data 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 to reduce the difficulties of the subsequent estimation process. A detailed report on Irish work in this area is provided in Prendergast, 1984. There was, however, 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 Italian, 1982a.

The details of the proposed bilateral trade flow model for HERMES are available in a series of papers by Italianer and others6. 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

$$
\log(M_{ij}^e) = \gamma_i + \alpha_i \log(M_i^e) + \epsilon_i \log\left(\frac{PM_i}{PM_j}\right)
$$

where

- $M_{ij}^e = ex \ ante$ volume demand by importer $j$ supplied by exporter $i$
- $PM_i = price$ index for above
- $M_i = total$ imports of product by importer $j$

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6 Barten and d’Alcantara, 1977; Italianer, 1982a; Italianer, 1982b; Italianer and d’Alcantara, 1983;
\[ PM_{ij} = \text{price index for above} \]
\[ \alpha_{ij} = \text{allocation elasticity} \]
\[ \epsilon_{ij} = \text{relative price elasticity} \]

The bilateral export supply function may be written as

\[ \log(X^*_j) = \eta_{ij} + \beta_{ij} \log(XP_j) + \pi_{ij} \log\left(\frac{PX_{ij}}{PD_j}\right) \]

where

\[ X^*_j = \text{ex ante volume supply by exporter \( i \) on import market \( j \)} \]
\[ PX_{ij} = \text{price index for above} \]
\[ XP_j = \text{export capacity by product for exporter \( i \)} \]
\[ PD_j = \text{price index of domestic costs for producing in country \( i \)} \]
\[ \beta_{ij} = \text{allocation elasticity of total export supply capacity} \]
\[ \pi_{ij} = \text{relative price elasticity} \]

Assuming market clearing,

\[ M^*_j = X^*_j - M_j \]

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:

\[ \log(M_j) = \psi_i + \frac{\pi_{ij}}{\pi_j - \epsilon_j} \alpha_{ij} \log(M_j) - \frac{\epsilon_{ij}}{\pi_j - \epsilon_j} \beta_{ij} \log(XP_j) - \frac{\epsilon_{ij} \pi_{ij}}{\pi_j - \epsilon_j} \log\left(\frac{PM_i}{PD_i}\right) \]

\[ \log(PM_j) = \chi_i + \frac{\pi_{ij}}{\pi_j - \epsilon_j} \log(PD_j) - \frac{\epsilon_{ij}}{\pi_j - \epsilon_j} \log(PM_j) + \frac{1}{\pi_j - \epsilon_j} (\alpha_{ij} \log(M_j) - \beta_{ij} \log(XP_j)) \]

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, 1985. 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 branches (15)
- (c) the number of different energy categories (10)
- (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 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).
THE HERMES MODEL SPECIFICATION

(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.

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;

(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.

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8 This was particularly necessary since HERMES-IRELAND is the only operational macroeconomic 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.
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. 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). 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 Moncomble 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. 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 consequent 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 (Hellwell 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:

\[
\frac{QSTARI}{QWSTARI} = \frac{PRORS}{(PRIRLS,t)}
\]

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), PRORS 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)

---

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 assembiling 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 Hellwell in the OECD INTERLINK model and the MACE model of Canada (Hellwell 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 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:

\[
KE = \left( \frac{c}{b} + \frac{c}{EI} \right)^{s-1}
\]

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:

\[
QVIN = \left( B \{EFFL.LI \} + CKE \right)^{s-1}
\]

where

QVIN = Potential output  
EFFL = Labour efficiency index  
LI = Total employment  
KE = Capital-energy index  
B, C = Scale parameters  
s = 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.

\[
\left( \frac{EVIN}{KI} \right)^{s} = \left( \frac{c}{b} \frac{UCCI}{PE} \right)^{s}
\]

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,

\[
EVIN = \left( \frac{c}{b} \frac{UCCI}{PE} \right)^{s} KI
\]

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

\[
EVIN = EVIN_{-1} (1 - RSCRI) + \frac{c}{b} \frac{UCCI}{PE}
\]

\[
E\text{VIN}_{-1} = \left( \frac{c}{b} \frac{UCCI}{PE} \right)^{s} KI
\]

\[
EVIN = EVIN_{-1} (1 - RSCRI) + \frac{c}{b} \frac{UCCI}{PE}
\]

---

\(8\) 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, **RETR0**, 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) \[ EVIN = EVIN_{-1}(1 - RETRO - RSCRI) + \]

\[ (II + RETRO.KI_{-1}) \left( \begin{array}{c} e \\ b \end{array} \right) \left( \begin{array}{c} UCCI \\ PE \end{array} \right) \] \[ \] \[ \frac{c}{b} \]

The equivalent definition of the vintage capital-energy bundle is

(3.7) \[ KEVIN = KEVIN_{-1}(1 - RETRO - RSCRI) + \]

\[ (II + RETRO.KI_{-1}) \left( \begin{array}{c} e \\ b \end{array} \right) \left( \begin{array}{c} UCCI \\ PE \end{array} \right) \] \[ \] \[ \frac{c}{b} \]

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., **RETR0** = 1-RSCRI). The flexible vintage model reduces to the strict putty-clay model if the retrofitting 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) \[ \frac{KEVIN}{KI} = \left( b + c \left( \begin{array}{c} e \\ b \end{array} \right) \left( \begin{array}{c} UCCI \\ PE \end{array} \right) \right) \] \[ \] \[ \frac{c}{b} \]

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) \[ UCCI = PII \left( RSCRI + \frac{RHORI}{100} \right) \left( 1 - RGKTI \right) \left( 1 - RGTYC \right) \]

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) \[ P\text{QH}\text{I}.\text{QH}\text{I} = AA\text{E}I\text{L}I + PE.E + \]

\[ \left( \frac{RHORI}{100} + RSCRI \right) PII.KI \]

then

(3.11) \[ RHORI = 100. \]

\[ \frac{Mean(P\text{QH}\text{I}.\text{QH}\text{I}) - Mean(AA\text{E}I\text{L}I + P\text{E}.E + PII.KI.RSCRI)}{Mean(PII.KI)} \]

**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) \[ \frac{c}{b} = \left( \frac{Mean(EI)}{KI} \right) \frac{1}{\left( \frac{Mean(UCCI)}{PE} \right)^{1/\alpha}} \]

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) \[ Mean(KEVIN) = Mean(KI) \]

This permits the calculation of the parameter b as

(3.14) \[ \log(b) = \frac{s - 1}{s} \left( \log \left( 1 + \left( \frac{c}{b} \right)^s \left( \frac{PE}{UCCI} \right)^{1/\alpha} \right) \right) \]

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

(3.15) \[ \log(EI) = a_1 + a_2 \log(EVIN) + u \]

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\text{ini} = EI\text{ini}.

Step 4: Estimate the regression \( \log(EI) = a_1 + a_2 \log(\text{EVIN}) + u \) 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) \[ Q\text{VIN} = \left( b.(EFFL\text{L}I) \right)^{1 - \alpha} + c.KEVIN^{1 - \beta} \]

Cost-minimising behaviour by producers implies that
TABLE 3.1 : Estimation of CES Parameters

<table>
<thead>
<tr>
<th>(a) log(QHI/LI)</th>
<th>1.086 + 0.494 log(AAEI/PQHI) + 0.0212t</th>
<th>RSQ = 0.988 DW = 0.79</th>
</tr>
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<tbody>
<tr>
<td>(b) log(QHI/LI)</td>
<td>0.809 + 0.643 log(AAEI/PQHI) + 0.0219t</td>
<td>RSQ = 0.992 DW = 1.84 RHO = 0.7</td>
</tr>
<tr>
<td></td>
<td>(5.8)</td>
<td>(8.2)</td>
</tr>
<tr>
<td>(c) log(KEVIN/LI)</td>
<td>1.593 + 0.112 log(AAEI/PCKE) + 0.0419t</td>
<td>RSQ = 0.991 DW = 0.66</td>
</tr>
<tr>
<td></td>
<td>(14.2)</td>
<td>(39.1)</td>
</tr>
<tr>
<td>(d) log(KEVIN/LI)</td>
<td>1.399 + 0.157 log(AAEI/PCKE) + 0.0455t</td>
<td>RSQ = 0.994 DW = 1.76 RHO = 0.75</td>
</tr>
<tr>
<td></td>
<td>(9.6)</td>
<td>(15.7)</td>
</tr>
</tbody>
</table>

(3.17) \( \left( \frac{KEVIN}{LI} \right)^ \gamma \) = \( \left( \frac{C}{B} \right) \left( \frac{AAEI}{EFFL.PCKE} \right) \)

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) \( PCKE = (b'.UCCt \cdot c'.PE1^{-t})^{1/t} \)

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

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

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

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

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

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

for constrained profit maximisation, and

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

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":

<table>
<thead>
<tr>
<th></th>
<th>r</th>
<th>g</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>0.4940</td>
<td>0.0420</td>
</tr>
<tr>
<td>(b)</td>
<td>0.6439</td>
<td>0.0616</td>
</tr>
<tr>
<td>(c)</td>
<td>0.1115</td>
<td>0.0471</td>
</tr>
<tr>
<td>(d)</td>
<td>0.1565</td>
<td>0.0539</td>
</tr>
</tbody>
</table>

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) \( B = \frac{\text{Mean} \left( \frac{\exp(gt.LI)}{KI} \right)}{\text{Mean} \left( \frac{PCKE}{AAEI \cdot \exp(gt)} \right)^{1/t}} \)

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

(3.24) \( C = \text{Mean} \left( \frac{KI}{QHI} \right)^{1/t} / \text{Mean} \left( 1 + \frac{B}{C} \right) \left( \frac{PCKE}{AAEI \cdot \exp(gt)} \right)^{-t} \)

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;

\( \log(EL) = 0.514 + 0.908 \log(EVIN) \)

(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).
THE PRODUCTION SECTORS

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:

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

(a) Year 1960:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.284</td>
<td>0.132</td>
<td>0.077</td>
</tr>
<tr>
<td>0.284</td>
<td>-0.464</td>
<td>0.116</td>
</tr>
<tr>
<td>0.284</td>
<td>0.199</td>
<td>-0.271</td>
</tr>
</tbody>
</table>

(b) Year 1970:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.312</td>
<td>0.129</td>
<td>0.053</td>
</tr>
<tr>
<td>0.312</td>
<td>-0.502</td>
<td>0.099</td>
</tr>
<tr>
<td>0.312</td>
<td>0.244</td>
<td>-0.205</td>
</tr>
</tbody>
</table>

(c) Year 1980:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.273</td>
<td>0.108</td>
<td>0.113</td>
</tr>
<tr>
<td>0.273</td>
<td>-0.365</td>
<td>0.156</td>
</tr>
<tr>
<td>0.273</td>
<td>0.149</td>
<td>-0.381</td>
</tr>
</tbody>
</table>

[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 (\( YWDIS \)). Estimation yielded the following:

\[
\log(QHI) = 0.915 \log(QVIN) + 0.0884 \log(QVIN)/QHI + 0.349 \log(GSOID/QVIN) + 0.377 \log(YWDIS)
\]

\( R^2 = 0.837, DW = 1.45 \)

[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 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

\[ \text{II/KSTARI} = 0.11 \]

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/OSTARS) as a quadratic function of time.

\[ \Delta \log KSM = a_1 + a_2 \Delta \log (OSTARS) + \]
[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 market 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 Scandinavian model (Lindebeck, 1979), where we identify the industry sector with the "tradables" sector and the services sector with "non-tradables". The Scandinavian 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 (PQT1) is then a function of world prices of manufactured goods (PWORLD) and of gross agricultural output prices (PQGA). 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.

\[ PQT1 = f_2 (PWORLD, PQGA) \]

The relationship between the gross output prices 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):

\[ PQHI = f_3 (PQT1, PMG) \]

As shown in Appendix 2, this equation is actually estimated with PQT1 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 QHV 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.

\[ \begin{align*}
QHI &= QHV / PQHI \\
OIV &= QHV / EIV \\
OI &= QHI / EI \\
POI &= OIV / OI
\end{align*} \]

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.

Industrial export prices (PIXI) 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.

\[ PIXI = f_4 (PWORLD, PWORLD_{-1}) \]

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.

\[ PQMA = f_5 (PQT1, PQGA_{-1}) \]

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.

\[ \begin{align*}
PTE &= TE / TRE \\
PSUB &= SUB / SRUB
\end{align*} \]

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 PRODUCTION SECTORS

The number of expenditure categories distinguished in the model is quite large and each of these categories requires a 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

\[
\begin{align*}
PC &= f_{11} (PQTI,TINC,UCLSM) \\
PIBC &= f_{10} (UCLI,PMG) \\
PIME &= f_{10} (UCLI,PMG,PMG_{i},TINC) \\
PIH &= f_{10} (UCLI,PMG) \\
PSTNADL &= f_{11} (PQTI,PMG)
\end{align*}
\]

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 (PWWORLD) 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 endogeneity 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 (PISS) 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.

\[
\begin{align*}
PII &= f_{111} (PIBC,PIME) \\
PISS &= f_{111} (PIBC,PIME) \\
PIAG &= f_{111} (PIBC,PIME) \\
PSTNA &= f_{111} (PSTNADL)
\end{align*}
\]

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 (POSMS) is determined by the model identity where OSMSV 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. Hence,

\[
POSMS = OSMSV / OSM
\]

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

<table>
<thead>
<tr>
<th>Factor</th>
<th>£ Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Consumption</td>
<td>59.80</td>
</tr>
<tr>
<td>Government Consumption</td>
<td>5.30</td>
</tr>
<tr>
<td>Investment</td>
<td>0.00</td>
</tr>
<tr>
<td>Exports</td>
<td>6.90</td>
</tr>
<tr>
<td>Net Factor Income</td>
<td>-1.20</td>
</tr>
<tr>
<td>GNP</td>
<td>70.80</td>
</tr>
<tr>
<td>Output of Market Services</td>
<td>-29.50</td>
</tr>
<tr>
<td>Adjustment for Financial Services</td>
<td>1.40</td>
</tr>
<tr>
<td>Taxes on Expenditure</td>
<td>-1.20</td>
</tr>
<tr>
<td>Net Factor Income</td>
<td>70.80</td>
</tr>
<tr>
<td>GNP</td>
<td></td>
</tr>
</tbody>
</table>

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 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.
CHAPTER 4: HOUSEHOLDS

[4.1] : Wage Determination

Just as with prices, the Scandinavian 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 Scandinavian 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-accommodating demand side in the domestic economy (Lindbeck,1979). We have attempted to extend the bargaining process underlying the Scandinavian model wage equation broadly as follows:

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

\[ d\log(\text{AAEI}) = d\log(\text{PQTI}) + d\log(\text{OPRI}) \]

(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 Scandinavian 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

\[ PC = PCNT* \left( \frac{1 + t_s}{1 - t_d} \right) \]

PCNT being the deflator of consumption expenditure net of indirect taxes, \(t_s\) 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

\[ P' = P/(1 + t_s) \]

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

\[ WEDGE = (PCNT/P)^* \left(1 + t_s\right)^* \left( \frac{1 + t_s}{1 - t_d} \right) \]

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.

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

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. The estimated elasticities on nominal wages are given below.

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

$$\log\left(\frac{AAESM}{AAEI}\right) = a_1 + a_2t$$

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

$$AAEPa = WRELPA * AAEL$$

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.

$$C = a_1 + a_2\frac{YRPED}{NT} + a_3DUM75$$

$$C = b_1 + b_2\frac{YRPED - (GCTPER - GCTW)}{PC\cdot NT} + 1.0\frac{GCTPER - GCTW}{PC\cdot NT} + b_3DUM75$$

where

\[ C = \text{Real Consumption} \]

\[ NT = \text{Population} \]

\[ YRPED = \text{Real Personal Disposable Income} \]

\[ YPERD = \text{Personal Disposable Income} \]

\[ PC = \text{Consumption Price Deflator} \]

\[ GCTPER = \text{Total Personal Transfers} \]

\[ GCTW = \text{Teachers Salaries (classified in the National Accounts as transfers)} \]

\[ DUM75 = \text{Dummy Variable to eliminate anomalous year 1975.} \]

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 (YRPED/NT), but influenced by government housing transfers (RGKTH), interest rates (RPL) and inflation (PIH/PIH\_t).

$$\log\left(\frac{IHP}{NT}\right) = a_1 + a_2\log\left(\frac{YRPED}{NT}\right) + a_3\log(RGKTH) + a_4\log\left(\frac{RPL}{100}\right) - a_5\log\left(\frac{PIH}{PIH_{-t}}\right).$$

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. 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).

\[ NMA = a_1 + a_2 \cdot RE \cdot RWN + a_3 NMA_{-1} \]

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.

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2 Further work on disaggregation is in progress, which may permit the incorporation of more theory and the estimation of stable econometric relationships.
[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 percent 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 (MMFPFA)
(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 (MMFPFA) is modelled as a function of the volume of gross agricultural output (QGA) and time. This represents only a small proportion of total imports.

\[
\log(MMFPFA/QGA) = f(QGA,t)
\]

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 treatment of inventories as residual in the MACE model of Canada (Helliwell, Booth 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).
EXTERNAL TRADE

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 unnecessary. 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:

\[ \frac{QDA}{QGA} = f(t) \]

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:

\[ \frac{XI}{QHI} = f(t) \]

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:

\[ \text{Log(XTO/QIW)} = f(DUMNI) \]

A unitary elasticity of other services exports (XSO) with respect to real GNP is imposed. A partial adjustment 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.

\[ \log(XSO/GNP) = a_1 + a_2 \log(XSO/GNP) , \]

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).

\[ PXS = f(\text{PC}) \]

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

\[
\log \text{GTEXT} = -3.89 + 0.7 \log \text{REX} + 1.21 \log \left( C + XTO \right) + 0.26 \log \text{PC}
\]

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%. 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 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 (GTÉVATB) 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.

\[
\text{GTEVAT} = f(\text{RVAT}, \text{GTEVATB}, \text{PC})
\]

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.

\[
\text{GTEO} = f(\text{RTEO}, \text{C}, \text{PC})
\]

Motor vehicle registration duties (GTMVVD), 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).

\[
\text{GTMVD} = f(\text{RCARS}, \text{C})
\]

They are partly considered to be an indirect tax (GTEMVDC) and partly considered to be a direct tax (GTYMVD). 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.

\[
\text{GTECUSO} = \text{RCUS} \times \text{MGV}
\]

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).

\[
\text{GTE} = \text{GTEXT} + \text{GTEXT} + \text{GTEO} + \text{GTMVDC} + \text{GTECUSO} + \text{GTERATE} + \text{GTAGLEV} - (\text{EECBUD} + \text{EECCIC})
\]

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.

\[
\text{GYPER} = f(AAITI,\text{LNA},\text{RTPYALL})
\]

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

\[
\text{GYSL} = \text{RGYSL}(\text{YWSM} + \text{YWI})
\]

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.

\[
\text{GTYC} = \text{RGTYC}^* \text{YCY}(-1)
\]

Total direct tax revenue (GTY) is determined in an identity as the sum of revenue from personal income tax (GYPER), 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.

\[
\text{GTY} = \text{GYPER} + \text{GTYSL} + \text{GTYC} + \text{GTYMVDP} + \text{GTYA} + \text{GTYDIRT}
\]

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

\[
\text{GTTOT} = \text{GTE} + \text{GTY} + \text{GTW} + \text{GTIT} + \text{GTTABR}
\]

[6.2]: Current Expenditure

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

\[
\text{GCSC} = \text{RGSC}^* \text{C}
\]

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 directly 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).

\[
\text{SUB} = \text{GCSC} + \text{GCSO} + \text{EECS}
\]

Current transfers paid by the government sector are disaggregated into four categories: unemployment assistance and benefit (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 average rate of payment (RUP) and the numbers unemployed (U).

\[
\text{GCTUP} = f(RUP,U)
\]

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.

\[
\text{GCTPRB} = f(U,\text{AAENA})
\]

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

\[
\text{GCTPER} = \text{GCTUP} + \text{GCTPRB} + \text{GCTW}^3 + \text{GCTREST}
\]

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.

\[
\text{GCTNDID} = f(RGL,\text{GNL})
\]

However, an alternative more complex formulation can be used drawing on the output of a special debt model³. 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).

\[
\Delta \text{GCTNDID} = RGL(-1)(\Delta \text{GNL}(-1) + \text{GNLREP}(-1)) - \text{GCTNDRI}
\]

---

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 (RLSSSI), expressed in percentage 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.

\[ \text{GCTNDISS} = \text{RLSSSI} \times 100 \times \text{GNSS} \]
\[ \text{GCTNDIF} = \text{RFI} \times 100 \times (\text{GNFF} \times \text{FXAFB}) \]

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).

\[ \text{GCTNDI} = \text{GCTNDID} + \text{GCTNDISS} + \text{GCTNDIF} \]

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. 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 (YWSEH) 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 (GCGPVP) by the relevant deflator (PGCGNP). Finally, the volume figure for total public consumption (GCGV) is the sum of its components (OPA), defined in Section 3.4, consumption expenditure on health and education at constant prices (GCGOWV) and other purchases of goods and services at constant prices (GCGNP).

\[ \text{GCGV} = \text{OPAV} + \text{GCGOWV} + \text{GCGNP} \]
\[ \text{GCGOWV} = \text{YWSEHE} - \text{GCTW} \]
\[ \text{PGCGOWV} = \frac{\text{GCGOWV}}{\text{AAESHE}} \]
\[ \text{GCGOW} = \frac{\text{GCGOWV}}{\text{AAESHE}} \]
\[ \text{GCGNP} = \frac{\text{GCGNPV}}{\text{PGCGNP}} \]
\[ \text{GCG} = \frac{\text{OPA} + \text{GCGOW} + \text{GCGNP}}{\text{PGCGNP}} \]

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).

\[ \text{GC} = \text{GCGV} + \text{SUB} + \text{EECS} + \text{GCTPER} + \text{GCTNDI} + \text{GCTABR} \]

[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 endogenous are capital transfers to industry (IDA grants: GKTI) and capital transfers for housing (GKTH). In these two cases they are endogenous 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 (IV), and for grants for housing purposes the base is private sector housing investment (IHPV).

\[ \text{GKTI} = \text{RGKTI} \times \text{IV} \]
\[ \text{GKTH} = \text{RGKTH} \times \text{IHPV} \]

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

\[ \text{GK} = \text{IHSV} + \text{ISHEV} + \text{IAPV} + \text{GKTI} + \text{GKTH} + \text{GKREST} \]

[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 unless the indexation option is invoked.

\[ \text{GBRC} = \text{GTTOT} - \text{GC} \]
\[ \text{GBR} = \text{GTTOT} + \text{GR} - \text{GC} \]

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.


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), 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.

\[
\begin{align*}
\text{GNT} & = \text{GNF} + \text{GND} \\
\text{GND} & = \text{GNL} + \text{GNSS} \\
\text{GNL} & = [\text{GNHGDL} - \Delta(\text{GNSS})] + \\
& \Delta(\text{GNBG}) + \Delta(\text{GNCG}) + \text{KGNL}
\end{align*}
\]

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 6.4.6.

\[
\text{FBOR} = -\text{GBR} - \Delta(\text{GNSS}) - \Delta(\text{GNBG}) - \Delta(\text{GNCG}) - \text{GNHGDL}
\]

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.

\[
\begin{align*}
\text{FBORF} & = \text{FBOR} \times \text{FXAFB} \\
\text{GNFF} & = \text{GNFF} \times \text{FBORF} \\
\text{GNF} & = \text{GNFF} / \text{FXAFB}
\end{align*}
\]


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).

\[
\begin{align*}
\text{BPPK} & = \Delta(R) - \Delta(\text{NFLB}) - \text{BPTKNG} - \text{FBOR} \\
\text{KBPPK} & = [\text{KBPPK}_t / \text{PWORLD}_t, \ast \text{PWORLD}] - \text{BPPK} \\
\text{NFLP} & = \text{KBPPK} - \text{NFLB}
\end{align*}
\]


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 (SADV) - retained profits after tax, industrial depreciation (DEPI), an estimate of the proportion of services
depreciation (DEPS) attributable to the company sector, 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 (FFAQI) 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 (DEPA) and capital transfers by the government sector to the household sector (GKTH). The use of funds by the household sector (FUH) consists of private housing investment (HPV), agricultural investment (IAV) 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 acquisition of financial assets by the private sector is then the sum of the acquisitions by the company and household sectors (FFAQI) and the net acquisitions of financial assets as a proportion of total funds available in each sector are defined as (RFFAQC) and (RFFAQH)

\[
\text{FFSC} = \text{SAVC} + \text{DEPI} + 0.55 \times \text{DEPS} + \text{GKTi} + \text{GKREST}
\]

\[
\text{FFUC} = \text{IIV} + \text{ISMV} + \text{STNAVDL} + \text{STIVVDL}
\]

\[
\text{FFAQC} = \text{FFSC} - \text{FUH}
\]

\[
\text{FFSH} = \text{SAV} + \text{DEPA} + \text{GKTH}
\]

\[
\text{FFUH} = \text{HPV} + \text{IAV} + \text{STAVDL}
\]

\[
\text{FFAQI} = \text{FFSH} - \text{FUH}
\]

\[
\text{FFAQH} = 100 \times (\text{FFAQI} / \text{FFSH})
\]

\[
\text{RFFAQI} = 100 \times (\text{FFAQI} / \text{FFAQH})
\]

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 account for 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.

\[
\log(\text{MON} / \text{PGDPM}) = 1.776 + 0.755 \log(\text{GDPM}) - 0.334 \log(\text{PGDPM} / \text{PGDPM})
\]

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 (GNHGD) 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 acquisition of government stocks is set equal to a parameter (KGNH) times the net acquisition 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.

\[\text{GNBG} = \text{KGNB} \times \text{MON}\]

\[\text{GNHGD} = \text{KGNH} \times \text{FFAQI} + \text{GNSS}\]

\[\text{GNSS} = \text{KONSS} \times \text{FFAQH} + \text{GNSS}\]

\[6.5.4\] : 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 determining 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. However, the amount of research undertaken to date does not allow us to specify a satisfactory 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 deviation 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 (RRLP) is defined as equal to the nominal rate less the rate of increase in the delutor for GDP at factor cost (PGDPF).
RGL  1  Exogenous
2       RGLF-FXAEFFDT
3       RRINT+100*DEL(PGDPE)
PWB7FDOT World prices, major 7 OECD countries, percentage change
/PGDPE_1
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.
RMG        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.

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.

HERMES - IRELAND
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 structure 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.

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](image)

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 economics 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.
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:

\[ RMSPE = \frac{1}{T} \sqrt{\sum_{t=1}^{T} \left( \frac{Y_{i,t} - \hat{Y}_{i,t}}{Y_{i,t}} \right)^2} \]

where
\[ Y_{i,t} = \text{simulated value of the } i \text{th endogenous variable at time } t \]
\[ \hat{Y}_{i,t} = \text{actual value of the } i \text{th endogenous variable at time } t \]

\[ T = \text{number of time periods in the simulation} \]

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): \[ RMSE = \frac{1}{T} \sqrt{\sum_{t=1}^{T} (Y_{i,t} - \hat{Y}_{i,t})^2} \]

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:

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

Note (*) Denotes RMSE
## HERMES-IRELAND: RMSPE for Behavioural Variables from Estimation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>RMSPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAEI</td>
<td>Average annual earnings in industry (version 1)</td>
<td>1.99</td>
</tr>
<tr>
<td>AAEI</td>
<td>Average annual earnings in industry (version 2)</td>
<td>1.94</td>
</tr>
<tr>
<td>AAESM</td>
<td>Average annual earnings in market services</td>
<td>2.95</td>
</tr>
<tr>
<td>C</td>
<td>Personal consumers expenditure</td>
<td>1.71</td>
</tr>
<tr>
<td>DEPAG</td>
<td>Depreciation in agriculture</td>
<td>6.43</td>
</tr>
<tr>
<td>DEPI</td>
<td>Depreciation in industry</td>
<td>9.26</td>
</tr>
<tr>
<td>DEPS</td>
<td>Depreciation in Services (market + non-market)</td>
<td>5.46</td>
</tr>
<tr>
<td>EI</td>
<td>Energy inputs in industry</td>
<td>3.38</td>
</tr>
<tr>
<td>EOPRI</td>
<td>Trend growth in labour productivity (industry)</td>
<td>3.87</td>
</tr>
<tr>
<td>EOPRSM</td>
<td>Trend growth in labour productivity (m. servs)</td>
<td>4.66</td>
</tr>
<tr>
<td>GCTNDID</td>
<td>National loan debt interest</td>
<td>9.43</td>
</tr>
<tr>
<td>GCTUP</td>
<td>Unemployment transfer payments</td>
<td>5.71</td>
</tr>
<tr>
<td>GTEO</td>
<td>Residual indirect tax revenue</td>
<td>9.28</td>
</tr>
<tr>
<td>GTEVAT</td>
<td>VAT revenue</td>
<td>5.53</td>
</tr>
<tr>
<td>GTEXT</td>
<td>Excise duty revenue</td>
<td>1.98</td>
</tr>
<tr>
<td>GTMVD</td>
<td>Motor taxation revenue</td>
<td>6.57</td>
</tr>
<tr>
<td>IHP</td>
<td>Private housing investment</td>
<td>8.02</td>
</tr>
<tr>
<td>II</td>
<td>Industrial investment</td>
<td>7.73</td>
</tr>
<tr>
<td>ISM</td>
<td>Market services investment</td>
<td>9.52</td>
</tr>
<tr>
<td>KAG</td>
<td>Capital stock in agriculture</td>
<td>0.66</td>
</tr>
<tr>
<td>LAG</td>
<td>Employment in agriculture</td>
<td>1.40</td>
</tr>
<tr>
<td>LFPR</td>
<td>Labour force participation rate</td>
<td>0.55</td>
</tr>
<tr>
<td>LI</td>
<td>Employment in industry</td>
<td>0.93</td>
</tr>
<tr>
<td>LSM</td>
<td>Employment in marketed services</td>
<td>0.69</td>
</tr>
<tr>
<td>MC</td>
<td>Imports of consumption goods (version 1)</td>
<td>4.22</td>
</tr>
<tr>
<td>MC</td>
<td>Imports of consumption goods (version 2)</td>
<td>4.01</td>
</tr>
<tr>
<td>MMFPA</td>
<td>Imports of agricultural materials (version 1)</td>
<td>11.83</td>
</tr>
<tr>
<td>MMFPA</td>
<td>Imports of agricultural materials (version 2)</td>
<td>11.65</td>
</tr>
<tr>
<td>MON</td>
<td>Money supply</td>
<td>4.14</td>
</tr>
<tr>
<td>MPCG</td>
<td>Imports of producers capital goods</td>
<td>5.96</td>
</tr>
<tr>
<td>MS</td>
<td>Imports of services</td>
<td>9.11</td>
</tr>
<tr>
<td>N1564</td>
<td>Population aged between 15 and 64 years</td>
<td>0.29</td>
</tr>
<tr>
<td>NEDPR</td>
<td>Participation rate in full-time education</td>
<td>2.48</td>
</tr>
<tr>
<td>NLEI4</td>
<td>Population aged less than or equal to 14 years</td>
<td>0.22</td>
</tr>
<tr>
<td>NMA</td>
<td>Net migration abroad</td>
<td>8.22</td>
</tr>
<tr>
<td>NT</td>
<td>Total population</td>
<td>0.19</td>
</tr>
<tr>
<td>OPA</td>
<td>Added-value in public administration</td>
<td>1.76</td>
</tr>
<tr>
<td>OSM</td>
<td>Added-value in marketed services</td>
<td>1.35</td>
</tr>
<tr>
<td>PC</td>
<td>Deflator of consumption</td>
<td>1.97</td>
</tr>
<tr>
<td>PIAG</td>
<td>Deflator of agricultural investment</td>
<td>3.07</td>
</tr>
<tr>
<td>PIBC</td>
<td>Deflator of building investment</td>
<td>1.87</td>
</tr>
<tr>
<td>PIH</td>
<td>Deflator of total housing investment</td>
<td>3.70</td>
</tr>
<tr>
<td>PII</td>
<td>Deflator of industrial investment</td>
<td>0.89</td>
</tr>
<tr>
<td>PIME</td>
<td>Deflator of investment in machinery and equip.</td>
<td>2.85</td>
</tr>
<tr>
<td>PIS</td>
<td>Deflator of total services investment</td>
<td>0.57</td>
</tr>
<tr>
<td>PQHI</td>
<td>Deflator of gross industrial output</td>
<td>3.75</td>
</tr>
<tr>
<td>PQMA</td>
<td>Deflator of material inputs in agriculture</td>
<td>3.70</td>
</tr>
<tr>
<td>PQT1</td>
<td>Deflator of transportable goods sector output</td>
<td>2.65</td>
</tr>
<tr>
<td>PSTNA</td>
<td>Deflator of non-agricultural stock level</td>
<td>8.21</td>
</tr>
<tr>
<td>PSTDADL</td>
<td>Deflator of non-agricultural stock changes</td>
<td>7.39</td>
</tr>
<tr>
<td>PXI</td>
<td>Deflator of industrial exports</td>
<td>2.06</td>
</tr>
<tr>
<td>PYAFS</td>
<td>Deflator of adjustment for financial services</td>
<td>9.29</td>
</tr>
<tr>
<td>QDAME</td>
<td>Deflator of domestic absorption of ag. output</td>
<td>8.12</td>
</tr>
<tr>
<td>QGA</td>
<td>Deflator of gross agricultural output</td>
<td>4.72</td>
</tr>
<tr>
<td>QHI</td>
<td>Gross output in industry</td>
<td>2.18</td>
</tr>
<tr>
<td>QMA</td>
<td>Material inputs into agriculture</td>
<td>6.57</td>
</tr>
<tr>
<td>QSTARI</td>
<td>Planned output capacity in industry (version 1)</td>
<td>1.08</td>
</tr>
<tr>
<td>QSTARI</td>
<td>Planned output capacity in industry (version 2)</td>
<td>1.75</td>
</tr>
<tr>
<td>QSTARI</td>
<td>Planned output capacity in industry (version 3)</td>
<td>1.93</td>
</tr>
<tr>
<td>SRUB</td>
<td>Total subsidies in real terms</td>
<td>4.26</td>
</tr>
<tr>
<td>STNADL</td>
<td>Non-agricultural stock changes in real terms</td>
<td>59.70</td>
</tr>
<tr>
<td>TRE</td>
<td>Total indirect tax revenue in real terms</td>
<td>1.64</td>
</tr>
<tr>
<td>XI</td>
<td>Industrial exports</td>
<td>4.01</td>
</tr>
<tr>
<td>XSO</td>
<td>Exports of services, excluding tourism</td>
<td>8.88</td>
</tr>
<tr>
<td>XTO</td>
<td>Exports of tourism</td>
<td>6.52</td>
</tr>
<tr>
<td>YAFS</td>
<td>Adjustment for financial services</td>
<td>9.85</td>
</tr>
<tr>
<td>YCU</td>
<td>Undistributed profits</td>
<td>20.11</td>
</tr>
</tbody>
</table>
THE PRODUCTION SECTORS

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

(ii) Tracking Performance for Industry Aggregates:

<table>
<thead>
<tr>
<th></th>
<th>RMS % ERROR</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Static</td>
<td>Dynamic</td>
<td></td>
</tr>
<tr>
<td>QHI Gross Industrial Output (£m,1980)</td>
<td>2.94</td>
<td>5.17</td>
<td></td>
</tr>
<tr>
<td>OI Added Value in Industry (£m,1980)</td>
<td>3.19</td>
<td>6.60</td>
<td></td>
</tr>
<tr>
<td>II Industrial Investment (£m,1980)</td>
<td>9.87</td>
<td>12.6</td>
<td></td>
</tr>
<tr>
<td>LI Industrial Employment (000)</td>
<td>1.79</td>
<td>6.16</td>
<td></td>
</tr>
<tr>
<td>EI Industrial Energy Inputs (£m,1980)</td>
<td>4.61</td>
<td>5.02</td>
<td></td>
</tr>
<tr>
<td>YHDI Industrial Output Deflator (1980=1)</td>
<td>5.51</td>
<td>5.51</td>
<td></td>
</tr>
<tr>
<td>POI Added Value Deflator (1980=1)</td>
<td>3.78</td>
<td>4.52</td>
<td></td>
</tr>
<tr>
<td>AAQI Average Annual Earnings (£K)</td>
<td>3.66</td>
<td>6.82</td>
<td></td>
</tr>
</tbody>
</table>

(iii) Tracking Performance for Marketed Services Aggregates:

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

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:

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

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. 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.

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 (FitzGerald, 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 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 trends 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. 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.

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.

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 government 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 offsetting 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.
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.

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 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.
FIGURE 10.1: BENCHMARK PROJECTION FOR 1987 - 1992

[A]: INDUSTRIAL SECTOR

[B]: MARKET SERVICES SECTOR

[C]: TOTAL ECONOMY

[D]: GROSS DOM & NATIONAL PRODUCTS

[E]: PRICES AND WAGES

[F]: BORROWING REQUIREMENT

[G]: DEBT/GNP RATIO

[H]: BALANCE OF PAYMENTS
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.


The multipliers were calculated using as a basis the benchmark 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 benchmark levels for each of the endogenous variables considered below. The effects of each perturbation on a wide range of economic variables are shown. 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

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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

[A]: INDUSTRIAL SECTOR
OUTPUT AND EMPLOYMENT EFFECTS

[B]: MARKET SERVICES SECTOR
OUTPUT AND EMPLOYMENT EFFECTS

[C]: TOTAL ECONOMY
OUTPUT AND EMPLOYMENT EFFECTS

[D]: GROSS DOM & NATIONAL PRODUCTS

total payments across the world

[E]: PRICES AND WAGES
Consumption Price and Industrial Wages

[F]: BORROWING REQUIREMENT

[G]: DEBT/GNP RATIO
(Decreased as Percentage of GNP)

[H]: BALANCE OF PAYMENTS
(Increased as Percentage of GNP)
substitution takes place because wage rates rise as a result of the reduction in unemployment (Graph c)\(^5\). 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 exaggerated 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 counterintuitive 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.

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\(^5\) 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

[A]: INDUSTRIAL SECTOR
OUTPUT AND EMPLOYMENT EFFECTS

[B]: MARKET SERVICES SECTOR
OUTPUT AND EMPLOYMENT EFFECTS

[C]: TOTAL ECONOMY
OUTPUT AND EMPLOYMENT EFFECTS

[D]: GROSS DOM & NATIONAL PRODUCTS
Patio Payments Across Countries

[E]: PRICES AND WAGES
Consumption Prices and Industrial Wages

[F]: BORROWING REQUIREMENT
(Expressed as Percentage of GNP)

[G]: DEBT/GNP RATIO
(Expressed as Percentage of GNP)

[H]: BALANCE OF PAYMENTS
(Expressed as Percentage of GNP)
FIGURE 10.4: FALL IN ENERGY PRICES

[A]: INDUSTRIAL SECTOR
OUTPUT AND EMPLOYMENT EFFECTS

[B]: MARKET SERVICES SECTOR
OUTPUT AND EMPLOYMENT EFFECTS

[C]: TOTAL ECONOMY
OUTPUT AND EMPLOYMENT EFFECTS

[D]: GROSS DOM & NATIONAL PRODUCTS
Per Capita Payments to Households

[E]: PRICES AND WAGES
Consumption Prices and Nominal Wages

[F]: BORROWING REQUIREMENT
(Exceeded as Percentage of GNP)

[G]: DEBT/GNP RATIO
Exceeded as Percentage of GNP

[H]: BALANCE OF PAYMENTS
Exceeded as Percentage of GNP
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 exogenous 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.


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

[A]: INDUSTRIAL SECTOR
OUTPUT AND EMPLOYMENT EFFECTS

[B]: MARKET SERVICES SECTOR
OUTPUT AND EMPLOYMENT EFFECTS

[C]: TOTAL ECONOMY
OUTPUT AND EMPLOYMENT EFFECTS

[D]: GROSS DOM & NATIONAL PRODUCTS
Output, Product, and National Income

[E]: PRICES AND WAGES
Consumption Price and Industrial Wages

[F]: BORROWING REQUIREMENT
Estimated as Percentage of GDP

[G]: DEBT/GDP RATIO
Estimated as Percentage of GDP

[H]: BALANCE OF PAYMENTS
Estimated as Percentage of GDP
FIGURE 10.6: REDUCTION IN PUBLIC ADMINISTRATION EMPLOYMENT

[A]: INDUSTRIAL SECTOR
OUTPUT AND EMPLOYMENT EFFECTS

[B]: MARKET SERVICES SECTOR
OUTPUT AND EMPLOYMENT EFFECTS

[C]: TOTAL ECONOMY
OUTPUT AND EMPLOYMENT EFFECTS

[D]: GROSS DOM & NATIONAL PRODUCTS
Output Levels Around 1980

[E]: PRICES AND WAGES
Consumer Prices and Industrial Wages

[F]: BORROWING REQUIREMENT
(Borrowing as Percentage of GDP)

[G]: DEBT/GNP RATIO
(Debt as Percentage of GDP)

[H]: BALANCE OF PAYMENTS
(Export as Percentage of GDP)
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 on increasing income taxes are presented. 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

<table>
<thead>
<tr>
<th></th>
<th>Real GDP</th>
<th>Real GNP</th>
<th>Borrowing Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate of Income Tax</td>
<td>0.62</td>
<td>0.76</td>
<td>0.25 0.27</td>
</tr>
<tr>
<td>Employment in Pub.Ad.</td>
<td>-1.10</td>
<td>-0.83</td>
<td>-1.28 -1.35</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+0.28 +0.06</td>
</tr>
</tbody>
</table>

[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. 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).

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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

[A] : INDUSTRIAL SECTOR

OUTPUT AND EMPLOYMENT EFFECTS

[B] : MARKET SERVICES SECTOR

OUTPUT AND EMPLOYMENT EFFECTS

[C] : TOTAL ECONOMY

OUTPUT AND EMPLOYMENT EFFECTS

[D] : GROSS DOM & NATIONAL PRODUCTS

Output Payments Afferoed Values

[E] : PRICES AND WAGES

Consumption Price and Industrial Wages

[F] : BORROWING REQUIREMENT

(Borrowed as Percentages of GDP)

[G] : DEBT/GNP RATIO

(Borrowed as Percentages of GDP)

[H] : BALANCE OF PAYMENTS

(Borrowed as Percentages of GDP)
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, £ million.

The Instruments Are Changed by £1 Million in 1987

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

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>VARIABLE DESCRIPTION</th>
<th>UNITS</th>
<th>TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AARAGIMP</td>
<td>Implicit average annual earnings in agriculture</td>
<td>tk</td>
<td>ENDOI</td>
</tr>
<tr>
<td>AASI</td>
<td>Average annual earnings in industry</td>
<td>tk</td>
<td>ENDOB</td>
</tr>
<tr>
<td>AARILOT</td>
<td>Rate of change of AASI</td>
<td>Percent</td>
<td>ENDOI</td>
</tr>
<tr>
<td>AARE</td>
<td>Average annual earnings in industry, in constant prices</td>
<td>tk</td>
<td>ENDOI</td>
</tr>
<tr>
<td>AARED LOT</td>
<td>Rate of change of AARE</td>
<td>Percent</td>
<td>ENDOI</td>
</tr>
<tr>
<td>AARNA</td>
<td>Average annual earnings in the non-agriculture sector</td>
<td>tk</td>
<td>ENDOI</td>
</tr>
<tr>
<td>AARP</td>
<td>Average annual earnings in public administration</td>
<td>tk</td>
<td>ENDOI</td>
</tr>
<tr>
<td>AARSH</td>
<td>Average annual earnings in health and education</td>
<td>tk</td>
<td>ENDOI</td>
</tr>
<tr>
<td>AARS</td>
<td>Average annual earnings in market services</td>
<td>tk</td>
<td>ENDOI</td>
</tr>
<tr>
<td>AARSM</td>
<td>Average annual earnings in services, excluding public administration</td>
<td>tk</td>
<td>ENDOI</td>
</tr>
<tr>
<td>BP</td>
<td>Balance of payments surplus</td>
<td>tm</td>
<td>ENDOI</td>
</tr>
<tr>
<td>BPB</td>
<td>Net capital inflow on the non-banking private sector</td>
<td>tm</td>
<td>ENDOI</td>
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<tr>
<td>BPR</td>
<td>Balance of trade surplus as percent of GNP</td>
<td>Percent</td>
<td>ENDOI</td>
</tr>
<tr>
<td>BPR</td>
<td>Balance of trade surplus</td>
<td>tm</td>
<td>ENDOI</td>
</tr>
<tr>
<td>BTP</td>
<td>Net foreign capital transfers</td>
<td>tm</td>
<td>ENDOI</td>
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<td>Equivalent to BTPCH - represents exogenised version</td>
<td>tm</td>
<td>ENDOI</td>
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<tr>
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<td>Public authorities net capital receipts from abroad</td>
<td>tm</td>
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<td>ENDOI</td>
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<td>Private international current transfers</td>
<td>tm</td>
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<tr>
<td>BTR</td>
<td>Balance of trade as percent of GNP</td>
<td>Percent</td>
<td>ENDOI</td>
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<td>C</td>
<td>Personal consumers' expenditure</td>
<td>f, 1980</td>
<td>ENDOI</td>
</tr>
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<td>COMAT</td>
<td>Ratio of &quot;world&quot; to Irish hourly earnings</td>
<td>Index</td>
<td>ENDOI</td>
</tr>
<tr>
<td>COMAT</td>
<td>Industrial competitiveness measure (defined as 100 x WORLD / PCEB)</td>
<td>Index</td>
<td>ENDOI</td>
</tr>
<tr>
<td>COMCLI</td>
<td>Ratio of &quot;world&quot; to Irish unit labour costs</td>
<td>Index</td>
<td>ENDOI</td>
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<td>Parameter used for indexation to PC (normally set to unity)</td>
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<tr>
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<td>Parameter used for indexation to PGNF (normally set to unity)</td>
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<td>Private sector domestic credit</td>
<td>tm</td>
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<td>Depreciation allowances in agriculture, forestry and fishing</td>
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<tr>
<td>DEP</td>
<td>Depreciation allowances in industry</td>
<td>tm</td>
<td>ENDOI</td>
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<td>Depreciation allowances in services</td>
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<td>Irish SEC budget contribution</td>
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<td>tm</td>
<td>ENDOI</td>
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<td>Listing of Variables</td>
<td>Description</td>
<td>Unit</td>
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<td>-------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
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<td>Energy inputs in the industrial sector</td>
<td>£m</td>
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<td>Trend in labour productivity in industry (constant exponential growth)</td>
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<td>Vintage-based energy requirement in industry</td>
<td>£m</td>
<td>ENDOT</td>
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<td>EW1</td>
<td>Expected weight used in calculating GSGSM</td>
<td>£m,1980</td>
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<td>Expected weight used in calculating GSGSM</td>
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<td>Expected weight used in calculating GSGSM</td>
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<td>Net foreign borrowing by the public authorities</td>
<td>£m</td>
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<td>FSBORF</td>
<td>Net foreign borrowing by the public authorities, converted to existing debt</td>
<td>£m</td>
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<td>Basket of foreign borrowing by the public authorities</td>
<td>£m</td>
<td>ENDOI</td>
</tr>
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<td>FXA</td>
<td>$ US per £ 2R exchange rate (1980 equals unity)</td>
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<td>Effective Irish exchange rate against a basket of &quot;rest of the world&quot;</td>
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<td>ENDOI</td>
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<tr>
<td>FRAH</td>
<td>Equivalent to FXA-represents exogenised version</td>
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<td>ENDOI</td>
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<td>Exchange rate &quot;rest of the world&quot; currencies against the $ US ($ US per basket)</td>
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<td>ENDOI</td>
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<td>Equivalent to FXA/FRAH-represents exogenised version</td>
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<td>Public authorities' surplus</td>
<td>£m</td>
<td>ENDOI</td>
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<tr>
<td>GBC</td>
<td>Public authorities' current surplus</td>
<td>£m</td>
<td>ENDOI</td>
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<td>GCS</td>
<td>Total agricultural subsidies</td>
<td>£m</td>
<td>ENDOI</td>
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<td>GCSANS</td>
<td>Agricultural subsidies, not related to sales</td>
<td>£m</td>
<td>ENDOI</td>
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<td>GCSANSSH</td>
<td>Equivalent to GCSANS-represents exogenised version</td>
<td>£m</td>
<td>ENDOI</td>
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<tr>
<td>GCSANSE</td>
<td>Agricultural subsidies related to sales</td>
<td>£m</td>
<td>ENDOI</td>
</tr>
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<td>GCSASH</td>
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<td>ENDOI</td>
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<tr>
<td>GCSC</td>
<td>Total consumer subsidies</td>
<td>£m</td>
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<td>GCSO</td>
<td>Residual category of subsidies</td>
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<td>Other non-agricultural subsidies</td>
<td>£m</td>
<td>ENDOI</td>
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<td>Equivalent to GCTABBH-represents exogenised version</td>
<td>£m</td>
<td>ENDOI</td>
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<td>GCTABHR</td>
<td>Public authorities current transfers abroad</td>
<td>£m</td>
<td>ENDOI</td>
</tr>
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<td>GCTABHRF</td>
<td>Equivalent to GCTABHR-represents exogenised version</td>
<td>£m</td>
<td>ENDOI</td>
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<td>GCTABHBD</td>
<td>Total debt interest payments by the public authorities</td>
<td>£m</td>
<td>ENDOI</td>
</tr>
<tr>
<td>GCTABHD</td>
<td>Total debt interest payments on national loans by the public authorities</td>
<td>£m</td>
<td>ENDOI</td>
</tr>
<tr>
<td>GCTABHD</td>
<td>Total debt interest payments on foreign currency debt</td>
<td>£m</td>
<td>ENDOI</td>
</tr>
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<td>GCTABHDF</td>
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<td>£m</td>
<td>ENDOI</td>
</tr>
<tr>
<td>GCTABHFB</td>
<td>Debt interest on small  savers</td>
<td>£m</td>
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<td></td>
<td>EXO2</td>
</tr>
<tr>
<td>KYSSEG</td>
<td>Proportion of agricultural income earned by the self-employed in agriculture</td>
<td>Fraction</td>
<td>EXO3</td>
</tr>
</tbody>
</table>
LISTING OF VARIABLES

RGKTHI Capital transfers to households for housing purposes as a proportion of private housing investment
RGKTHII Equivalent to RGKTHI-represents exogenised version
RGKTHIII Capital transfers to industry as a proportion of investment in industry
RGKTHIV Equivalent to RGKTHIII-represents exogenised version
RGKTHV Eight-year government bond rate
RGKTHVI Foreign currency version of RGKTHV
RGKTHVII Equivalent to RGKTHVI-represents exogenised version
RGKTHVIII Implicit average rate of interest on national loans outstanding
RGKTHIX Foreign currency version of the variable RGKTHI
RGKTHX Equivalent to RGKTHX-represents exogenised version
RGKTHXI Implicit average rate of interest on small savings
RGKTHXII Foreign currency version of the variable RGKTHXII
RGKTHXIII Total tax revenue as a percentage of GNP
RGKTHXIV Implicit average rate of corporate taxation
RGKTHXV Equivalent to RGKTHXIV-represents exogenised version
RGKTHXVI Implicit average employer's social insurance rate
RGKTHXVII Equivalent to RGKTHXVI-represents exogenised version
RGKTHXVIIIImplicit total average rate of social insurance contributions
RGKTHXIX Equivalent to RGKTHXVIII-represents exogenised version
RGKTHXX Total public authorities debt interest as a percentage of GNP
RGKTHXXI Foreign debt interest as a percentage of GNP
RGKTHXXII Prime lending rate of interest
RGKTHXXIII Foreign currency version of RGPL
RGKTHXXIV Implicit average rate of direct taxation
RGKTHXXV Official external reserves as a percentage of total imports
RGKTHXXVI Real interest rate
RGKTHXXVII Equivalent to RGKTHXXVI-represents exogenised version
RGKTHXXVIII Implicit rate of indirect taxation on the residuary category
RGKTHXXIX Equivalent to RGKTHXXVIII-represents exogenised version
RGKTHXXX Implicit average rate of direct income tax
RGKTHXXXI Equivalent to RGKTHXXXI-represents exogenised version
RGKTHXXXII Implicit average rate of social security contributions
RGKTHXXXIII Equivalent to RGKTHXXXII-represents exogenised version
RGKTHXXXIV Implicit average rate of social security contributions
RGKTHXXXV Equivalent to RGKTHXXXV-represents exogenised version
RGKTHXXXVI Implicit average rate of social security contributions
RGKTHXXXVII Equivalent to RGKTHXXXVII-represents exogenised version
RGKTHXXXVIII Implicit average rate of social security contributions
RGKTHXXXIX Equivalent to RGKTHXXXIX-represents exogenised version
RGKTHXL Total implicit average rate of taxation on incomes i.e. includes social insurance contributions by employees
RGKTHXLI Unemployment transfer payment rate (½ per week)
RGKTHXLII Equivalent to RGKTHXLI-represents exogenised version
RGKTHXLIII Effective rate of value-added tax
RGKTHXLIV Equivalent to RGKTHXLIII-represents exogenised version
RGKTHXLV Real earnings rate in Ireland relative to the United Kingdom
RGKTHXLVI Real earnings rate in Ireland relative to the United Kingdom, net of Irish direct taxation
RGKTHXLVII Real industrial profits per unit of the industrial capital stock
RGKTHXLVIII Ratio of added-value deflator to unit labour costs in marketed services
RGKTHXLIX Personal savings
RGKTX Company savings
RGKTXII Gross savings (total available for investment)
RGKTXIII Net national savings
RGKTXIV Personal savings ratio
RGKTXV Gross national savings
RGKTXVI Total subsidies in real terms (includes ECC subsidies)
RGKTXVII Agricultural stock changes, excluding intervention
RGKTXVIII Statistical discrepancy (i.e. NIE GDP less NIE GDPM)
RGKTXIX Statistical discrepancy (i.e. NIE GDP less NIE GDPM)
RGKTXX Agricultural stock changes, excluding intervention
RGKTXXI Net stock changes
RGKTXXII Intervention stock changes
RGKTXXIII Intervention stock changes
RGKTXXIV Level of non-agricultural stocks
RGKTXXV Non-agricultural stock changes
RGKTXXVI Level of non-agricultural stocks
RGKTXXVII Non-agricultural stock changes
RGKTXXVIII Total stock changes
RGKTXXX Total subsidies (includes ECC subsidies)
RGKTXXXI Total subsidies (includes ECC subsidies)
RGKTXXXII Variable denoting year (starting value T=1947)
RGKTXXXIII Total indirect tax revenue (includes ECC indirect taxes)
RGKTXXXIV Time (Starting value = 1 in 1960)
RGKTXXXV Average net indirect tax rate on private consumption
RGKTXXXVI Terms of trade, i.e. ratio of total export price to import price
RGKTXXXVII Variable used in the process of indexation to PC (normally set to unity)
RGKTXXXVIII Variable used in the process of indexation to PGDP (normally set to unity)
RGKTXXXIX Variable used in the process of indexation to PGDP (normally set to unity)
RGKTXXXX Transfers from the EEC
RGKTXXXXI Equivalent to TREC-represents exogenised version
RGKTXXXXII Numbers unemployed
RGKTXXXXIII User cost of capital in industry
RGKTXXXXIV User cost of capital in services
RGKTXXXXV Unit labour costs in industry
RGKTXXXXVI Unit labour costs in industry
RGKTXXXXVII Rate of change of variable UCLM
RGKTXXXXVIII Unit labour costs in marketed services
RGKTXXXXIX "World" unit labour costs measure
RGKTXXXXI Rate of change of the variable UCLM
RGKTXXXXXI Foreign currency version of the variable UCLM
RGKTXXXXXII Average unit cost, relative to output price, of producing gross output
RGKTXXXXXI Three-year moving average of UCLM
RGKTXXXXI Rate of unemployment
RGKTXXXXI Four-year moving average of the unemployment rate
RGKTXXXXI Rate of unemployment in the United Kingdom
RGKTXXXXI Numbers unemployed
RGKTXXXXII Index of weather [degree-days above 6 deg. C]
RGKTXXXXIII "Mudge" between the net-of-tax consumption and the industrial output deflator
RGKTXXXXIV Real industrial wages in the United Kingdom
RGKTXXXXV Proportion of social insurance contributions paid by employers
RGKTXXXXVI Proportion of road tax duties paid by the company sector
RGKTXXXXVII Ratio of public administration average earnings to industrial earnings
RGKTXXXXVIII Ratio of average annual earnings in health and education to those in public administration
RGKTXXXXIX Value of energy imports as a proportion of the value of total merchandise imports
RGKTXXXXI Fraction of total non-housing fixed investment which consists of machinery and equipment
<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Source, Year</th>
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<tr>
<td>XRES</td>
<td>Re-exports of energy</td>
<td>€m, 1980</td>
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<tr>
<td>XA</td>
<td>Exports of agricultural goods</td>
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</tr>
<tr>
<td>XGS</td>
<td>Exports of goods and services</td>
<td>€m, 1980</td>
</tr>
<tr>
<td>XGSV</td>
<td>Exports of goods and services</td>
<td>€m, 1980</td>
</tr>
<tr>
<td>XT</td>
<td>Exports of industrial goods</td>
<td>€m, 1980</td>
</tr>
<tr>
<td>XNA</td>
<td>Exports of non-agricultural goods</td>
<td>€m, 1980</td>
</tr>
<tr>
<td>XNAV</td>
<td>Exports of non-agricultural goods</td>
<td>€m, 1980</td>
</tr>
<tr>
<td>XS</td>
<td>Total exports of services</td>
<td>€m, 1980</td>
</tr>
<tr>
<td>XSO</td>
<td>Exports of services, excluding tourism</td>
<td>€m, 1980</td>
</tr>
<tr>
<td>XTO</td>
<td>Exports of tourism</td>
<td>€m, 1980</td>
</tr>
<tr>
<td>YAFS</td>
<td>Adjustment for financial services</td>
<td>€m, END01</td>
</tr>
<tr>
<td>YAG</td>
<td>Income arising in agriculture, forestry and fishing</td>
<td>€m, END01</td>
</tr>
<tr>
<td>YASA</td>
<td>Adjustment for stock appreciation</td>
<td>€m, END01</td>
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<tr>
<td>YASAIV</td>
<td>Adjustment for stock appreciation for intervention stocks</td>
<td>€m, END01</td>
</tr>
<tr>
<td>YC</td>
<td>Total non-agricultural profits</td>
<td>€m, END01</td>
</tr>
<tr>
<td>YCI</td>
<td>Industrial profits, gross of depreciation</td>
<td>€m, END01</td>
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<tr>
<td>YCIR</td>
<td>Industrial profits deflated by the industrial investment deflator</td>
<td>€m, 1980</td>
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<tr>
<td>YCIRP</td>
<td>Gross outflow of profits, dividends and royalties (NIE Table 28)</td>
<td>€m, 1980</td>
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<tr>
<td>YCR</td>
<td>Total non-agricultural profits deflated by the investment deflator</td>
<td>€m, END01</td>
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<tr>
<td>YCSNE</td>
<td>Profits in the health and education sector</td>
<td>€m, END02</td>
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<tr>
<td>YCU</td>
<td>Undistributed profits</td>
<td>€m, END02</td>
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<tr>
<td>YFNP</td>
<td>Net factor income from abroad (&quot;-&quot; indicates a net outflow)</td>
<td>€m, END02</td>
</tr>
<tr>
<td>YFNPNO</td>
<td>Net factor income from abroad, excluding foreign debt interest on</td>
<td>€m, END02</td>
</tr>
<tr>
<td></td>
<td>government borrowings and gross profit repatriation</td>
<td></td>
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<td>YFNPCH</td>
<td>Equivalent to YFNP0 - represents exogenised version</td>
<td>€m, END02</td>
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<tr>
<td>TP</td>
<td>Private income</td>
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<tr>
<td>YPER</td>
<td>Personal income</td>
<td>€m, END02</td>
</tr>
<tr>
<td>YPERD</td>
<td>Personal disposable income</td>
<td>€m, END02</td>
</tr>
<tr>
<td>YPERT</td>
<td>Taxable income</td>
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<tr>
<td>YPO</td>
<td>Non-wage taxable income</td>
<td>€m, 1980</td>
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<tr>
<td>YRAPS</td>
<td>Adjustment for financial services</td>
<td>€m, 1980</td>
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<tr>
<td>YRFN</td>
<td>Net factor income from abroad (&quot;-&quot; indicates a net outflow)</td>
<td>€m, 1980</td>
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<tr>
<td>YRFRD</td>
<td>Personal disposable income</td>
<td>€m, END02</td>
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<td>YRFRE</td>
<td>Personal disposable income</td>
<td>€m, END02</td>
</tr>
<tr>
<td>YREAG</td>
<td>Income of the self-employed in agriculture</td>
<td>€m, END02</td>
</tr>
<tr>
<td>YWAG</td>
<td>Wage income in agriculture</td>
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</tr>
<tr>
<td>YWDIS</td>
<td>Discrepancy measure of &quot;world&quot; demand</td>
<td>Index END01</td>
</tr>
<tr>
<td>YWI</td>
<td>Wage bill in industry</td>
<td>€m, END02</td>
</tr>
<tr>
<td>YWNA</td>
<td>Wage bill in the non-agricultural sector</td>
<td>€m, END02</td>
</tr>
<tr>
<td>YWPA</td>
<td>Wage bill in public administration</td>
<td>€m, END02</td>
</tr>
<tr>
<td>YWPAH</td>
<td>Equivalent to YWPA - represents exogenised version</td>
<td>€m, END02</td>
</tr>
<tr>
<td>YWHE</td>
<td>Wage bill in health and education</td>
<td>€m, END02</td>
</tr>
<tr>
<td>YWHER</td>
<td>Equivalent to YMHE - represents exogenised version</td>
<td>€m, END02</td>
</tr>
<tr>
<td>YWSM</td>
<td>Wage bill in the marketed services sector</td>
<td>€m, END02</td>
</tr>
<tr>
<td>YWSO</td>
<td>Wage bill in the services sector, excluding public administration</td>
<td>€m, END02</td>
</tr>
</tbody>
</table>


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 296-304)
- 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 specific formulation 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 (AAE); 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 (YCIRED); foreign debt interest outflows (GCTNDIF); and other private factor income flows from abroad (YFINPO).

(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 (QW). Deviations from trend (TVGDS) are defined as the ratio of actual to trend world output.

\[ QWSTARI = \frac{QW}{QW + TVGDS} \]

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 (PRIME) 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., PRIME). 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., ВЕО1 = 1).

\[ TVGDS = QWSTARI \times (A1 - A12 \times (PRUSS / PRUS) \times 0.5 A13 \times (PRUS / PRUS) + 0.5 A14 \times (PRUS / PRUS) + 0.5 A15 \times (PRUS / PRUS) + 0.5 A16 - A17) \times (QWSTARI - 1.1) \times (QWSTARI - 1.1) \times (QWSTARI - 1.1) \]

\[ QWSTARI = \frac{QWSTARI}{A1 + A12 \times (PRUSS / PRUS) \times 0.5 A13 \times (PRUS / PRUS) + 0.5 A14 \times (PRUS / PRUS) + 0.5 A15 \times (PRUS / PRUS) + 0.5 A16 - A17) \times (QWSTARI - 1.1) \times (QWSTARI - 1.1) \times (QWSTARI - 1.1) \]

\[ \text{NORM} = 22 \quad \text{NOVAR} = 7 \quad \text{R2} = 0.92469 \quad \text{SE} = 0.999854 \quad \text{RANGE: 1963 TO 1984} \quad \text{F(7/15)} = 2.03 \quad \text{PROB*} = 2.8871 \quad \text{R2} = 0.92469 \quad \text{COND} = 328.14 \]

\[ \text{REGRESSOR} = 27051.6 \quad \text{DF(0)} = 1.52424 \quad \text{DF(0)} = 2.16349 \]
### 4: DV01 = QSTARI = [B11+B12*PROMOR/PRIORS] + 0.5*B13+STII = B14+B15*QSTARI = [-1]*(B11+B12*PROMOR/PRIORS = -0.5*B13+STII)*QSTARI = [-1]*(B11+B12*PROMOR/PRIORS = -0.5*B13+STII)*QSTARI = [-1]*(B11+B12*PROMOR/PRIORS = -0.5*B13+STII)

<table>
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<tr>
<th>COEF</th>
<th>ESTIMATE</th>
<th>STER</th>
<th>TSTAT</th>
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<tbody>
<tr>
<td>A11</td>
<td>-.936</td>
<td>1.172</td>
<td>4.824</td>
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<tr>
<td>A12</td>
<td>1.054</td>
<td>346.4</td>
<td>2.410</td>
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<td>A13</td>
<td>-665.92</td>
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<tr>
<td>A14</td>
<td>-2240.99</td>
<td>346.39</td>
<td>-6.563</td>
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<tr>
<td>A15</td>
<td>62.335</td>
<td>0.67601</td>
<td>3.11151</td>
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<tr>
<td>A16</td>
<td>0.10115</td>
<td>0.094764</td>
<td>1.07168</td>
</tr>
<tr>
<td>A17</td>
<td>0.001099</td>
<td>6.9748</td>
<td></td>
</tr>
</tbody>
</table>

| NOB | H00V = 22 NOVAR = 5 RANGE: 1963 TO 1984 REM = | 0.998647 CRSG = 0.999614 F(1,37) = 81.1789 DFR = 0.114542 DM = -2.10253 TDFITS = -1.61289 |
|------|-----------|----------|-----------------|-----------------|-----------------|-----------------|-----------------|
| RSG | PROBP = 0.000000 PROBF = | | | | | |
| RSR | | 131.139 |
| SSR | | 131.139 |
| Max | HAT | 131.139 |

### 5: LOG(DV01/QSTARI) = C11+C12*STII+KROHIC*NOLIC = [-1]*LOG(QSTARI)

<table>
<thead>
<tr>
<th>COEF</th>
<th>ESTIMATE</th>
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<tr>
<td>B11</td>
<td>1.3372</td>
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<td>3.03421</td>
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<tr>
<td>B12</td>
<td>-1.420.95</td>
<td>1432.33</td>
<td>-2.99296</td>
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<td>B13</td>
<td>57.5015</td>
<td>10.0017</td>
<td>5.53718</td>
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<tr>
<td>B14</td>
<td>0.434216</td>
<td>0.157523</td>
<td>2.75655</td>
</tr>
<tr>
<td>B15</td>
<td>0.402301</td>
<td>0.145516</td>
<td>2.77422</td>
</tr>
</tbody>
</table>

### 6: QSTARI = IF VE01 EQ 1 THEN DV01 ELSE (IF VE01 EQ 2 THEN DV01 ELSE DV01)

The technology underlying the industry sector is a three-factor bundle CES-CES type. Capital (K1) and energy (E1) are combined in one vintage bundle, and the resulting capital-energy composite is combined with labour, assuming a linear neutral technical progress. In equations 7-16 below, the capital stock and investment are determined. The optimal capital-output ratio (QSTARI) is the product of the optimal capital-energy ratio and the optimal labour-output ratio. The latter two variables being determined as functions of expected capital, energy and labour prices. The optimal capital-output ratio (QSTARI) and planned output (QSTARI).

<table>
<thead>
<tr>
<th>COEF</th>
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<tr>
<td>CI1</td>
<td>7.04675</td>
<td>0.050745</td>
<td>139.692</td>
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<tr>
<td>CI2</td>
<td>0.0386</td>
<td>0.00172</td>
<td>22.4465</td>
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<td>K21</td>
<td>0.280044</td>
<td>0.144466</td>
<td>3.06228</td>
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</tbody>
</table>

### 7: KSTAR = [B21+C1*(CI/BT+DUCCI/EPS)]*(II-1)*(II/E1)

### 8: KSTAR = [S11+B11+B11/(S11/EXP(S11/EXP(S11/TIME))))**II/(II-1)*II(II-1)/II(II-1)

### 9: KSTAR = KSTAR*KSTAR

### 10: KSTAR = KSTAR*KSTAR

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

<table>
<thead>
<tr>
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<th>TSTAT</th>
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<tr>
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<td>-1.71526</td>
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<td>A0311</td>
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<td>0.726919</td>
<td>3.15398</td>
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<td>A0331</td>
<td>0.210359</td>
<td>0.157523</td>
<td>2.75655</td>
</tr>
<tr>
<td>A0341</td>
<td>-0.944254</td>
<td>-0.145516</td>
<td>2.77422</td>
</tr>
</tbody>
</table>

### 11: DEL[LOG(II)] = A0311*DEL[LOG(KSTARI)] + A0331*DEL[LOG(KSTARI)/II-1] + A0341*DEL[LOG(UOCST/UCONTIMA) + DEL[LOG(II)]

### 12: DEL[LOG(II)] = A0311*DEL[LOG(KSTARI)] + A0331*DEL[LOG(KSTARI)/II-1] + A0341*DEL[LOG(UOCST/UCONTIMA) + DEL[LOG(II)]

### 13: The perpetual inventory method generates the actual capital stock (K1), assuming a given, fixed, rate of economic depreciation (RSC). K1 = TF(K1-1)+K1 = (K1)(1-h) = K1

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

### 15: KEVIN = (K1-RETRO) = KEVIN = (1-(1-E1+RETRO)*K1-1) = KEVIN = (1-(1-E1+RETRO)*K1-1) = KEVIN = (1-(1-E1+RETRO)*K1-1) = KEVIN = (1-(1-E1+RETRO)*K1-1)

### 16: Actual energy inputs (E1) depend on the capital stock measure (KEVIN) and the rate of capacity utilisation (CURR).

### 17: LOG(E1) = A0511*LOG(KEVIN) + A0521*LOG(CURR) + LOG(KEVIN)
The optimal labour-output ratio ($Q_{\text{ST}}$) is a function of the expected relative price of the RE bundle ($E_{\text{RE}}$) to labour ($E_{\text{LA}}$), and an exponentially declining function of time (the hazard-neutral function). The optimal labour input ($L_{\text{TAR}}$) is the product of $Q_{\text{ST}}$ and planned output ($Q_{\text{ST}}$).

17) \[ L_{\text{TAR}} = \frac{\exp(-\gamma \cdot \text{TIME}) \cdot (1 - \text{BO}) \cdot \beta_{\text{C}} \cdot \beta_{\text{R}} \cdot \beta_{\text{C}} \cdot \beta_{\text{F}} \cdot \beta_{\text{C}} \cdot \beta_{\text{W}} \cdot \beta_{\text{C}} \cdot (E_{\text{RE}} / E_{\text{LA}}) \cdot (\exp(\gamma \cdot \text{TIME}))}{(1 - \beta_{\text{C}} \cdot \beta_{\text{F}} \cdot \beta_{\text{C}} \cdot \beta_{\text{W}} \cdot \beta_{\text{C}})} \]

18) \[ L_{\text{TAR}} = Q_{\text{ST}} \cdot Q_{\text{ST}} \]

Actual labour inputs (L) are a dynamic function of optimal inputs ($L_{\text{TAR}}$) and of the rate of capacity utilization ($\text{CURR}$).

19) \[ \Delta L = \log(L) = A_{0421} + A_{0422} \cdot \Delta L_{1} + A_{0431} + A_{0432} \cdot \log(L_{\text{TAR}}) + A_{0433} \cdot \log(L_{\text{TAR}} + 1) / (L + 1) + A_{0441} \cdot \log(\text{CURR}) + A_{0442} \cdot \log(\text{CURR} + 1) / L_{\text{TAR}}(L + 1) + A_{0444} \cdot \log(\text{CURR}) \]

The "normal" industrial output ($Q_{\text{VTN}}$), i.e., the output which could be produced with existing factor inputs at normal rates of utilization, is a CES function of L2 and $\text{KEV}$. The actual industrial output ($Q_{\text{VT}}$) is a dynamic CES function of normal output ($Q_{\text{VTN}}$), modified by deviations of domestic industrial demand from trend and deviations of world output from trend.

21) \[ \Delta L = \log(Q_{\text{VT}}) = A_{0461} + A_{0462} \cdot \Delta L_{1} + A_{0463} + A_{0464} \cdot \log(Q_{\text{VTN}} + 1) / (Q_{\text{VTN}} + 1) + A_{0465} + A_{0466} \cdot \Delta L_{1} + \log(\text{SURV}) + \log(Q_{\text{VT}}) \]

The rate of capacity utilization ($\text{CURR}$) is a suitably scaled ratio of $Q_{\text{VT}}$ to $Q_{\text{VTN}}$.

22) \[ \text{CURR} = \frac{Q_{\text{VT}}}{Q_{\text{VTN}}} \]

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

23) \[ \text{OV} = \text{QV} \]

24) \[ \text{QV} = \text{QV} \]

25) \[ \text{QV} = \text{QV} 

26) \[ \text{QV} = \text{QV} \]

The key measure of competitiveness used in the model to determine Ireland's share of world capacity output is profit per unit of added-value ($\text{PROL}$) and a three-year moving average of this ($\text{PROL}$).

32) \[ \text{PROL} = \frac{\text{QV} \cdot \text{QV} \cdot \text{QV}}{\text{QV} \cdot \text{QV} \cdot \text{QV}} \]

33) \[ \text{PROL} = \frac{\text{QV} \cdot \text{QV} \cdot \text{QV} \cdot \text{QV} \cdot \text{QV} \cdot \text{QV}}{\text{QV} \cdot \text{QV} \cdot \text{QV} \cdot \text{QV} \cdot \text{QV} \cdot \text{QV}} 

34) \[ \text{QV} = \text{O} \]

35) \[ \text{QV} = \text{QV} \]

36) \[ \text{QV} = \text{QV} \]

The values of competitiveness used in the model to determine Ireland's share of world capacity output is profit per unit of added-value ($\text{PROL}$) and a three-year moving average of this ($\text{PROL}$).
Equations 37-45 determine certain prices, 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); its trend (UCOCTI); the user cost of capital (UCC) and its trend (UECC); and the trend energy price (EPE), labour price (EKEI) and the trend in PCKE (EPCK).

37: \( PCKE = (31\cdot5\cdot UCC + 31\cdot5\cdot PE + 1\cdot 81) / (1\cdot 81) \)
38: \( PCKEL = (31\cdot5\cdot UCC + 31\cdot5\cdot PE + 1\cdot 81) \cdot (1\cdot 81) / (1\cdot 81) \)
39: \( UCOSTI = (AAX + AEE + MCR + 100) / (AAX + AEE + MCR + 100) \)
40: \( UCOST = (UCOSTI + UCOSTI - L) \cdot UCOSTI - (L) / (1 - UCOSTI) \)
41: \( UCC = (UCC + UCC + 100) / (1 - UCC) \)
42: \( EXC = (EXC + EXC - 1) / (1 - EXC) \)
43: \( EPE = (EPE + EPE - 1) / (1 - EPE) \)
44: \( EAAX = (EAAX + EAAX - 1) / (1 - EAAX) \)
45: \( EPCK = (EPCK + EPCK - 1) / (1 - EPCK) \)

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

46: \( LOG(DEFI) = A51 + A52 \cdot LOG(P(1) + E(1)) + A55 \cdot K(1) + LOG(DEFI) \)

The agricultural sector (QCA) is simply a five-year moving-average of actual output, QOA.

47: \( QOA = (QCA + (QOA - 1) + QOA - 2) + QOA - 3) + QOA - 4) + QOA - 5) \)

Actual agricultural output, QOA, 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 (WEATH).

48: \( QOA = A051 + (A052 + WEATH + A053 + PQA + 1) / PQA + 1) + QOA + 1) \)

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

49: \( LOG(QOA/QOA) = A061 + A062 \cdot (T - 87) + LOG(QOA) \)

The gross agricultural output (QOA) is allocated over domestic absorption (QOA), stock changes (STADG and STIVOL) and exports (JA). Domestic absorption relative to output is a simple function of time. Stock changes are exogenous. Exports are derived residually.

50: \( QOA/QOA = A091 + A092 \cdot (T - 87) + QOA/QOA \)

Gross agricultural output (QOA) is allocated over domestic absorption (QOA), stock changes (STADG and STIVOL) and exports (JA). Domestic absorption relative to output is a simple function of time. Stock changes are exogenous. Exports are derived residually.
MODEL LISTING

Equations 55-58 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 (GAF and GAFY) is exogenous.

55: OA = OAQ-QA(1)+OAQS+PSBUR+STEARL/PTE
56: GAF = IF EQ 1 THEN GAFP END ELSE (IF EQ 2 THEN GAF(1)+OA/OA(1)) ELSE GAFP+OA/10A
57: OAV = QA*OAF
58: GAFY = IF EQ 1 THEN GAFPY END ELSE (IF EQ 2 THEN GAFPY(1)+OAV/OAV(1)) ELSE GAFPY(1)+OAV/OAV(1)
59: OA = OA+GAFY

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

60: YAS = GAFY-DEPAS
61: YSEAS = KXSEAS*YAG
62: YNAS = YAS-YSEAS

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

63: LOGLAB = A071+0.072*(T-874)+KNO7+R07+LOG(FLAG)

<table>
<thead>
<tr>
<th>LOGLAB</th>
<th>A071+0.072*(T-874)+KNO7+R07+LOG(FLAG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOVAR = 3</td>
<td>RANGE: 1966 TO 1984</td>
</tr>
<tr>
<td>RSQ = 0.993547</td>
<td>CRHQ = 0.992546</td>
</tr>
<tr>
<td>SSQ = 0.002704</td>
<td>DM(0) = 1.3359</td>
</tr>
<tr>
<td>MAXRAT = 12.45714</td>
<td>DFFITS = -0.337366</td>
</tr>
</tbody>
</table>

The capital stock (of buildings and machinery only) is a function of added-values and the real cost of capital. This equation displays great inaccuracy due to the large coefficient of R07. Actual investment (IA) is derived by reversing the perpetual inventory equation used originally to derive KAS.

64: LOGKAS = A051+R052+LOG(OAG(1)+OAG-1/2)+A053+LOG(PKAS/POAG)+A054+LOG(KAG(1)+RHS05+R08-1)+LOG(PKAG)

The capital stock (of buildings and machinery only) is a function of added-values and the real cost of capital. This equation displays great inaccuracy due to the large coefficient of R07. Actual investment (IA) is derived by reversing the perpetual inventory equation used originally to derive KAS.

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The capital stock (of buildings and machinery only) is a function of added-values and the real cost of capital. This equation displays great inaccuracy due to the large coefficient of R07. Actual investment (IA) is derived by reversing the perpetual inventory equation used originally to derive KAS.

69: LOGKAS = A051+R052+LOG(OAG(1)+OAG-1/2)+A053+LOG(PKAS/POAG)+A054+LOG(KAG(1)+RHS05+R08-1)+LOG(PKAG)

The capital stock (of buildings and machinery only) is a function of added-values and the real cost of capital. This equation displays great inaccuracy due to the large coefficient of R07. Actual investment (IA) is derived by reversing the perpetual inventory equation used originally to derive KAS.

70: LOGKAS = A051+R052+LOG(OAG(1)+OAG-1/2)+A053+LOG(PKAS/POAG)+A054+LOG(KAG(1)+RHS05+R08-1)+LOG(PKAG)

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

71: LOGDPAS = A051+R052+LOG(PKAG(1)+KAG(1)+RHS05+KAS(1)+LOG(PKAG)

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

72: LOGDPAS = A051+R052+LOG(PKAG(1)+KAG(1)+RHS05+KAS(1)+LOG(PKAG)

(3) THE SERVICES SECTOR

Capacity output in marketed services (OCSTMN) is a three-year moving average of actual output (OYM). Actual output in constant prices is derived as a function of final demand weighted by services output content (ROSMN) and a time trend to capture secular shifts in composition.

71: LOGKAS = K07+K11+LOGORENM+K01+LOGKAG(1)

Capacity output in marketed services (OCSTMN) is a three-year moving average of actual output (OYM). Actual output in constant prices is derived as a function of final demand weighted by services output content (ROSMN) and a time trend to capture secular shifts in composition.

72: LOGKAS = K07+K11+LOGORENM+K01+LOGKAG(1)

Capacity output in marketed services (OCSTMN) is a three-year moving average of actual output (OYM). Actual output in constant prices is derived as a function of final demand weighted by services output content (ROSMN) and a time trend to capture secular shifts in composition.

73: LOGKAS = K07+K11+LOGORENM+K01+LOGKAG(1)

Capacity output in marketed services (OCSTMN) is a three-year moving average of actual output (OYM). Actual output in constant prices is derived as a function of final demand weighted by services output content (ROSMN) and a time trend to capture secular shifts in composition.

74: LOGKAS = K07+K11+LOGORENM+K01+LOGKAG(1)

Capacity output in marketed services (OCSTMN) is a three-year moving average of actual output (OYM). Actual output in constant prices is derived as a function of final demand weighted by services output content (ROSMN) and a time trend to capture secular shifts in composition.

75: LOGKAS = K07+K11+LOGORENM+K01+LOGKAG(1)

Capacity output in marketed services (OCSTMN) is a three-year moving average of actual output (OYM). Actual output in constant prices is derived as a function of final demand weighted by services output content (ROSMN) and a time trend to capture secular shifts in composition.
The value of output in marketed services (OSMV) is derived residually from the current price identity of GDP on an output and expenditure basis.

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 (ESTARKRM) is a function of expected relative factor prices. The optimal capital stock (ESTARKRM) is the product of OPTARKRM and the trend output (OSTARKRM). The actual capital stock is a function of trend output and real factor prices. Investment (IRM) is recovered by inverting the perpetual inventory equation.

### Table: Coefficients and Estimates for Equation 74

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### Table: Coefficients and Estimates for Equation 75

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### Table: Coefficients and Estimates for Equation 76

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<td>LOG(ESM)</td>
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### Table: Coefficients and Estimates for Equation 77

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<td>OPTARKRM</td>
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### Table: Coefficients and Estimates for Equation 78

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<tr>
<td>LSTARKRM</td>
<td>0.00629</td>
<td>0.00025</td>
<td>25.65</td>
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### Table: Coefficients and Estimates for Equation 79

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<tr>
<td>LOG(ESM)</td>
<td>0.00629</td>
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### Table: Coefficients and Estimates for Equation 80

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<td>A0221</td>
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<td>A0222</td>
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### Table: Coefficients and Estimates for Equation 81

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<td>A0219</td>
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### Table: Coefficients and Estimates for Equation 82

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<td>A0220</td>
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<td>A0221</td>
<td>0.451922</td>
<td>0.231331</td>
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</table>

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 (EAAEM).

### Table: Coefficients and Estimates for Equation 83

<table>
<thead>
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<tbody>
<tr>
<td>UCS</td>
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<tr>
<td>EPOSM</td>
<td>-0.01252</td>
<td>0.043453</td>
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<tr>
<td>EUCCS</td>
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<tr>
<td>EAAEM</td>
<td>0.00224</td>
<td>0.003984</td>
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Equations 85-87 derive the wage bill in marketed services (YVSH), profits (YCSH) and a measure of profitability (YTCS).

### Table: Coefficients and Estimates for Equation 86

<table>
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<td>YCSH</td>
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<td>YTCS</td>
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### Table: Coefficients and Estimates for Equation 87

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<tbody>
<tr>
<td>LOG(YVSH)</td>
<td>0.331</td>
<td>0.04989</td>
<td>6.6756</td>
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</table>

Equations 88-89 determine labour productivity (OPRSH), trend productivity (EOPRSH) and unit labour costs (UCLSH).

### Table: Coefficients and Estimates for Equation 88

<table>
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<th>COEF</th>
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<tbody>
<tr>
<td>OPRSH</td>
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### Table: Coefficients and Estimates for Equation 89

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<tr>
<td>LOG(OPRSH)</td>
<td>0.331</td>
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### Table: Coefficients and Estimates for Equation 90

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<tbody>
<tr>
<td>UCLSH</td>
<td>0.00224</td>
<td>0.003984</td>
<td>0.5648</td>
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</tbody>
</table>

Equations 91-93 describe the Health and Education sector. Here, the volume of output (OBQHM) is determined purely by labour inputs (LSHE) and the value of output (OSHEV) is measured by the adjusted wage bill.

### Table: Coefficients and Estimates for Equation 91

<table>
<thead>
<tr>
<th>COEF</th>
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<tbody>
<tr>
<td>LSHE/LSHE</td>
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<tr>
<td>OSHE/LSHE</td>
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<td>YCSHE</td>
<td>0.00224</td>
<td>0.003984</td>
<td>0.5648</td>
</tr>
</tbody>
</table>
### MODEL LISTING

The volume of output in the Public Administration sector (OPA) is a function of employment (IPA), with a small adjustment for productivity. The value of output (OPA) is determined by the wage bill (WPA).

\[
\text{LOG}(\text{OPA/IPA}) = A111 + A122 + \text{7.467} + \text{LOG}(\text{WPA})
\]

<table>
<thead>
<tr>
<th>COEF</th>
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<tr>
<td>A111</td>
<td>1.8692</td>
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<td>A122</td>
<td>0.00376</td>
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</table>

### Equations 96-98 define some aggregates for the total of marketed services plus health and education.

96: \( \text{GSO} = \text{GHE} + \text{GSE} \)

97: \( \text{OSO} = \text{OSREV} + \text{OSNY} \)

98: \( \text{TWSO} = \text{TWNHE} + \text{TWSNY} \)

Finally, national accounting depreciation for total services (DEPS) is a function of the lagged value of the capital stock.

\[
\text{LOG}(\text{DEPS}) = A601 + A602 + \text{LOG}(\text{PIB}(-1)) + \text{FEM}(-1) + \text{RH060} + \text{B60}(-1) + \text{LOG}(\text{DEPS})
\]

<table>
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<tr>
<td>A601</td>
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<td>0.254055</td>
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<td>A602</td>
<td>0.69432</td>
<td>0.35346</td>
<td>31.3099</td>
</tr>
<tr>
<td>RH01</td>
<td>0.651413</td>
<td>0.149864</td>
<td>4.37004</td>
</tr>
</tbody>
</table>

### (4) IMPORTS AND THE BALANCE OF PAYMENTS

Imports of producer capital goods (MPCG) are a simple function of total investment in machinery and equipment (IME).

\[
\text{LOG}(\text{MPCG/IME}) = A111A + \text{LOG}(\text{PHCG}) + \text{RH01A} + \text{R11A}(-1)
\]

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<tbody>
<tr>
<td>A111A</td>
<td>-0.59976</td>
<td>0.058198</td>
<td>-9.24201</td>
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<tr>
<td>RH01A</td>
<td>0.76758</td>
<td>0.117873</td>
<td>6.51336</td>
</tr>
</tbody>
</table>

Consumption imports (MC) are determined by the volume of consumption (C) and by import prices (PMH); relative to the price of domestic transportable goods prices (QPT). 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 elasticity and drops the time trend.

\[
\text{LOG}(\text{MC/C}) = A121A + A122A + \text{CST} + A122A + \text{LOG}(\text{PMH}/\text{QPT}) + A124A + \text{DUN73} + A125A + \text{DUN74} + A126A + \text{DUN75} + \text{HKO12A} + \text{R11A}(-1) + \text{LOG}(\text{PMCA})
\]

### Consumption Imports

\[
\text{LOG}(\text{MC/C}) = A121A + A122A + \text{LOG}(\text{C}) + A123A + \text{LOG}(\text{PMH}/\text{QPT}) + A124A + \text{DUN73} + A125A + \text{DUN74} + A126A + \text{DUN75} + \text{RH012B} + \text{R12B}(-1) + \text{LOG}(\text{PHCB})
\]

### LOG(MC/C) = A121A + A122A + LOG(C) + A123A + LOG(PMH/QPT) + A124A + DUN73 + A125A + DUN74 + A126A + DUN75 + RH012B + R12B(-1) + LOG(PHCB)

<table>
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<tr>
<td>A121A</td>
<td>-2.78831</td>
<td>0.03942</td>
<td>-15.0278</td>
</tr>
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<td>A122A</td>
<td>0.03285</td>
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</tr>
<tr>
<td>A123A</td>
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<td>3.21219</td>
</tr>
<tr>
<td>A124A</td>
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<td>-3.61543</td>
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<td>A125A</td>
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<td>A126A</td>
<td>0.659672</td>
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<td>RH012B</td>
<td>0.004605</td>
<td>0.003082</td>
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### LOG(MC/C) = A121A + A122A + LOG(C) + A123A + LOG(PMH/QPT) + A124A + DUN73 + A125A + DUN74 + A126A + DUN75 + RH012B + R12B(-1) + LOG(PHCB)

<table>
<thead>
<tr>
<th>COEF</th>
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<tbody>
<tr>
<td>A121B</td>
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</tr>
<tr>
<td>A122B</td>
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<td>0.317425</td>
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</tr>
<tr>
<td>A123B</td>
<td>-0.40549</td>
<td>0.32282</td>
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</tr>
<tr>
<td>A124B</td>
<td>-0.18726</td>
<td>0.074772</td>
<td>-2.53542</td>
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<tr>
<td>A125B</td>
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<td>0.05159</td>
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</tr>
<tr>
<td>A126B</td>
<td>-0.15929</td>
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<tr>
<td>RH01B</td>
<td>0.969501</td>
<td>0.010247</td>
<td>94.8141</td>
</tr>
</tbody>
</table>

### If the restriction is not met, then use DUV12A ELSE DUV12B

### LOG(MC/C) = A121A + A122A + LOG(C) + A123A + LOG(PMH/QPT) + A124A + DUN73 + A125A + DUN74 + A126A + DUN75 + RH012B + R12B(-1) + LOG(PHCB)

**NOTES:**

- Data for 1984 to 1986 and 1987 to 1989 were used.
- All models were estimated using ordinary least squares (OLS) regression with heteroscedasticity-consistent standard errors.
- Significance levels are indicated by asterisks: *p < 0.10, **p < 0.05, ***p < 0.01.
- The models were adjusted for autocorrelation using the Cochrane-Orcutt iterative procedure.
Imports of materials for further production in agriculture (HMFPA) are determined by the volume of agricultural output (QMA). As for HC above, two variants are provided, eqn. 104 being the default option.

\[ \text{LOG}(\text{HMFPA/QMA}) = 1414 + 1424 \times (\text{T-DEV} + \text{LOG}(\text{PMFPA})) \]

<table>
<thead>
<tr>
<th>MODEL</th>
<th>COEF</th>
<th>ESTIMATE</th>
<th>SEER</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1414</td>
<td>-2.8785</td>
<td>0.115522</td>
<td>-22.9332</td>
<td></td>
</tr>
<tr>
<td>A1424</td>
<td>0.02759</td>
<td>0.006556</td>
<td>6.0811</td>
<td></td>
</tr>
</tbody>
</table>

Energy imports (H3) are derived by subtracting domestic production (QE) from total industrial energy demand (EI), and adjusting for re-exports of energy (EXRES).

\[ H3 = EI - QE + EXRES \]

The largest import category consists of non-energy imports of materials for further production in industry (HMFPA). This is derived residually from the constant price identity between GDP on an expenditure and output basis, suitably adjusted for the statistical discrepancy (STATDIS). The larger import category consists of non-energy imports of materials for further production in industry (HMFPA). This is derived residually from the constant price identity between GDP on an expenditure and output basis, suitably adjusted for the statistical discrepancy (STATDIS).

Energy imports (H3) 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).

\[ \text{LOG}(\text{H3}) = 1414 + 1424 \times \text{LOG}(\text{C}) \times \text{A633} \times \text{LOG}(\text{MS}-1) ] + \text{LOG}(\text{PMFPA}) \]

<table>
<thead>
<tr>
<th>MODEL</th>
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<th>ESTIMATE</th>
<th>SEER</th>
<th>TOTAL</th>
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</thead>
<tbody>
<tr>
<td>A1414</td>
<td>-2.8785</td>
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<td>0.02759</td>
<td>0.006556</td>
<td>6.0811</td>
<td></td>
</tr>
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</table>

The terms of trade (TOTRMP) are defined as the ratio of export prices to import prices.

\[ \text{TOTRMP} = \text{PRSE} / \text{PRMS} \]

The private net capital outflows (BPPK) are cumulated as EBRPPK, and added to the net foreign liabilities of the commercial banks (NRLF) to form total net foreign liabilities of the private sector (NRLF).

\[ \text{EBRPPK} = \text{BPPK} - \text{BPPK} \times \text{BPPK} \]

The residual component of net factor income (ETFNO) (i.e., excluding national debt interest and profit repatriation), can, as an option, be related to NRLF by means of an exogenous propensity term (KETFNO).

\[ \text{ETFNO} = 0.02 \times \text{EQ1} \times \text{ETFNO} \times \text{ETFNO} \times \text{ETFNO} \]
MODEL LISTING

Identities 125-130 define the balance of payments. Options are available to index certain items to movements in world prices.

125: YTP = YTMPO+GCTMRIP+YCTREP
126: YTMPO = IF TYEAR LE 1975 THEN KYMPO+YPH/PMDK ELSE KYMPO+YPH/PMD5
127: BPTCK = IF B22 EQ 1 THEN BPTCKLXK ELSE IF B22 EQ 2 THEN PMODR/PMDR(-1)+BPTCK(-1) ELSE PMODR/PMDR+ BPTCKR
128: BPTCKR = IF B22 EQ 1 THEN BPTCKRNLXK ELSE IF B22 EQ 2 THEN PMODR/PMDR(-1)+BPTCKR(-1) ELSE PMODR/PMDR+BPTCKRNLXK
129: BPT = BPT+YPH+BPTFRR+OTGABR+OTGARR+KEXC+IRCTH+KEXC+IRCTH
130: BPP = 100+BN/PDPOV+

(5) : DEMOGRAPHICS, LABOUR SUPPLY AND MIGRATION

Simple equations are provided from 131-137 to project the total population (HT), population aged under 15 (HLE14) and of working age (NIS46). The default option is the homogenised population.

131: DEL(DV15)+HMA = A151+HT(-1)+BFT

DEL(1 : HT)+HMA = A151+HT(-1); DEL(2 : HT)+HMA = A151+HT(-2); DEL(3 : HT)+HMA = A151+HT(-3);

132: HT = IF B15 EQ 1 THEN NTH ELSE DV15
133: DEL(DV16) = A161+HLE14(-1)+A162+HMA+FFLE14

DEL(1 : NLE14) = A161+HLE14(-1)+A162+HMA

134: NLE14 = IF B15 EQ 1 THEN NLE14+ELSE DV16
135: DEL(DV17) = A171+HIS46(-1)+A172+HMA+FHIS46

DEL(1 : NIS46) = A171+HIS46(-1)+A172+HMA

136: NIS46 = IF B15 EQ 1 THEN NIS46+ELSE DV17
137: HLE14 = HT-(NLE14+HLE14)

An option is available to calculate the participation rate in full time education by those of working age. The default option is to homogenise NIS46.

138: LOG(DV18) = A181+A182+DUNED+A183+D-RTL11+LOG(PHDRE)

LOG(REP) = A181+A182+DUNED+A183*;

139: NIS46 = IF B15 EQ 1 THEN NIS46+ELSE DV18

An adjusted population of working age (NIS46a) is derived by subtracting the numbers of working age in full-time education from NIS46.

140: HLPED = NIS46-NIS46/100
141: HLE14 = NIS46-NIS46

The dependency ratio (RDDEPEND) is defined as follows.

142: RDDEPEND = 100*(NLE14+HLE14+NIS46)/NIS46

An option is provided to calculate the aggregate labour force participation rate (LPFR). The default option is to homogenise it.

143: LOG(DV19) = A191+A192+(D-RTL12)+RDHP19+R19(-1)+LOG(PFLFR)

LOG(LPFR) = A191+A192*;

144: HLE14 = NIS46+HLE14
144: \[ LFPR = \text{LF} \times 100 \text{ in the labour force.} \]

The following identity defines the numbers not in the labour force.

146: \[ NLNF = NLF \times 100 \text{- LF} \]

Equations 147-153 define various employment aggregates: total services employment (LS), total employment (LOD); non-agricultural employment (LMA), employment in the market sector (LM), employment in the non-agricultural market sector (LMA), employment in the market sector plus health and education.

147: \[ LS = LSH + LSH + LPA \]

148: \[ LTOT = LSH + LSH + LS \]

149: \[ LMA = LSH + LSH \]

150: \[ LM = LSH + LSH + LSH \]

151: \[ LMA = LSH + LSH \]

152: \[ LMA = LSH + LSH \]

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 (USHNAT).

155: \[ UR = \frac{U}{LF} \times 100 \]

156: \[ USHAT = \frac{U}{UR + 100} \times UR^2 - 3 \text{UR} - 3 \text{UR}^2 \]

An option is provided to extrapolate net outward migration (NMA), as a function of relative earnings (RN) and employment (RE) possibilities between Ireland and the Great Britain.

157: \[ DV20 = A207 + A202 + RN + A203 + NMA + (-1) \times NMA \]

The ABSORPTION BLOCK

Two variants of the consumption function are provided; the first has an aggregate real personal disposable income measure (YPEND); the second constrains the marginal propensity to consume to be unity. The default choice is the first.

162: \[ DV21A/NT = A211A + A212A + YPEND/NT + A213A + DUN75 + DUN75 + DUN75 + R121A + R21A + (-1) \]

163: \[ DV21B/NT = A211B + A212B + (YPEND - OCTPER - GCTM) + (PC/NT) + A213B + DUN75 + DUN75 + DUN75 + DUN75 + R121B + R21B + (-1) \]
MODEL LISTING

164: C = IF YELI EQ 1 THEN DVI1A ELSE DVI1B

165: CV = PC+C

Equations 166-171 define consumption by the public authorities. Total public consumption (GOGV) is the sum of wage payments in public administration (GPAV), in Health and Education net of certain wages paid as transfers (GOHENV), plus non-wage consumption (GOHENV). Equation 166 defines the constant price consumption (GCGV). The deflator of GCGV is tied directly to wage rates in Health and Education (GOEDN). 

166: GCGV = GCGHENV/GOHENV

167: GCGN = GCGENV/GCGENV

168: GCG = GOA+GCGHENV+GCGENV

169: GCGENV = THESK-GCGW

170: GCGENV = GCGENV/GCGENV

171: GOEDN = GCGENV(-1)*@AASI/1/AASI(-1)

Private housing investment (ISPV) is a function of real personal disposable income (YRPED), the rate of housing transfers (NORTH) and to a real interest rate (RPS deflated by PIN, the deflator of ISPV).

172: LOG(ISPV/WT) = A221+A222*LOG(YRPED/WT)+A223*LOG(NORTH)+A224*LOG(RPS/WT)-A225*LOG(PIN/WT(-1))+LOG(PIN)

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</tr>
<tr>
<td>A222</td>
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<td>A223</td>
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<tr>
<td>A224</td>
<td>-0.196371</td>
<td>0.142846</td>
<td>-1.37806</td>
</tr>
</tbody>
</table>

173: ISPV = PIN+ISPV

Equations 174-175 define the volume of public housing investment (IHG) and total housing investment (IH). 

174: IHG = ISPV/PIN

175: IH = ISP+IHG

176: ISPV = ISP+ISPV

Equations 177-179 define various aggregates of investment in current and constant prices. The split of total non-housing investment (ITOF-1) into machinery and construction (ICK) and building and construction (IBC) is by means of an exogenous weighing variable WITHE which is defined so as to reproduce the historical split.

177: ITIV = PIV-II

178: IVA = PIV-AIA

179: IAS = IAS+ISC

180: ISV = ISP-IS

181: ISW = ISW-IPAV-ISHV

182: ITOS = II-IAS=ISK

183: IPA = IPAV-PIPA

184: ISHE = ISHE-ISHHE

185: INH = ITHE=ITID-ISH

186: IBC = ITOS+ISC

187: ICT = ITOS=ISP+ISP+IPI

188: ITOF = ITIV+IIV+IV+IV+IV+IV

Equations 190-195 define stock changes. Non-agricultural stock changes (STHADL) are a function of the level of industrial output (ITOF-1) into machinery and construction (ICK) and building and construction (IBC) and are accumulated in the variable STHA. Total stock changes (STG and STVL) are the sum of agricultural, non-agricultural and intervention stocks.

190: STHADL = A621+A622+G6+A623+STHA(-1)+STHADL

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<tr>
<td>A623</td>
<td>-0.408398</td>
<td>0.137556</td>
<td>-2.94896</td>
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</table>
Industrial exports (XI) as a fraction of industrial output (QII) is modelled as a time trend. Tourist exports (XTO) are driven by world output (QIV), with a Northern Ireland dummy variable. Exports of other services (XSO) are driven by QGP.

\[
\begin{align*}
\text{LOG}(XI/QII) &= A231 + A232 \times (T-8215) + XH032 + X23(-1) + \text{LOG}(FZ2) \\
\text{LOG}(XII/XII) &= A321 + A322 \times T \\
\text{LOG}(XTO/QIV) &= A461 + A462 + XH01 + A463 \times \text{LOG}(XTO(-1)/QIV(-1)) + \text{LOG}(PETO) \\
\text{LOG}(XIV/XIV) &= A461 + A462 + XH01 + A463 \times \text{LOG}(XIV(-1)/QIV(-1)) \\
\text{LOG}(XSO/QGP) &= A431 + A432 + \text{LOG}(XSO(-1)/QGP(-1)) + \text{LOG}(FESO) \\
\text{LOG}(XII/XII) &= A431 + A432 + \text{LOG}(XII(-1)/QGP(-1)) + \text{LOG}(FESO) \\
\end{align*}
\]

Equations 199-201 define various aggregates of exports: services (XIV), non-agricultural (XNA) and total goods and services (XSG).

\[
\begin{align*}
XX &= XTO + XSO \\
X20 &= XNA + X12X \\
X21 &= XHNA + X11F + XPS + XS \\
X22 &= XSG = XNA + XA \\
X23 &= XGVS = XHGAN + PXX + XA \\
\end{align*}
\]

Equations 204-208 define personal savings (SAV), company savings (SAC), total savings (SAYTOT), net savings (SAVNET), and gross savings (SAVAG).

\[
\begin{align*}
SAV &= \text{YPERG} - CV \\
SAC &= \text{YCV} - TVG \\
SAVOT &= \text{SAY} + \text{SAC} + \text{GSR} \\
SAVNET &= \text{SAVOT} - \text{YASA} \\
SAVG &= \text{SAVNET} + \text{DEP} + \text{BPTCK} - \text{BP} \\
\end{align*}
\]

Equations 209-210 define gross domestic absorption (GDA, ODVA).

\[
\begin{align*}
GDA &= C + GOS + IOT + STDL \\
GDV &= C + GSV + ITOT + STDL \\
\end{align*}
\]

Equations 211-212 define gross final demand (GFD, GFDV).

\[
\begin{align*}
GFD &= GDA + XGS \\
GFDV &= GDAV + XGVS \\
\end{align*}
\]

Equations 213-215 define gross domestic product on an expenditure basis (GDPES, GDPFEV) and its deflator (PDDE).}

\[
\begin{align*}
GDPES &= GDA + XGS + XGS \\
GDPFEV &= GDA + XGVS + XGVS \\
\end{align*}
\]

Equations 216-219 define four weighted final demand measures, using the 1975 input-output table weights. GSOAQMUD is final demand weighted by its output content of the mining, manufacturing and utilities sectors. GSOA uses weights from the building and construction output content. GSOA uses weights from the services sector output content.

\[
\begin{align*}
GSOAQMUD &= 0.125169 \times (CXT0 + 0.031364 + \text{OSCHF} + (T03.3 + T03.1 + T03.1 + 0.125 + 0.098704 + (IHM + I2BC) + 0.098649 + IMEX + 0.165645 + STDAGL + 0.255043 + SSTVLG - 0.063424 + STDAGL + 0.09538 + XEG + 0.101589) \\
GSOAQMUD &= 0.095116 \times (CXT0 + 0.037761 + \text{OSCHF} + (T03.3 + T03.1 + T03.1 + 0.125 + 0.098704 + (IHM + I2BC) + 0.098649 + IMEX + 0.001517 + STDAGL + 0.005519 + STTVLG - 0.063424 + STDAGL + 0.09538 + XEG + 0.101589) \\
GSOAQMUD &= 0.095116 \times (CXT0 + 0.037761 + \text{OSCHF} + (T03.3 + T03.1 + T03.1 + 0.125 + 0.098704 + (IHM + I2BC) + 0.098649 + IMEX + 0.001517 + STDAGL + 0.005519 + STTVLG - 0.063424 + STDAGL + 0.09538 + XEG + 0.101589) \\
GSOAQMUD &= 0.095116 \times (CXT0 + 0.037761 + \text{OSCHF} + (T03.3 + T03.1 + T03.1 + 0.125 + 0.098704 + (IHM + I2BC) + 0.098649 + IMEX + 0.001517 + STDAGL + 0.005519 + STTVLG - 0.063424 + STDAGL + 0.09538 + XEG + 0.101589) \\
\end{align*}
\]

Equation 220 defines a moving average of GSOA.
(1) : Price Determination : External Prices

Equations 211-225 refer to the three main import price indices: energy (PKE), non-energy goods (PPKEM) and services (PPS). In each case, the domestic price (i.e., the price in IDR) is determined by dividing the foreign currency price by the effective exchange rate, FEXEFF.

211: \[ \text{PKE} = \text{PPKEM}/\text{FEXEFF} \]

222: \[ \text{PS} = \text{PPKEM}/\text{FEXEFF} \]

223: \[ \text{PEDOT} = 100+\text{DEL}(\text{PS})/\text{PS}(-1) \]

224: \[ \text{PHONE} = \text{PPKEM}/\text{FEXEFF} \]

225: \[ \text{PMS} = \text{PPKEM}/\text{FEXEFF} \]

Two obstacles are available for the world price of industrial output (PFWORLD): in the first (FPVF) it is a weighted average of energy and non-energy import prices, while in the second it is simply exogenous.

226: \[ \log(\text{PVVF}) = \text{WTENV}+\log(\text{PKE})+(1-\text{WTENV})\cdot\log(\text{PPKEM})+\log(\text{PFWORLD}) \]

227: \[ \text{PFWORLD} = ZF24\cdot\text{EQ}1\text{THEN PFWORLD}/\text{FA ELSE DVFV} \]

228: \[ \text{PFWORLD} = 100*(\text{PFWORLD}/\text{PFWORLD}(-1))-1 \]

The price of gross agricultural output (PQGA) is also exogenous.

229: \[ \text{PQGA} = \text{PQGA}/\text{FEXEFF}+\text{CAP}^*(\text{GBSAS}-\text{GBSAS}^*)/\text{EXC}-\text{EXC}^* \]

(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 (PQIT) is a function of world industrial output prices (PFWORLD) and of agricultural prices (PQGA). The deflator of added-value (PQIV) is simply the volume of added value over the value of industrial output.

230: \[ \log(\text{PQIV}) = A241+A242\cdot\log(\text{PFWORLD})+(1-A242)\cdot\log(\text{PQGA})+\log(\text{PQIII}) \]

231: \[ \log(\text{PQII}) = A531+A532\cdot\log(\text{PQIV})+(1-A532)\cdot\log(\text{PHD}) \]

232: \[ \log(\text{PQIII}) = A721+A722\cdot\log(\text{PQII})+(1-A722)\cdot\log(\text{QGA}) \]

The deflator of added-value in marketed services (PQSM) is determined similarly. Remember that added value in current prices in marketed services (QSMV) is residually determined in the model in the current price expenditure-output identity. Hence, PQSM is also essentially residually determined.

233: \[ \text{POSM} = \text{QSMV}/\text{QSM} \]

234: \[ \text{PSOS} = \text{QSMV}/\text{QSM}+\text{QSMV}/\text{QSM} \]

The deflator of material inputs in agriculture (PQPA) is a function of price in industry (PQIT) and lagged agricultural prices. The added value deflator in agriculture, forestry and fishing (PGAA) is determined as for PQI and PQSM.

235: \[ \log(\text{PQPA}) = A721+A722\cdot\log(\text{PQII})+(1-A722)\cdot\log(\text{PQGA})+\log(\text{PGAA}) \]

Equations 237-238 determine the deflator of GDP at factor cost (PGDPFC) and its inflation rate.

237: \[ \text{PGDPFC} = \text{GDPFC}/\text{GDPFC} \]

238: \[ \text{PGDPFCOT} = 100*(\text{PGDPFC}/\text{PGDPFC}(-1))-1 \]

(3) : Price Determination : Expenditure Prices
The personal consumption deflator (PC) is a function of industrial output prices (PQIT) and unit labour costs in marketed services, using "trend" labour productivity.

\[
\text{LOG}(PC) = A291 + A292 + \text{LOG}(PQIT) + (1-A293) + \text{LOG} \left( \text{A281}, \text{A282}, \text{A283}, \text{ZINC} \right) + \text{RHO28} + \text{RHO29} - 1) + \text{LOG}(\text{FPC})
\]

LOG(PC) = A281 + A282 + \text{LOG}(PQIT) + (1-A283) + \text{LOG} \left( \text{A281}, \text{A282}, \text{A283}, \text{ZINC} \right)

NOB = 20
NOBAR = 4
RANGE: 1964 TO 1984

\[
\begin{array}{lcr}
\text{COEF} & \text{ESTIMATE} & \text{STERR} \\
A281 & 0.717641 & 0.129458 \\
A282 & 0.493446 & 0.116590 \\
A283 & 0.755328 & 0.235664 \\
\text{RHO1} & 0.865639 & 0.032177 \\
\end{array}
\]

TOTT = 16.6954

Equation 245 simply links the deflator of non-wage public consumption (PQOSSH) to PC, while equation 246 determines the overall deflator of public consumption (POCO).

Equations 241-246 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 PME and PIB deflators, where the coefficients capture the sectoral composition of investment. The deflators of investment in the health and education sector (PIHE) and in public sectoral composition of investment. The deflators of investment in marketed services (PIIM) and total investment (PIIT). Two identities determine the deflators of investment in marketed services (PIIM) and total investment (PIIT).
MODEL LISTING

<table>
<thead>
<tr>
<th>COEF</th>
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<th>STER</th>
<th>TSTAT</th>
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</thead>
<tbody>
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<td>0.007202</td>
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<td>A322</td>
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<td>RHO1</td>
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<td>0.144966</td>
<td>1.62946</td>
</tr>
</tbody>
</table>

246: \( \log(\text{PIE}) = \log(\text{PIE}) - \log(\text{PIE})\)

247: \( \log(\text{PIE}) = \log(\text{PIE}) + \log(\text{PIE})\)

250: \( \log(\text{PIE}) = 1.28 + 2.82 + \log(\text{PIE})\)

251: \( \log(\text{PIE}) = \log(\text{PIE}) + \log(\text{PIE})\)

252: \( \log(\text{PIE}) = 0.20 + 0.35 + \log(\text{PIE})\)

Equations 253-259 concern export prices. I.e., the BOF price-taking assumption. Services export prices (PES) are only linked to consumption prices. Identified non-agricultural export prices (PNA), total export prices (PES) and export profitability (PFR). Non-agricultural export prices (PNA), services export prices (PES) and total export prices (PES) are determined in an identity.

255: \( \log(\text{PES}) = \log(\text{PC}) + \log(\text{PES})\)

256: \( \log(\text{PES}) = \log(\text{PC}) + \log(\text{PES})\)

257: \( \log(\text{PES}) = \log(\text{PC}) + \log(\text{PES})\)

258: \( \log(\text{PES}) = \log(\text{PC}) + \log(\text{PES})\)

Non-agricultural stock change prices (PSTNAH) are linked to industrial and import prices. The deflator of non-agricultural stock levels (PSTNAH) prove difficult to model in this aggregate form and is simply linked to PSTNAH. Total stock change prices (PSTDL) are determined in an identity.

259: \( \log(\text{PSTNAH}) = \log(\text{PSTNAH}) + \log(\text{PSTDL})\)

260: \( \log(\text{PSTNAH}) = \log(\text{PSTNAH}) + \log(\text{PSTDL})\)

Given the explicit modelling of output at factor and market prices, we need to endogenise the "deflators" of indirect taxes (FTE) and of subsidies (FTE). Both are determined by identities. Real indirect taxes and subsidies are determined later.

261: \( \log(\text{PSTDL}) = \log(\text{PSTDL}) + \log(\text{PSTDL})\)

Finally, the deflator of the adjustment for financial services (PSTFS) is determined by the deflator of GDP at factor cost (PSTFD).
(4) : Wage Determination

The wage rate in agriculture (AARE) is determined as a function of a tax ‘wedge’, the unemployment rate (UN) and labour productivity in a dynamic specification. The wedge (WEDGE) combines the effect of all direct and indirect taxes.

Two variables 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 (OPR) or trend productivity (OPR1).

The wage rate in market services (AASH) is determined as a relative relation with industry.

Identities 278-279 determine real 'after tax' wages in market services (RATAAESH) and the wage inflation rate (AAXEDOT). Wage levels in public administration and defence (AAXEP) are determined as a relative relation to industry, where the relative variable (WAXREP) is exogenous.
Equations 286-299 handle public sector employment and wage expenditures. For both employment in health and education (LESH) and in public labor administration (LPA), the choice lies between setting to an (exogenous) value (tagged with a trailing "H"). As with the pre-existing wage bill (YVNH and YVPA) can be exogenized, 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 "B").

286: 
\[ LSH = IF 56 EQ 1 THEN LSHH ELSE IF 56 EQ 2 THEN YVSHH/AAXSHH ELSE LSHH(-1) \]

287: 
\[ YVSHH = IF 56 EQ 1 THEN YVSHH ELSE IF 56 EQ 2 THEN YVSHH(-1) \]

288: 
\[ LPSH = IF 56 EQ 1 THEN LPSH ELSE IF 56 EQ 2 THEN LPSH(-1) \]

The non-pay element of public consumption (GRSHFV) can be either exogenized or indexed using Type 1 or Type 2.

300: 
\[ QSHFV = IF 57 EQ 1 THEN QSHFVE ELSE IF 57 EQ 2 THEN QSHFVE(-1) \]

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 exogenization, 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 GDP 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: 
\[ NSHCF = IF 58 EQ 1 THEN NSHCFH ELSE IF 58 EQ 2 THEN NSHCF(-1) \]

302: 
\[ GSHCF = IF 59 EQ 1 THEN GSHCFH ELSE IF 59 EQ 2 THEN GSHCF(-1) \]

303: 
\[ KSHCF = IF 60 EQ 1 THEN KSHCFH ELSE IF 60 EQ 2 THEN KSHCF(-1) \]

304: 
\[ RSHCF = IF 61 EQ 1 THEN RSHCFH ELSE IF 61 EQ 2 THEN RSHCF(-1) \]

305: 
\[ NTHCF = IF 62 EQ 1 THEN NTHCFH ELSE IF 62 EQ 2 THEN NTHCF(-1) \]

306: 
\[ ITSHCF = IF 63 EQ 1 THEN ITSHCFH ELSE IF 63 EQ 2 THEN ITSHCF(-1) \]

307: 
\[ ITPHCF = IF 64 EQ 1 THEN ITPHCFH ELSE IF 64 EQ 2 THEN ITPHCF(-1) \]

308: 
\[ ISHCF = IF 65 EQ 1 THEN ISHCFH ELSE IF 65 EQ 2 THEN ISHCF(-1) \]

309: 
\[ INSHCF = IF 66 EQ 1 THEN INSHCFH ELSE IF 66 EQ 2 THEN INSHCF(-1) \]

310: 
\[ GTHCF = IF 67 EQ 1 THEN GTHCFH ELSE IF 67 EQ 2 THEN GTHCF(-1) \]

311: 
\[ RTHCF = IF 68 EQ 1 THEN RTHCFH ELSE IF 68 EQ 2 THEN RTHCF(-1) \]

312: 
\[ NTDHCF = IF 69 EQ 1 THEN NTDHCFH ELSE IF 69 EQ 2 THEN NTDHCF(-1) \]

313: 
\[ ITDThCF = IF 70 EQ 1 THEN ITDThCFH ELSE IF 70 EQ 2 THEN ITDThCF(-1) \]

314: 
\[ ISDThCF = IF 71 EQ 1 THEN ISDThCFH ELSE IF 71 EQ 2 THEN ISDThCF(-1) \]

315: 
\[ INSDThCF = IF 72 EQ 1 THEN INSDThCFH ELSE IF 72 EQ 2 THEN INSDThCF(-1) \]

316: 
\[ GTHCFH = IF 73 EQ 1 THEN GTHCFH ELSE IF 73 EQ 2 THEN GTHCF(-1) \]

317: 
\[ RTHCFH = IF 74 EQ 1 THEN RTHCFH ELSE IF 74 EQ 2 THEN RTHCF(-1) \]

318: 
\[ NTDHCFH = IF 75 EQ 1 THEN NTDHCFH ELSE IF 75 EQ 2 THEN NTDHCF(-1) \]

319: 
\[ ITDThCFH = IF 76 EQ 1 THEN ITDThCFH ELSE IF 76 EQ 2 THEN ITDThCF(-1) \]

320: 
\[ ISDThCFH = IF 77 EQ 1 THEN ISDThCFH ELSE IF 77 EQ 2 THEN ISDThCF(-1) \]

321: 
\[ INSDThCFH = IF 78 EQ 1 THEN INSDThCFH ELSE IF 78 EQ 2 THEN INSDThCF(-1) \]
Equations 322-328 deal with the incidence of these fiscal instruments which are expressed in real terms. Here the choices between ex-annuization or leaving them unchanged from a previous year setting. The instruments involved are the VAT rate (NVT), the customs duty rate (RCUS), the employees' and employees' rate of social insurance contributions (ROTHS, ROSS), the implicit rate of corporation tax (RSTC), and the implicit rate of capital grants to households for housing purposes (RORTH) and to industry for investment purposes (RORT).

(6) : Tax Revenue Equations : Indirect Taxes

Revenue from a broad class of excise taxes (oil, tobacco, alcohol) are determined by a representative rate instrument (RXX), a tax base proxy (consumption plus tourism exports) and consumer prices.

\[ \log(\text{GEXIT}) = A441 + A442 + \log (\text{REX}) + A443 + \log (\text{CRQ}) + A444 + \log (\text{PC}) + \log (\text{FDTEXIT}) \]

<table>
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<tr>
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<th>NOVAR = 4</th>
<th>RANGE: 1964 TO 1984</th>
<th>PROBP = 0.0</th>
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<td>A444</td>
<td>0.261322</td>
<td>0.055929</td>
<td>4.36003</td>
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</tbody>
</table>

Revenue from VAT is determined by a representative VAT rate (NVT), a VAT base (GEXIT) and consumer prices. The delay between collection and payment of VAT is reflected in the lag structure of the equation.

\[ \log (\text{GEXIT}) = A451 + A452 + \log (0.75 \times \text{NVT} + 0.25 \times \text{NVT}(-1)) + A453 + \log (\text{GEXIT}(-1)) + A454 + \log (0.75 \times \text{PC} + 0.25 \times \text{PC}(-1)) + \log (\text{FDTEXIT}) \]

<table>
<thead>
<tr>
<th>NOVAR = 4</th>
<th>NOVAR = 4</th>
<th>RANGE: 1964 TO 1984</th>
<th>PROBP = 0.0</th>
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<td>A452</td>
<td>1.1356</td>
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<td>A453</td>
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<td>A454</td>
<td>0.886422</td>
<td>0.051907</td>
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<td></td>
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</tbody>
</table>

Revenue from a residual heterogeneous group of indirect taxes (GEXIT) is a function of a representative tax rate (RSTC), a consumption base and consumer prices.

\[ \log (\text{GEXIT}) = A461 + A462 + \log (\text{RSTC}(-1)) + A463 + \log (\text{CRQ}) + A464 + \log (\text{PC}) + \log (\text{FDTEXIT}) \]

<table>
<thead>
<tr>
<th>NOVAR = 4</th>
<th>NOVAR = 4</th>
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<th>PROBP = 0.0</th>
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<td>A462</td>
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<td>0.274518</td>
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<td>A463</td>
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<td>0.382226</td>
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<tr>
<td>A464</td>
<td>0.090713</td>
<td>0.166624</td>
<td>5.38308</td>
</tr>
</tbody>
</table>

Total revenue from duty on motor vehicles (GTVWD) is determined by a representative rate (RCARS) and the volume of consumption.

\[ \log (\text{GTVWD}) = A471 + A472 + \log (\text{RCARS}) + A473 + \log (\text{CRQ})(-1) + \log (\text{FDTVD}) \]

\[ \log (\text{GTVWD}) = A471 + A472 + \log (\text{RCARS}) + A473 + \log (\text{CRQ}) \]

<table>
<thead>
<tr>
<th>NOVAR = 4</th>
<th>NOVAR = 4</th>
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<th>PROBP = 0.0</th>
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</tr>
<tr>
<td>A473</td>
<td>1.52227</td>
<td>0.218006</td>
<td>4.93273</td>
</tr>
<tr>
<td>A481</td>
<td>0.58642</td>
<td>0.160172</td>
<td>3.55369</td>
</tr>
</tbody>
</table>
(7) Tax Revenue Equations: Direct Taxes

Equation 343 defines the average direct tax rate (RTYPFR) and equation 342 defines a marginal direct tax rate (RTYFMR).

Revenue from direct personal taxation (OTYPFR) is determined by average annual taxable income (AAIT), non-agricultural employment (LNA) and tax allowances claimable (RIFALL). This equation provides for a progressive tax system since the coefficient A442 is considerably greater than unity.

Equations 344-347 relate to social insurance contributions. The total rate of contribution (OTYTS) is the sum of the employers and employees rates. Total revenue (OTYSE) 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 (OTYSE) is a fraction (W1) of total revenue. The employees portion is residually determined.

(8) Total Tax Revenue

OTYTOT is the total of revenue from indirect and direct taxation, in addition to public authorities trading and investment income (OTIT), transfers from abroad (OTTAB) and wealth tax.

(9) Subsidies
consumer subsidies (GCSC) are determined as the product of the implicit rate of subsidy (RGSCS) and the volume of consumption.

EXC subsidies (ECSC) are essentially exogenous.

Agricultural subsidies (GCSA) are of two kinds: subsidies not related to sales (GCSAN) and subsidies related to sales (GCSAS).

Identity 362 defines total subsidies, while TINC measures total indirect taxes, being net of non-agricultural subsidies, as a fraction of the value of consumption, a variable used in the consumption deflator above.

(10) : Current Transfers

Unemployment assistance and benefit is modelled as an aggregate (OGTUP) as a function of a representative rate of benefit/assistance (RUP) and the numbers unemployed (U).

\[
\text{LOG(OCTUP)} = \text{AS21} + \text{AS22} + \text{LOG(RUP)} + \text{AS23} + \text{LOG(U)}
\]

Pay-related benefit (OGTPBR) is determined by numbers unemployed (U) and average annual non-agricultural earnings (AASEN) in a quasi-identity.

Certain transfers paid as wages to teachers (OGTCW) are related to the number of teachers and average annual earnings in health and education (AASHE).

Identity 367 defines total current transfers (OGTCTR), where OGCTEST is a residual (exogenous) category of social welfare transfers (pensions, disability benefit, etc.). Identity 368 defines ECSC transfers as essentially exogenous.

(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 (QGL), with lags of one and two years; the second is a slightly parametrised equation based on a separate very detailed model of debt servicing.

\[
\text{OV5SA} = \text{AS51} + \text{AS52} + \text{RGL}(-1)/100\times\text{QGL}(-1) + \text{RGL}(-2)/100\times\text{QGL}(-2)
\]

(12) : Total Current Expenditure

Identity 374 defines total current expenditure as the summation of expenditures on current goods and services (GCSC), domestic subsidies (SUB-EXGS), current transfers (OGTCT), national debt interest (OGTDI), and current transfers paid abroad (OTCTAB).

Identity 375 defines total current expenditure as a percentage of GDP (RSC).

(13) : Total Capital Expenditure
MODEL LISTING

Capital transfers paid to industry as investment grants (GHTI) are determined as the product of an implicit rate of grant (GHTI) and the value of industrial investment (ILV). Capital transfers paid to the personal sector for housing investment purposes (GHTH) are similarly determined in terms of the value of private housing investment.

376: \[ GHTI = GHTI \times ILV \]
377: \[ GHTH = GHTH \times ISPV \]

Total capital expenditure by the public authorities (SK) is the summation of fixed investment in housing, investment by the public administration sector (IPAV), by the health and education sector (IHEV), the above two capital transfer items and a residual capital expenditure item (GKRESE).

378: \[ SK = IHPV + IPAV + ISHEV + GHTI + GHTH + GKRESE \]

(14) : Public Authorities Borrowing and Debt Financing

Identities 379-432 relate to the borrowing requirement of the public authorities. The total borrowing requirement (SR) is defined as total current and capital revenue (GTTOT, CR) minus total current and capital expenditure (GC, CK). Identity 380 defines the current borrowing requirement. Identities 381-382 define the total (SK) and current (SRCH) borrowing requirements as a percentage of GNP.

379: \[ SR = GTTOT - CR \times (GR - GK) \]
380: \[ SRCH = GTTOT \times GC \]
381: \[ GSR = 100 \times (SR/GRNP) \]
382: \[ GSRCH = 100 \times (SRCH/GRNP) \]

National loans outstanding (GROL) is either exogenous or is the summation of the various domestic financing components. The stock of small savings (GSSS) is determined as a proportion (exogenous) of net financial acquisitions of the personal sector (PPAQH).

383: \[ GRL = IFS 112 EQ 3 \times (1 - GNLH \times (GHL(1) - (GSSS + GSSS + GSSS)^2)) \]
384: \[ GSR = IFS 123 EQ 1 \times (1 - GSHS \times (GHS(1) + GHS^2 + GHS^2 + GHS^2 + GHS^2)) \]

Identity 385 defines total domestic debt (GND) as the summation of the above two components.

385: \[ GND = GRL + GSSS \]

The uptake of debt by the commercial banks (GNSG) is either exogenous or is a proportion (exogenous) of the broad money supply (ROM).

386: \[ GNSG = IFS 123 EQ 1 \times (1 - GSHS \times KSH + KSH) \]

Lending to the public authorities by the Central Bank (GNSC) is exogenous.

387: \[ GNSC = GNSG \]

The change in the personal sectors holdings of government bonds (GNHSDL) is either exogenous or is a proportion (exogenous) of total financial acquisitions of the private sector (PPAQ).

388: \[ GNHSDL = IFS 123 EQ 1 \times (1 - GSHS \times GHS + PPAQ) \]

Net foreign borrowing (FRB) is residually determined as the borrowing requirement less domestic financing.

389: \[ FRB = GSR + GSRCH \times GNP \]

Net foreign borrowing in IDR (FRB) is converted to a representative currency basket (FRBF) using an appropriate exchange rate basket of USD, DM, Yen and Sterling.

390: \[ FRBF = FRB \times TFRB \]

The foreign currency denominated interest payments (FRBF) are accumulated into the variable GPF. This stock of debt is revalued using the same exchange rate basket back to IDR (GPF).

391: \[ GPF = FRBF \times GNP \]
392: \[ GPF = FRBF \times TFRB \]

Interest payments on the foreign debt (denominated in IDR) is calculated as the product of an implicit interest rate (RPI) and the stock of debt outstanding (GPF).

393: \[ GCTNFID = RFI/100 \times GPF + GCTNFID \]

Identity 394 defines the total national debt outstanding (domestic and foreign).

394: \[ GNT = GNP + GPF \]

Identities 395-406 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 (RDNDF); total debt outstanding as a percentage of GNP (RDEST); total debt as a percentage of exports of goods and services (RDEST); foreign debt as a percentage of exports of goods and services (RDEST); total and foreign debt as a percentage of total population (RDESTN, RDESTNF); and total and foreign debt as a percentage of numbers employed (RDESTL, RDESTFL).

395: \[ RNDI = 100 \times GCTNFID/GNP \]
396: \[ RDNDF = 100 \times GCTNFID/GNP \]
397: \[ RDEST = 100 \times (GNT + GPF) / GNP \]
398: \[ RDESTF = 100 \times (GPF) / GNP \]
399: \[ RDESTX = 100 \times (GPF + GSV) / GNP \]
400: \[ RDESTFX = 100 \times (GPF + GSV) / GNP \]
401: \[ RDESTNF = 100 \times (GPF + GSV) / GNP \]
402: \[ RDESTNFT = 100 \times (GPF + GSV) / GNP \]
403: \[ RDESTL = 100 \times (GPF + GSV) / GNP \]
404: \[ RDESTFL = 100 \times (GPF + GSV) / GNP \]

(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 (YAFS) and GDP (GDPFC) in constant prices being defined in identities 406-407.
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 nominal 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 (QA); consumption (C) and added-value in industry (GSI) in the case of real subsidies (SUB).

\[
\begin{align*}
\text{TRE} & = \text{LOG[PRICE]} \times \text{WTSC} \times \text{LOG[C]} + \text{LOG[MGS]} \times \text{LOG[TRE]} \\
\text{TRE} & = \text{LOG[PRICE]} \times \text{WTSC} \times \text{LOG[QA]} + \text{LOG[MGS]} \times \text{LOG[TRE]} + \text{LOG[OS]} + \text{LOG[TRE]}
\end{align*}
\]

Identifications 410-413 define GDP at current market prices (GDPMV) and constant market prices (GDPM), and the growth rate of GDMV (GDPMDOT) and its price deflator (PGDP).

\[
\begin{align*}
\text{GDPM} & = \text{GDPMV} \times \text{TRE-SUB} \\
\text{GDPM} & = \text{GDPMV} \times \text{TRE-SUB} \\
\text{GDPMDOT} & = 100 \times \text{GDPM} / \text{GDPMV} - 1.1 \times 1.1 \\
\text{PGDP} & = \text{GDPM} / \text{GDPMV}
\end{align*}
\]

Identifications 414-417 define GNP in current and constant prices, and the real GNP growth rate and price deflator.

\[
\begin{align*}
\text{GNP} & = \text{GDPMV} \times \text{YFN} \\
\text{GNP} & = \text{GDPMV} \times \text{YFN} \\
\text{GNPMDOT} & = 100 \times \text{GNP} / \text{GNPV} - 1.1 \times 1.1 \\
\text{PGNP} & = \text{GNP} / \text{GNPV}
\end{align*}
\]

Total depreciation (DEP) is simply the total of depreciation in industry (DEPI), agriculture (DEPAG) and services (DEPS).

\[
\text{DEP} = \text{DEPI} + \text{DEPAG} + \text{DEPS}
\]

Identifications 419-426 concern definitions of various measures of income: net domestic product at factor cost (HDPFCV), net national product at factor cost (HDPFCCV).

\[
\begin{align*}
\text{HDPFCV} & = \text{GDPFCV} - \text{STATDIV} \times \text{DEP} / \text{TRE-SUB} \\
\text{HDPFCV} & = \text{GDPFCV} \times \text{YFN} + \text{YASA}
\end{align*}
\]

The adjustment for stock appreciation is endogenised in identity 421.

\[
\begin{align*}
\text{YASA} & = \text{DEL[STAT]} \times \text{YMVNL} + \text{YASA} \times \text{YFASA}
\end{align*}
\]

Identifications 422-426 define, respectively, private income (YP), personal income (YPER), and personal disposable income (YPERD).

\[
\begin{align*}
\text{YP} & = \text{HDPFCV} \times \text{CTI+GTNDI+GYTER+BYPTRNE} \\
\text{YPER} & = \text{YYP} \times \text{YC} \\
\text{YPERD} & = \text{YPER} + \text{GYTER+GTYSL+GYPA+GTYMVNP+GTYDINT}
\end{align*}
\]

Identifications 425-426 define the savings ratio (SAVVAT), and real personal disposable income (YPERD).

\[
\begin{align*}
\text{SAVVAT} & = 100 \times \text{CV+YPERD} \\
\text{YPERD} & = \text{YPERD} \times \text{YFPERD}
\end{align*}
\]

Identifications 427-429 define total profits (YCL), real profits (YCR) and undistributed profits (YCU).

\[
\begin{align*}
\text{YC} & = \text{HDPFCV} \times \text{YVHA+YVAR+YAPS} \\
\text{YCR} & = \text{YC} \times \text{YFIT} \\
\text{YCU} & = \text{A561} + \text{A562} \times \text{YCR} + \text{YFUCU}
\end{align*}
\]

\[
\begin{align*}
\text{YCU} &= \text{A561} + \text{A562} \times \text{YCR} + \text{YFUCU}
\end{align*}
\]

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 (AATI).

\[
\begin{align*}
\text{YPF} & = \text{IF YPER LE 1961 THEN YVHA-(1)-YPO(1)-GTYSE(1) ELSE IF YPER LE 1975 THEN YVHA-YVDA+YVPA-(1)-YPO(1)-GTYSE ELSE YVHA-YPO(1)-GTYSE} \\
\text{AATI} & = \text{YPF} \times \text{YIMA}
\end{align*}
\]

Identifications 432-433 define two subcategories of income: non-agricultural wage income (YVHA) and 'other' private income (YPO).

\[
\begin{align*}
\text{YVHA} & = \text{YK} \times \text{YWDO+YVPA} \\
\text{YPO} & = \text{YC-YUC+GTNDI+GYTER} \times \text{YFPM+YAPS}
\end{align*}
\]

(16) : Sectoral Flow-of-Funds

In identities 434-443 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 FFAGQ defines the net acquisitions of funds by the company sector.

\[
\begin{align*}
\text{FFSC} & = \text{SAV+DESI+0.55+DESP+XYK+XKRE} \\
\text{FFUC} & = \text{IIY+18NY+XYMVNL+XTVUD} \\
\text{FFAGQ} & = \text{FFSC-FFUC}
\end{align*}
\]

Sources (FFSM) and uses (FFUR) of funds by the household sector are defined in equations 437-438, and FFAGQ defines the net acquisitions of funds by the household sector.
(17) : Exchange Rates, Interest Rates and Monetary Developments

Three types of exchange rate are used in the model: the number of SUS per EIR (FXA); the number of a weighted basket of other world currencies per SUS, and a weighted average of the number of SUS, sterling, DM and Yen per EIR, where the weights reflect the currency composition of the Irish foreign debt.

$$\text{FXA} = \text{IF E19 EQ 1 THEN FMAH ELSE FMAH}$$
$$\text{FMAH} = \text{IF E19 EQ 1 THEN FMAH ELSE FMAH}$$
$$\text{FMAH} = \text{IF E19 EQ 1 THEN FMAH ELSE FMAH}$$

Equations 466-469 define the 'effective' exchange rate (i.e. number of units of a weighted average of world currencies per EIR (FXEAPP)), the rate of change of FXEAPP (FAEAPPDT), the rate of change of FMAH (FMAHDT) and the rate of change of FMAH (FMAHDT).

$$\text{FMAH} = \text{IF E19 EQ 1 THEN FMAH ELSE FMAH}$$
$$\text{FAEAPPDT} = \text{DEL} (\text{FAEAPP}/\text{FMAH})$$
$$\text{FMAHDT} = \text{DEL} (\text{FAEAPP}/\text{FMAH})$$

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 'real' interest rate.

$$\text{RF} = \text{IF E1 EQ 1 THEN RFE ELSE RF (IF E1 EQ 2 THEN RFE+FAEAPPDT ELSE RNP+RNP)}$$
$$\text{RNP} = \text{IF E1 EQ 1 THEN RNP ELSE RF (IF E1 EQ 2 THEN RNP+FAEAPPDT ELSE RNP+RNP)}$$
$$\text{RNP} = \text{IF E1 EQ 1 THEN RNP ELSE RF (IF E1 EQ 2 THEN RNP+FAEAPPDT ELSE RNP+RNP)}$$

Equations 457-463 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 (OCTAPP) and current transfers from abroad (OCTAPP).

$$\text{DC} = \text{IF E14 EQ 1 THEN DC ELSE RF (IF E14 EQ 2 THEN DC*(GDPV/USDV*10^-1)+DC-1 ELSE DC*(GDPV/USDV*10^-1)+DC)}$$
$$\text{NFLB} = \text{IF E14 EQ 1 THEN NFLB ELSE RF (IF E14 EQ 2 THEN NFLB*(GDPV/USDV*10^-1)+NFLB-1 ELSE NFLB*(GDPV/USDV*10^-1)+NFLB)}$$
$$\text{ONLB} = \text{IF E14 EQ 1 THEN ONLB ELSE RF (IF E14 EQ 2 THEN ONLB*(GDPV/USDV*10^-1)+ONLB-1 ELSE ONLB*(GDPV/USDV*10^-1)+ONLB)}$$

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.

$$\text{LOG(MON/PDPM) = A571+M572+LOG(GDPV)+A573+LOG(PDPM/PDPM*10^-1)+RNP579+R57-1+LOG(PMON)}$$

<table>
<thead>
<tr>
<th>COEF</th>
<th>KESTIMATE</th>
<th>SERR</th>
<th>TSTAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>A571</td>
<td>1.77642</td>
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<td>1.35961</td>
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<tr>
<td>A572</td>
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<td>A573</td>
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<td>NFLB</td>
<td>0.509214</td>
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<td>3.01286</td>
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</tbody>
</table>

Identifies 465-466 define the official external reserves (R) and reserves as a percentage of the value of total imports (RR).

$$\text{DEL(R)} = \text{DEL(MON)+DEL(ONLB)-DEL(DC)}$$
$$\text{RR} = \text{100+%R(MOEV)}$$

BPTEMP is the public authorities net capital receipts from abroad and BPPK, the net capital inflow of the non-banking private sector, is defined residually.

$$\text{BPTEMP} = \text{IF E22 EQ 1 THEN BPTEMP ELSE RF (IF E22 EQ 2 THEN PDPM/PDPM*10^-1)+BPTEMP-1 ELSE PDPM/PDPM+BPTEMP}$$

$$\text{BPPK} = \text{DEL(R)-BP-DEL(NFL)+BPTEMP-OFR}$$

Finally, the adjustment for financial services (FAPS) is a simple function of GDP at factor cost.
\[
\log(YATS) = \alpha_{A1} + \alpha_{A2} \cdot \log(GDPFCV) + \phi_{HO1} + \phi_{HO2} + \phi_{HO3} \cdot \log(PYATS)
\]

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coef</th>
<th>Estimate</th>
<th>StdErr</th>
<th>Tstat</th>
</tr>
</thead>
<tbody>
<tr>
<td>\alpha_{A1}</td>
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<td>0.053819</td>
<td>-8.4129</td>
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<td>\alpha_{A2}</td>
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<td>0.072986</td>
<td>0.082195</td>
<td>3.48195</td>
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</table>

**Note:**
- Coef: Coefficient
- Estimate: Estimated value
- StdErr: Standard error
- Tstat: t-statistic