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THE CONSTRUCTION, CALIBRATION AND INTERPRETATION OF IMA*GE*, A CGE MODEL OF THE IRISH ECONOMY WITH PARTICULAR FOCUS ON AGRICULTURE

by

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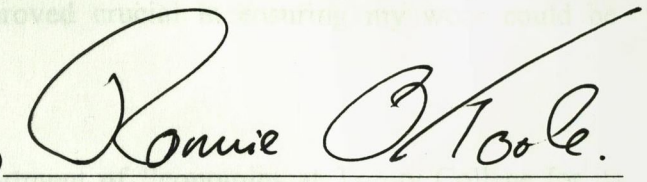
Submitted for Doctor of Philosophy in Economics

The University of Dublin, Trinity College, Dublin, Ireland

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RONNIE O'TOOLE

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The model is based on the ORANI model developed by the Centre of Policy Studies in Australia. Through an active program of software development, modelling courses, detailed documentation of methods, and provision of a generic model to be adopted for other countries, the centre has tried to encourage the development of CGE modelling throughout the world. It is hoped that this thesis reflects in some small way the good habits passed on by the Australian team.

Special thanks must be given to my family for their unwavering encouragement and moral support throughout this thesis. Given that the size of my extended family has grown so substantially since I began the thesis (and is set to grow even further!), I cannot name everybody here, but I would like to acknowledge the incredible support given to me by my parents Ronnie and Attracta.

Schließlich möchte ich meiner Frau und besten Freundin Constanze danken, daß sie den langen Weg mit mir gegangen ist.

Ronnie O'Toole
October, 2001

For Linda

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Summary

This thesis details the construction, calibration and interpretation of IMA*GE*, a CGE model of the Irish economy. The name IMA*GE* is an acronym of "Irish Model of Agriculture, General Equilibrium". This name captures the two key elements of the model, firstly that it is specifically designed to capture the key mechanisms that drive the Irish agricultural sector, and secondly that this is achieved in a general equilibrium framework.

The structure of this thesis is as follows. Chapter 2 and Chapter 3 begin by documenting the construction of the base 1993 version of the model. The former discusses the form of the model code, the technology assumptions, i.e. functional forms, underlying the model and the method used for solving the model. Chapter 3 explains the data requirements for CGE models of the type employed, and explains the process used to reconcile the (at times conflicting) data from the various input-output sources. The chapter continues by explaining in some detail the methods used to extend the existing data set so as to arrive at a detailed breakdown by occupation type, by household type and by land type. A separate section is devoted to issues behind the allocation of subsidies to ensure an adequate modelling of the Common Agricultural Policy. Finally, the choice of model parameters is explained.

Chapter 4 has three principal purposes. The aim of the first section is to employ the model as developed over the previous two chapters to estimate the economy wide impact of the MacSharry reforms of the Common Agriculture Policy on the wider Irish economy. This is done in some detail in an attempt to assess model validity. This exercise raises a number of difficult issues, particularly the need to develop model closures to simulate the relatively intricate workings of the Common Agricultural Policy. Chapter 4 also shows that taking into account general equilibrium effects can have a very large bearing on simulation results. Calculating the own output effect of a 1% increase in the price of cattle, we find that the general equilibrium simulation result is a decrease in cattle output of –0.54%, while the partial equilibrium simulation result is around 20% larger in magnitude at –0.65%.

This result is achieved despite defining partial equilibrium analysis in a broader way than conventionally. Finally, chapter 4 conducts a sensitivity analysis on the simulation results run to measure the impact of the 2001 Foot and Mouth disease outbreak on the Irish economy. This is to ascertain the sensitivity of the results to the values of particular key parameters.

A central criticism of CGE models is that they are outdated in the sense that the input-output tables which underlie them are usually published around 4-5 years after the year in question. This can lead to questions as to the relevance of policy proscriptions derived from the model. This argument might be particularly valid in the case of Ireland from 1993 – 1998 (the period for which the update is conducted) due to the very substantial economic growth that took place during that time. A number of updating techniques have been developed to overcome this problem. Chapter 5 is divided up into a brief discussion of directed and non-directed methods. In section 5.4 we introduce the ESA95 methodology that will form the basis for the compulsory production of annual input-output tables in Europe and compare it with the method employed in this thesis. The evidence seems to be that traditional demand driven or supply driven models (i.e. directed methods) prove to be poor estimators of future input-output tables. Methodologies that do not assume the stability of one or other of the coefficient sets (i.e. non-directed methods) have also proved to be of little benefit.

Chapter 6 had two primary aims, the first of which is to update the 1993 database from 1993 to 1998, while the second is to interpret the changes in the technology and taste variables to try and provide a breakdown explaining the nature of Ireland's economic experience over the five-year period under examination.

The former is done via a so-called historical simulation. The principal difficulty in relation to the historical simulation was in choosing which data to impose, and at what level of disaggregation the data was to be used. Frequently two pieces of data proved to be inconsistent, either causing the model not to solve at all or for it to diverge rapidly. These are not necessarily large 'problems' in an economic sense, but push the model into solutions which are not compatible with our underlying

assumptions. For example, we might find have a labour growth and wage growth assumption, which when added to separate value added assumptions might imply a negative flow to capital for a particular industry. If we assume initially that we are at equilibrium, then this negative flow is difficult to sustain. Therefore, if we are to assume a positive flow to capital, clearly the value-added flow and the wage growth assumptions are inconsistent.

The interpretation of the technology and taste variables is done via the decomposition simulation. While this method has proved popular in Australia where it was originally developed, the feasibility of the methodology to explain the type of growth experienced by Ireland over the period from 1993 to 1998 is thrown into doubt by the results presented here. In particular, the performance of the Irish economy over the period in question was dominated by the impact of an increase in FDI that impacted primarily on two industries, namely machinery and chemicals. Had this resulted in a large increase in demand for intermediate products, the CGE/IO framework might prove more enlightening. However these two industries are highly vertically integrated, and source the main bulk of their inputs from overseas, usually from other branches of the same multi-national. Therefore very little of the story of the success of the Irish economy can be illustrated through the methodology employed in this chapter – of far greater importance are issues such as technology transfer, learning by doing, monetary policy, fiscal policy, corporation tax, the advent of the Euro etc.

Finally, the purpose of chapter 7 is to forecast the economy for each year from 1999 – 2005 so as to create a baseline for each year against which the reforms set out in the Agenda 2000 reform proposals could be analysed. The updating procedure here involved a less sophisticated approach than that used in chapter 6. As with the historical simulations, we construct the baseline scenario by exogenising many typically endogenous macro variables, and allowing typically exogenous technology variables to vary endogenously to ensure these targets are met. Also, many typically exogenous variables that are readily observable are also shocked, for example, aggregate labour supply. The chapter proceeds to implement the Agenda 2000 shocks in each year. The effects on the gross output of farms (excluding dairy and

cattle output) suggest that the reforms gave these enterprises a significant boost, with gross output increasing by almost 2% in 2002. The effects on the gross output of manufacturing and services are largely neutral – this is not because general equilibrium effects 'don't matter', but rather that the effects largely offset each other in this particular set of simulations.

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CHAPTER 1

INTRODUCTION

This thesis details the construction, calibration and interpretation of IMA*GE*, a CGE model of the Irish economy. The name IMA*GE* is an acronym of "Irish Model of Agriculture, General Equilibrium". This name captures the two key elements of the model, firstly that it is specifically designed to capture the key mechanisms that drive the Irish agricultural sector, and secondly that this is achieved in a general equilibrium framework. We will now briefly justify the use of a general equilibrium framework to model the Irish agricultural industry.

Traditionally, economics is taught based on the assumption of ceteris paribus – in other words, partial equilibrium. A student's first exposure to economics consists of crossing supply and demand curves. Where the two intersect, supply equals demand, and the market price of the good is hence determined. A list of factors that could shift the supply and demand curves is appended to the analysis. While mention will be made of the likely sign of each shift, no attempt will be made to estimate which of the shifts will dominate, and how important the 'net shift' is likely to be.

Clearly, therefore, the usefulness of general equilibrium analysis depends on the importance of the shifts in the supply and demand curves relative to the movements along them. When measuring the impact of a 10% increase in the price of salt, movements along the supply and demand curves are likely to dominate, while if we are measuring the impact of a 10% increase in the price of labour, shifts in all commodity and factor markets are likely to be significant. Quite apart from an issue such as this, the economy wide impact of a change in a particular sector of the economy is also of considerable interest. This is particularly relevant in an area such as agriculture whereby lobbyists frequently cite economy-wide benefits felt in sectors other than the wider food complex as a rationale for continued support.

Agriculture in Ireland is clearly of a sufficient size to justify the employment of a general equilibrium framework. While the boom in the Irish economy in the past decade has accelerated an already steady diminution in the importance of agriculture in the Irish economic landscape, it remains one of Ireland's largest industries. The latest data for Gross Agricultural Product indicates that agriculture on its own contributed 3.5% to GDP at factor cost in 2000, down from 17.3% a quarter of a century ago, a process which has continued despite continued subsidies under the EU's Common Agricultural Policy. The fact that the rationale behind much of European agricultural support rests on support of the wider rural complex, a chief motivation of the IMAGE model is to measure the impact of proposed reforms of agricultural policy on upstream and downstream industries linked to agriculture and on agricultural factor incomes, as well as the impact on the wider economy.

The CAP evolved from the separate policies of the various member states with the aim of achieving the four following objectives:

- Increased productivity
- A fair standard of living for farmers
- Stable markets
- Regular food supplies
- Reasonable prices for consumers

It was based on three principles:

- A single market in farm products with common prices and free movement of agricultural goods within the community
- Preference for community members
- Shared costs

However the inflationary background of the 1970s and early 1990s induced sharp price increases for agricultural products, resulting in a growing problem of overproduction in Europe. Technological advances on the farm exacerbated this problem though consumption grew much more slowly. Before long, market balance had to be attained through costly intervention and export refunds, which put a major strain on the EU budget. In 1988 an agricultural guideline that limited growth of agricultural expenditure to a maximum level, backed up be market stabilisers, were introduced. Traditionally, all producers, regardless of size or volume of output, have benefited substantially from high levels of internal prices. In 1992, the MacSharry reforms broke the link between price support and production, levels of support were reduced and compensation was paid to farmers on a per hectare or per animal basis. Extensification and the use of production processes that protect the environment were also encouraged under the agri-environmental accompanying measure. This process was deepened in the Agenda 2000 reforms at the end of the decade.

As agriculture's importance has diminished, so have many of the traditional arguments in favour of its support. Matthews (2000) makes four arguments against the status quo.

- Firstly, when measured at world prices rather than artificially inflated EU prices, farming makes a negligible contribution to Irish GNP.
- Secondly, farm household incomes are at least as high as non-farm incomes largely due to off-farm opportunities.
- Thirdly, much of the cost of support falls on the Irish taxpayer and consumer, not on the EU.
- The current transfer system is very inefficient, with a great loss between cost to the consumer/taxpayer and benefit to the farmer.

Despite this, a political consensus behind the retention and protection of the Common Agricultural Policy has survived, protected by popular misconceptions regarding the current state of farming and its role in the economy. The nature of the CAP has changed. The broad thrust of reform initiatives begun by Ray MacSharry in

1992 of moving away from price support in favour of direct 'cheque in the post' support have been extended in the Agenda 2000 reforms. As such, concerns in relation to the manner in which food is produced and its impact on the rural environment are receiving greater weight.

The primary aim of the thesis is the construction of a CGE model for Ireland, and the development and application of techniques to update the model to ensure the relevance of solutions. The model is then applied to estimate the economy wide impact of the MacSharry and Agenda 2000 reforms of the Common Agricultural Policy. The model being presented is to our knowledge the third major effort towards the development of a CGE model for Ireland. The first was by Denny, Hannon and O'Rourke described in Denny et al (1994a, 1994b, 1995a, 1995b), which focussed on fiscal issues. The second was by Moloney (1997) and concentrated on migration flows. The IMA*GE* model distinguishes 34 industries, the first eight of which relate to farm level production, plus a separate industry for each of forestry and fishing and 34 corresponding commodities. There are two sources of commodities, namely domestic and overseas, while for some relevant agricultural export commodities three export markets (namely the UK, Continental Europe and Rest of the World) are distinguished. There are ten occupational groups and three household types, namely urban, rural farm, and rural non-farm. Margin commodities that are complements in production, such as transport or trade margins, are treated separately from the main industry structure, while great care is taken in ensuring an inter-industry modelling of the investment flows required to construct capital units. As such, the IMA*GE* model is by far the most detailed and complex CGE model of Ireland to date.

The structure of this thesis very much reflects the cumulative nature of the process of constructing a CGE model. The chapters are in general not self-contained. For example, a full understanding of the simulation results requires knowledge of the functional forms that produce them. In turn, the output of these functional forms depends on the data assumptions involved in their calibration. Both the nature of the functional forms, the process of calibration and the choice of updating method will

impact significantly on the values derived for the updated (SAM) Social Accounting Matrix. Readers wishing to avoid much of the detail involved in constructing and updating the model are advised to read chapter 5 and chapter 7.

Chapter 2 and Chapter 3 deal with the construction of the base 1993 version of the model. The former details the form of the model, the structures which underlie it and the solution methods employed in solving the model once shocked. The latter, chapter 3, deals with the collection of the data required to calibrate the model. In effect, virtually all CGE models assume that the base year economy is in equilibrium, so the process of calibration of the functional forms such as CES and Leontief is simply a process of applying budget shares and externally imposed elasticity parameters. The outcome of the calibration process is a CGE model for the base year which represents the starting equilibrium point.

Chapter 4 has three aims. The first is an application of the 1993 version of the model to estimate the impact of the MacSharry reforms of the Common Agricultural Policy on the Irish economy. This is a complex procedure, as recognition must be made of the fact that, in reality, there are numerous shocks to the exogenous variables. For example, to measure changes in the production of cereals due to the MacSharry reforms requires an imposition of a technology change due to set-aside, a change in import prices, a change in export prices and a change in direct subsidies. The second aim of the chapter is to measure the importance of general equilibrium effects missed by partial equilibrium models. We do this by computing a full general equilibrium solution and then, using the Leontief and Ghoshian inverses, deconstruct this result into that part which could be explained in a partial equilibrium context and that part which could only be explained with a general equilibrium model. The final aim of this chapter is to conduct a sensitivity analysis of the results of a key policy simulation in order to find if the results of the simulation are very sensitive to the parameters and closures chosen. In particular, we examine the sensitivity of the simulation results to changes in the macro closure, factor market closures, primary factor elasticities and Armington parameters.

Given the immense complexity involved in any attempt to update a Social Accounting Matrix and the fact that no existing method has proved to be substantially more successful in prediction than relatively naïve approaches, the Input-Output community has spawned a multitude of potential approaches. In Chapter 5 we survey the principal methods employed and compare the newly declared European standard for the estimation of updated input-output models for those years that a full input-output construction exercise is not conducted with the approach used in Chapter 6 of this thesis.

Chapter 6 proceeds by updating the base 1993 model to 1998. This updating process is greatly complicated by the fact that data from different sources is frequently contradictory, so much of the effort required is in ensuring that exogenous targets of 'observables' can be met without requiring the underlying technological structure of the economy to shift violently, which often occurs when the model is forced to reconcile inconsistent data. The final version of the updating procedure reveals technological and taste variables derived as a consequence of matching the imposed observed data and the functional forms underlying the model.

Chapter 7 has two functions. Firstly, the 1998 model derived in chapter 6 is used to forecast to 2005, providing a set of consistent input output tables for each of the intervening years. This process of forecasting – as opposed to updating – is much more simple due to the fact that less is known about the future than the past. Much of the work in updating is spent reconciling seemingly inconsistent data and imposing data at a very disaggregated level. Secondly, the model uses these updated tables to estimate the economy wide impact of the Agenda 2000 reforms of the Common Agricultural Policy.

The final chapter, Chapter 8, summarises the main findings of the thesis and discusses issues for further research arising from it.

CHAPTER 2

MODEL CODE, STRUCTURE AND SOLUTION METHODS

2.1 Introduction

This thesis details the construction, calibration and interpretation of IMA*GE*, which is an acronym of "Irish Model of Agriculture, General Equilibrium". The IMAGE model is based on the widely known ORANI model (Dixon et al. 1980) of the Australian economy developed as part of the IMPACT project and which has been used extensively for policy analysis in Australia for nearly two decades. Adaptations of ORANI already exist for several countries, including Thailand, South Africa, Pakistan, Brazil, the Philippines, Japan, Indonesia, Venezuela, Taiwan and Denmark. The model also owes much to the MONASH model of Australia by Dixon and Rimmer (2000), the dynamic successor to ORANI.

However the underlying model code differs from the ORANI-G model in a number of respects. Firstly, the IMA*GE* model includes a factor of production land, which is in itself composed of three different soil types reflecting the range of uses that the land could be put to. Secondly, the model extends the single household to three distinct household groups, namely urban households, rural non-farm households and rural farm households. The IMA*GE* model also incorporates a detailed treatment of subsidies, with an allowance for subsidies to the factors of production and exports, both of which are crucial for an adequate modeling of the mechanisms underlying the CAP.

The model has a theoretical structure that is typical of many AGE (applied general equilibrium) models. It is a static model, as it does not have any mechanism for the accumulation of capital. It is based entirely on the assumption of perfect competition, with no individual buyer or seller being able to influence price. Given that the primary area of interest is agriculture, which is characterised by a large

number of producers of a homogenous product, non of whom can affect price by their actions, the use of perfect competition is appropriate, though for other economy wide knock-on effects perfect competition is not as defendable. Demand and supply equations are derived from the solution of optimisation problems (e.g. profit or utility maximization) for private sector agents. The model allows for multiple household types, export destinations, land types and labour occupations. It also incorporates an explicit treatment of government revenue and expenditure. The core model consists of equations describing:

- Producers' demands for produced inputs and primary factors;
- Producers' supplies of commodities;
- Demands for inputs to capital formation;
- Household demands;
- Export demands;
- Government demands;
- The relationship of basic values to production costs and to purchasers' prices;
- Market-clearing conditions for commodities and primary factors;
- Macroeconomic variables and price indices;

The discussion in this chapter is developed on the basis of a chronological sequence of how a model might be constructed. An explanation as to how the model is implemented in the TABLO code is presented in Section 2.2. The functional forms, output linkages and price linkages underlying the model are discussed in section 2.3. The next step is to determine a closure for the model, and this is discussed in section 2.4. Section 2.5 discusses the approach used to solve the model, while section 2.6 concludes. The full TABLO code is shown in Appendix 1, and frequent reference is made to it throughout the chapter.

2.2 The Equation System

The model is implemented using the GEMPACK software (Harrison and Pearson, 1998). The equations file in GEMPACK is a so-called TABLO file which at first glance might seem quite complex, though this not the case, as the actual 'language'

is conventional algebra. Any difficulty lies in the (necessary) inclusion of a large number of coefficients, variables, formulae and equations to adequately model a complex economic structure.

2.2.1 The TABLO Language

Care must be taken in interpreting the wording of TABLO, in that particular words have slightly more specific usage than in every day language. We will now briefly describe the important elements of the TABLO syntax.

Set

A collection of economic objects – e.g. commodities, industries, household types. In the line below we define a SET *commodities* to be called *COM*, specify that they are to be named C1, C2, C3, ... , C34, and (as a useful comment) showed at the end of the line that the subscript *c* will be reserved for this set.

```
Set   COM          # Commodities #              (C1 - C34);          ! c !
```

All sets bar two are defined at the beginning of the program. The exceptions are only used in one short part of the program, so they are defined later on when they are needed rather than over-cluttering the opening section.

It is also possible that a SET is to be partitioned for some reason through the definition of (say) two new sets. To ensure that the program recognises that applying these two new SETs is equivalent to applying the original SET, we specify that they are subsets. For example in the model the SET of industries is subdivided into agriculture and non-agriculture so as to calculate results such as Gross Agricultural Output. To ensure that the program recognises where these new SETs originate, we include the *"is subset of"* statement as below.

```
AGIND       is subset of IND;
NONAGIND    is subset of IND;
```

Variable

A variable in the mathematical sense is called one of two names in the ORANI coding convention, namely a COEFFICIENT (which is discussed below) or a VARIABLE. The word VARIABLE is retained for an economic variable that occurs in one or more equations. While typically a VARIABLE will be represented as a percentage-change, this can be altered. This is most often done when the denominator in the calculation of a percentage-change variable could realistically take the value of zero. For example, if the Balance of Trade happened by chance to be zero, then any percentage-change in this variable would be indeterminate, though an ordinary (Irish £) change would be perfectly admissible. Below we define the variable *x1(c,s,i)*, the percentage change in demands for intermediate commodities at basic prices.

```
Variable
(All,c,COM)(All,s,SRC)(All,i,IND) x1(c,s,i) # Intermediate demand for commodities #
```

Coefficient

This is the current value of a levels variable. It can appear as the coefficient of a variable in an equation, a value of base data as read in from a data file, or some value derived from base data. The example below represents the second case whereby V1BAS, the flows of intermediate inputs at basic prices, is defined. COEFFICIENTs can either be parameter (constant throughout a simulation) or non-parameter (which is the default setting). There is no programming reason as such as to why a COEFFICIENT command is required. It is included in the code more as a presentational device to ease interpretation.

```
Coefficient  ! Basic Flows of Commodities!
(All,c,COM)(All,s,SRC)(All,i,IND)  V1BAS(c,s,i)
#Intermediate#;
```

Formula

The word FORMULA is reserved for those operations that involve the manipulation of a coefficient. To ease legibility, a FORMULA that calculates a coefficient

frequently appears directly after the definition of the coefficient. In the case shown below, aggregate household consumption of each commodity by source is first of all 'introduced' by means of a COEFFICIENT statement, and then calculated by means of a FORMULA. If the qualifier 'initial' is used, then the FORMULA is only calculated during the first step of a multi-step simulation.

```
Coefficient
(All,c,COM)(All,s,SRC) V3BAS_H(c,s)# Households:Agg #;
Formula
(All,c,COM)(All,s,SRC) V3BAS_H(c,s) = Sum(h,HOU, V3BAS(c,s,h));
```

Update

An algebraic specification of how a given coefficient is to be updated after each step of a multi-step simulation. The example below shows a nice illustration of COEFFICIENT, FORMULA and UPDATE. First, the domestic base price is defined for each good, which is initially set at 1 by use of a formula. Note that FORMULA is qualified by 'initial', otherwise the program would reset prices at 1 at the beginning of every step of the calculation. Finally, to specify how the domestic price is to change, we include an UPDATE statement.

Note the unusual syntax of the UPDATE statement. On the left hand side we have *P0DOM*, a levels coefficient, while on the right hand side we have *p0*, a percentage-change variable. Therefore the rule for update statements is to read the '=' as a 'by increasing it by'. So in the example below, it should be read as 'Update the levels coefficient *P0DOM* by increasing it by *p0*'.

```
Coefficient (All,c,COM) P0DOM(c) # levels domestic basic prices #;
Formula (Initial) (All,c,COM) P0DOM(c) = 1; !arbitrary initial
setting!

Update (All,c,COM) P0DOM(c) = p0(c,"dom");
```

Equation

An algebraic specification of economic behaviour using both coefficients and variables. Note the name of the equation *E_x1lab*, given the purpose of the equation is to calculate *x1lab*. The use of this naming convention is actually used later on in TABmate to allow the program to 'suggest' a possible closure of the model. It does this by assuming that any VARIABLE that has an EQUATION named after it will be assumed endogenous.

```
Equation E_x1lab  # Demand for labour by industry and skill group #
(All,i,IND)(All,o,OCC)
x1lab(i,o) = x1lab_o(i) - SIGMA1LAB(i)*[p1lab(i,o) - p1lab_o(i)];
```

File, Read, Write & Display

The TABLO file contains the model relationships and interconnections, but must draw on external files to get much of the raw data, and ensure that all of this data is given an appropriate name within the model. FILE is the command used for naming files that contain data that will be used by the program. Below, the principle data set (named MDATA) is specified.

```
File MDATA # Data File #;
```

This file contains numerous vectors and matrices representing the different requirements of the model. For example, the vector with header (name) of 1ARM is the vector of Armington elasticities used in the bottom 'source' nest for intermediate production. Below the READ command specifies that the header "1BAS" will be known as the coefficient V1BAS in the model equations and formulae.

```
Read
 V1BAS From File MDATA Header "1BAS";
```

Finally, the WRITE command sends coefficient data to a specified data file, and has an identical syntax as shown for the READ command above.

2.2.2 Variables, Coefficients and Parameters of the model

While an effort has been made in constructing variable names to keep as close to the original ORANI naming scheme as possible, the fact that the listed equations include both levels and change variables results in a need to broaden the classification.

The adopted nomenclature will help the reader in understanding many of the equations. As far as possible, names for variables and coefficients conform to a system in which each name consists of 2 or more parts, as follows:

First, a letter indicating the type of variable:

a	technical change
Δ	ordinary (rather than percentage) change
f	shift variable
H	Indexing Parameter
p	price (IR£)
p$	price (foreign currency)
S	input Share
σ	elasticity of substitution
t	tax
V	Levels Value, IR£
w	% change value, IR£
x	input quantity

Secondly, one of the digits 0 to 6 indicating user:

1	current production
2	investment
3	consumption
4	export
5	government
6	inventories

0	all users, where user distinction is irrelevant

Thirdly, a variable might also have three or more letters if needed:

Bas	At basic prices
Cap	capital
Cif	imports (boarder prices)
Imp	imports (duty paid)
Lab	labour
Lnd	Land
Lux	Supernumerary part of consumption in LES
Prim	all primary factors
Pur	At Purchasers' prices
Sub	Subsistence part of consumption in LES
Tar	Tariffs
Tax	indirect taxes
Tot	total or average over all inputs for some user

Finally, some variables will have an underscore (such as with VARIABLE_i) indicating in this case that VARIABLE has been summed over the set of industries.

2.2.3 Coding Conventions

Before explaining the various 'functions' contained in TABLO, it might be useful to specify some house keeping rules, which will be obeyed when constructing the model.

Firstly, all names must be unique. For example, no two variables can be given the same name, and no equation can be given the same name as (say) a variable. TABLO does not differentiate between upper and lower case, so the variable *X_S(i)* and *x_s(i)* are indistinguishable as far as the program is concerned. By convention, variables are written in upper case when they are in levels and in lower-case when in

percentage-change form, with the distinction being made solely to ease interpretation.

For example, in Excerpt 21 (partially reproduced below), the variable *x3* appears in the TABLO file, which represents the rate of change of demand by each household type for each commodity by source. In reproducing the levels equation, *X3* is used to denote the level of demand by each household type for each commodity by source.

This results in commodity demands of:

$$X3(c,s,h) = A3(c,s) * X3_S(c,h) * \left(A3(c,s) * \frac{P3(c,s)}{P3_S(c)} \right)^{\sigma_3(c)} \qquad (1)$$

which are written in TABLO form as:

```
! Excerpt 21 - 23 of TABLO input file: !
Coefficient (all,c,COM) SIGMA3(c) # Armington elasticities:
households #;
Read SIGMA3 from file H2DATA header "3ARM";

Equation E_x3  # Source-specific commodity demands #
(all,c,COM)(all,s,SRC)(all,h,HOU)
x3(c,s,h)-a3(c,s,h) = x3_s(c,h) - SIGMA3(c)*[
p3(c,s,h)+a3(c,s,h) - p3_s(c,h)];

Equation E_p3_s  # Effective price of commodity composite #
(all,c,COM)(all,h,HOU) p3_s(c,h) = sum{s,SRC,
S3(c,s,h)*[p3(c,s,h)+a3(c,s,h)]};
```

Secondly, as the TABLO file is quite long, we will retain the ORANI convention of breaking the code into numerous excerpts for ease of reference. Each excerpt is around 20 lines long, and will generally have a fairly well defined purpose.

Thirdly, as with any computer program, it is always useful to include detailed comments to aid the de-bugging process and ensure that others can easily interpret your work. Comments can be included in exclamation marks in TABLO. Alternatively, additional descriptions can be put in hashes. These are very similar to comments, though are taken 'more seriously' by TABLO. For example, if you use hashes to give a longer, more detailed name to a variable, then this longer name will be reproduced in the data files.

```
! A comment which will be completely ignored by the program !
# Usually used to give more information and will travel between various GEMPACK files #
```

2.3 Structure of the Model

2.3.1 Production

The model allows every industry to produce several commodities by using domestic or imported intermediates and a primary factor composite consisting of land, labour and capital. This would suggest a potentially very large and complex system that would be extremely difficult to calibrate. To keep the model to a manageable size, we assume, firstly, that each industry only produces one good and secondly, that input-output separability holds, which means the generalised production function for some industry:

$$H(inputs) = G(outputs) \tag{2}$$

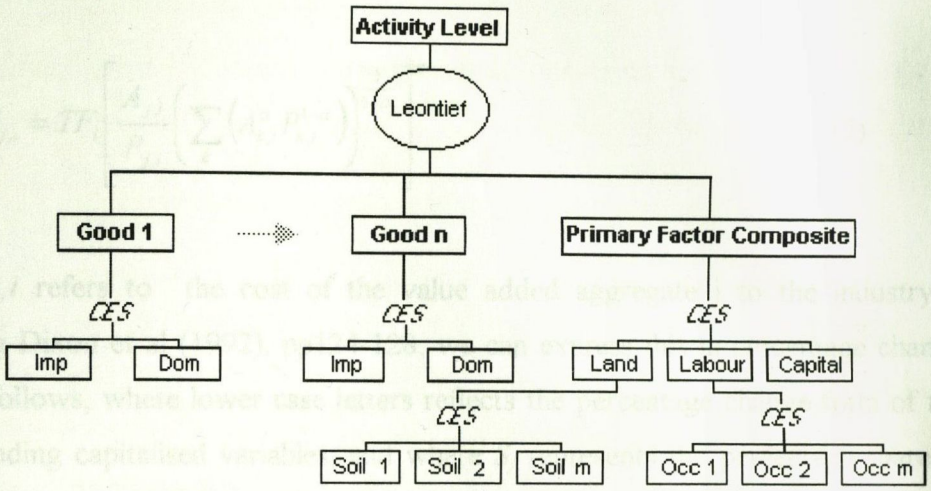
may be written as:

$$H(inputs) = Z = G(outputs) \tag{3}$$

where Z is an index of industry activity. The resulting structure for the H function is represented by Figure 2.1 below.

Figure 2.1

Form of Industrial Production



At the top level of the nest the volume employed of each of the n intermediate inputs and the primary factor composite by each firm is assumed to be in a constant proportion. Further, each of the intermediate goods is the product of a hypothesised 'mixing' industry which combines the (non-homothetic by the Armington assumption) imports and domestic production of good i. Each of these mixing industries are characterised by a CES function. The primary factor composite is formed through a combination of land, labour and capital, with labour and land being formed by a composite of a number of occupations and soil types respectively.

2.3.1.1 Demand for Primary Factors

Demand for Primary Factor Composites

The next level up (as shown in figure 2.1) shows how the three factors of production (land, capital and labour) are combined via a CES aggregation function to form the primary factor composite. Firms minimize costs in forming the aggregate primary factor (TF) for industry i by combining the factors of production land, capital and labour subject to the following CES aggregation function:

$$TF_i = \left[\sum_j A_{j,i} F_{j,i}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \qquad (4)$$

where F_f represents each factor, and σ is the elasticity of substitution. This generates the following factor demand functions:

$$F_{j,i} = TF_i \left[\frac{A_{j,i}}{P_{j,i}} \left(\sum_k \left(A_{k,i}^{\sigma} P_{k,i}^{1-\sigma} \right) \right)^{\frac{1}{1-\sigma}} \right]^{\sigma} \qquad (5)$$

where Pj,i refers to the cost of the value added aggregate j to the industry i. Following Dixon et al (1992), pp124-128, we can express this in percentage change form as follows, where lower case letters reflects the percentage change form of the corresponding capitalised variables, and where S_j represents the percentage share in total payments to value added of the factor j:

$$f_{j,i} = tf_i - \sigma(pf_j - \sum_j S_j pf_j) \qquad (6)$$

Excerpt 16 shows the equivalent percentage-change form as inputted into TABLO using the variable classification underlying the model, which shows that demand for each factor is proportional to overall factor demand and a price term, assuming that the technical change variables are set exogenously at zero. The responsiveness of the factor intensity use in each industry depends on the magnitude of $\sigma_{VA(i)}$ for each industry.

Demand for Labour by Occupation

As can be seen from Figure 2.1, labour employment in an industry is a CES composite of the various occupation types, namely agricultural workers, producers, labourers, transport/communication, clerical, finance, service, professional/technical and others. Labour demand for each occupation and industry group is proportional to the total demand for labour in that industry. Changes in the relative price of the occupations induce substitution in favour of the cheaper occupations, subject to the CES aggregation function. The responsiveness of occupational employment in each

industry depends on the magnitude of $\sigma_{1lab(i)}$ for each industry. Given a particular level of demand for labour, the industry can reorganize the occupational makeup of the labour force depending on the relative price movements for each occupation.

Firms minimize costs in forming the aggregate labour demand (*TL*) for industry *i* by combining the various labour occupations subject to the following CES aggregation function:

$$TL_i = \left[\sum_o AL_{o,i} L_{o,i}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{7}$$

where $L_{o,i}$ represents each factor, and σ is the elasticity of substitution. This generates the following occupational demand functions:

$$L_{o,i} = TL_i \left[\frac{AL_{o,i}}{W_{o,i}} \left(\sum_k \left(AL_{k,i}^{\sigma} W_{k,i}^{1-\sigma} \right) \right)^{\frac{1}{1-\sigma}} \right]^{\sigma} \tag{8}$$

where *Wj,i* refers to the cost of the value added aggregate j to the industry i. Following Dixon et al (1992), pp124-128, we can express this in percentage change form as follows, where lower case letters reflects the percentage change form of the corresponding capitalised variables, and where $WS_{k,i}$ represents the percentage share in total wage payments to occupation *o* in industry i:

$$l_{o,i} = tl_i - \sigma \left(w_{o,i} - \sum_k WS_{k,i} w_{o,i} \right) \tag{9}$$

The second part of Excerpt 15 (page 263) as shown in appendix 1 shows the calculation of the industry *i* labour price index, which as mentioned above is derived from the CES aggregation function. This is calculated in terms of % change, and is a weighted average of the change in the price of each occupation employed in industry

i, weighted by labour flows to each occupation. Take for example the situation whereby the cost of semi-skilled workers increased by 5%, and this occupation accounts for 50% of the wage bill of (say) the construction industry. In this case, the labour price index for the construction industry will rise by 2.5%, assuming that the cost of each of the other occupations remains unchanged.

A similar exercise can be conducted for the demand for land of each soil type each occupation and industry group is proportional to the total demand for land in that industry.

2.3.1.2 Demand for Intermediate Inputs

The level of demand for intermediate products is divided into two levels. The Armington (1969, 1970) assumption that imports are imperfect substitutes for domestic supplies is employed. The interpretation is that (assuming no change in the taste/technology variables) the amount of each commodity demanded by industry *i* from, (say), domestic suppliers, for use in further processing is proportional to the amount of that commodity demanded by industry *i* and a price term.

The combination of the domestic and import variant is done in a hypothetical mixing industry which produces a homogenous product, regardless of the makeup of the inputs. The output of each of the hypothetical mixing industries for each commodity is then combined in Leontief (fixed share) proportions with the primary factor aggregate, in what is the last stage of production. The Leontief production function is equivalent to a CES production function with the elasticity of substitution set at zero. Again, assuming that the taste/technology parameters are set exogenously, this implies that the amount of the primary factor and intermediary demands for each commodity used depends only upon the level of industrial 'activity' in the industry in question, and not on the relative prices of these inputs.

More formally, firms minimize costs in forming the industry output (X) for industry *i* by combining intermediate products and the primary factor composite subject to the following Leontief aggregation function:

$$X_i = \min\left[\sum_j \frac{I_{j,i}}{A_{j,i}} + \frac{TF_i}{AF_i}\right] \tag{10}$$

where $I_{j,i}$ represents each intermediate input, and the variables beginning with A are technology shift variables. This generates the following intermediate demand functions:

$$I_{j,i} = A_{j,i} X_i \tag{11}$$

with a corresponding equation for aggregate demand for the primary factor composite. Following Dixon et al (1992), pp124-128, we can express this in percentage change form as follows, where lower case letters reflect the percentage change form of the corresponding capitalised variables:

$$i_{j,i} = a_{j,i} + x_i \tag{12}$$

The equivalent percentage-change form as inputted into TABLO using the variable classification underlying the model shows two shift variables A1PRIM and A1TOT. A1PRIM is equivalent to AF_i above, while the variable A1TOT is a 'total input' technology shift variable which will shock AF_i and $A_{j,i}$ by an equal amount. Therefore is A1TOT is shocked by 1%, then 1% more of each input will be required to produce the same amount of output.

The final equation in Excerpt 18 (equation *E_p1tot*) incorporates the zero pure profits in production condition. Ignoring the taste/technology variables, it can be seen that the left hand side is the (change) in output price while the right hand side is a weighted average of input prices. Under the assumption of competitive pricing and a constant returns to scale technology, these must be equal. Again note the logic behind the naming of the zero pure profit equation. Finally, the model allows the

facility for one industry to produce a number of commodities, though this is not utilised in the current version of the model.

An important feature of the model, as with many CGE models, is that it incorporates the law-of-one–price within the country. In other words, it is assumed that the price of a commodity differs between any two markets only by the margin costs. So, for example, the price of fruit and vegetables sold from the farm directly to households is the same as the price paid by the food manufacturer for the same price. If a price differential developed, the law of one price assumes that goods-market arbitrage trades the price differential away. The law of one price is a highly contentious assumption. Apart from barriers to trade such as tariffs and transportation costs, other explanations that explain the empirically noted result that the law of one price does not hold are different consumption preferences between users, the advantage of buying in bulk, the advantages of being a regular customer and differing non-tradable elements of goods.

2.3.2 Household Demand

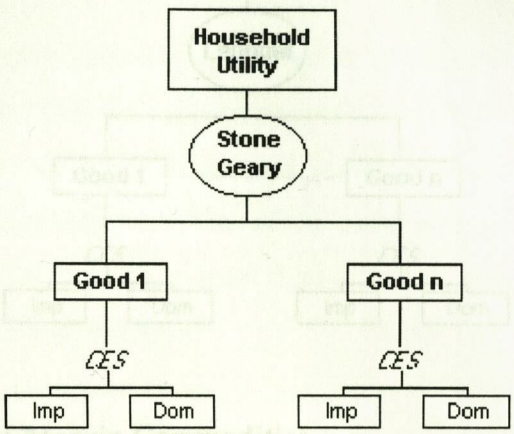
As regards household demand, the first decision is the choice of functional form to be used. Perhaps the most convenient would be demand functions derived by the maximisation of a Cobb-Douglas utility function. This results in demand functions with constant expenditure elasticities, unitary own-price elasticities and zero cross price elasticities. The alternative is to derive demands from a CES (Constant Elasticity of Substitution) utility function, of which the Cobb-Douglas is a special case. The unitary substitution elasticity in the latter can now be replaced by any positive constant.

The third option, which is used, is to base household consumption on a Stone-Geary utility function, which will lead to a so-called LES (linear expenditure system). Household consumption is divided into two components, a minimum or subsistence amount and a luxury or supernumerary amount. This displacement of the origin allows a simple functional form for supernumerary demand, while also ensuring that the empirically observed changes in consumption patterns as income rises are not

violated. Figure 2.2 shows the representation of the nesting structure for household demand.

Figure 2.2

Form of Household Demand



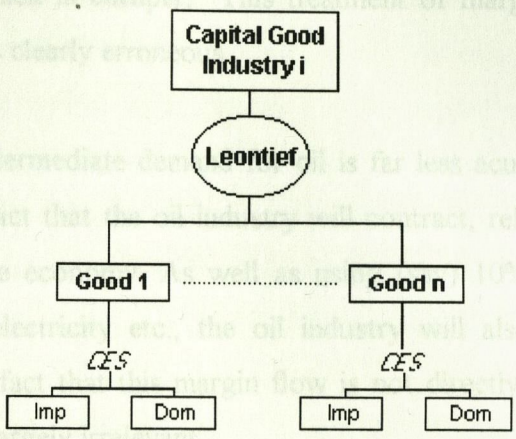
2.3.3 Investment Demand

Figure 2.3 shows the schematic representation of the production structure for units of fixed capital. As can be seen, the structure is very similar to that governing the production of goods, though no primary factors are used directly in the production of fixed capital. The discussion of the investment demand equations follows closely that of the intermediate production. At the bottom level investors choose combinations of the domestic and imported varieties of the product, so as to minimise total costs.

At the top level a Leontief technology is assumed, with each of the goods being used in fixed proportions. The final equation in Excerpt 20 incorporates the condition of zero pure profits in the production of fixed capital. The left hand side is the change in the total amount spent on capital goods, while the right hand side is a weighted average of input costs. Again, assuming competitive pricing and a constant returns to scale technology, these must be equal.

Figure 2.3

Form of Investment Demand



2.3.4 Treatment of Margin Commodities

Excerpt 25 contains all the equations specifying the margin demands[1] of the various categories of user.

One of the main problems with the published CSO input-output tables (and with input-output tables of most countries) as they stand is that margin commodities are treated as any other industry is treated. So, for example, wholesale/ retail margins are used as an intermediate input by other industries and are 'demanded' by consumers directly from the industry, rather than by the industry itself. Ideally we would like to be able to assign a margin flow to every underlying 'real' flow in the economy. To what extent is it a problem that we do not have this data, and to what lengths should we go to alleviate it?

By way of example, consider the impact of a doubling of oil prices due to the imposition of a green tax, the proceeds of which are then used to reduce tax on other consumer goods. Assume that this will reduce the quantity of oil demanded by the consumer by around 30% and that the quantity demanded of all other goods increases

[1] In IMA*GE* Transport and Trade Margins are generally assumed to be the margin commodities.

by around 5%. We will then have a rise in demand for margin commodities of 5%. It should be obvious that this margins figure takes no account of the reduced need for margin commodities because of the fall in use of oil products. In fact, the consumer is to a degree substituting away from using oil in favour of using the product 'transfer of oil', which is cheaper. This treatment of margins as substitutes rather than complements is clearly erroneous.

The problem for intermediate demand for oil is far less acute. If oil prices double, the model will predict that the oil industry will contract, releasing spare capacity to other sectors of the economy. As well as using (say) 10% less capital, 10% less labour, 10% less electricity etc., the oil industry will also use 10% less margin commodities. The fact that this margin flow is not directly linked to an underlying commodity flow is largely irrelevant.

It will only become relevant if, instead of shocking some commodity, or some industry, we change the underlying technology structure somehow. For example, if we wanted to implement a technologically driven decrease of oil use by farmers, then by changing the appropriate input-output coefficient, we have left total margin usage unchanged. So despite a reduction in oil demands in the economy, the exact same amount of resources is needed to transfer this reduced bulk from seller to buyer. Such types of shocks are relatively rare in CGE analyses and do not pose a problem. If a technological shock such as described above is to be implemented, a change in margin use will have to be calculated externally to the model. Therefore, a compromise can be reached. Where substitution possibilities are limited (e.g. Leontief technology), the treatment of margin commodities as a separate industry is adequate. Where substitution possibilities are significant (e.g. LES) this approach is inadequate. There seem to be significant advantages in allocating margin flows to their corresponding final demand flow, but no significant advantage in implementing a similar set of flows for intermediate production. In conclusion, we will ignore margin commodities for intermediate flows and just incorporate them in the inter-industry structure, though we will allocate margin commodities appropriately for final demand flows.

2.3.5 Exports

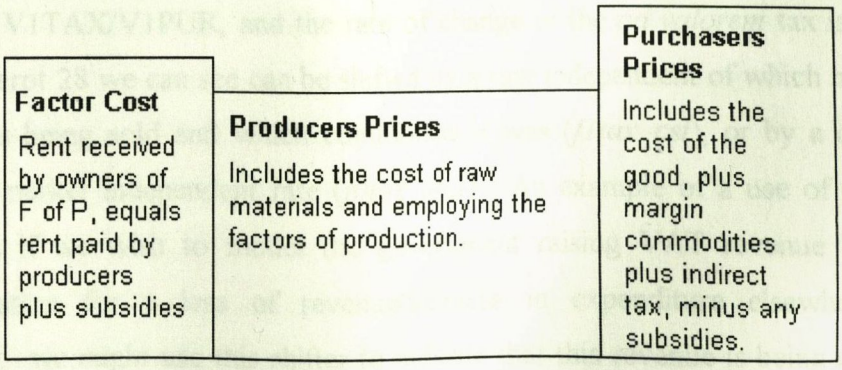
The export demand curve faced by Irish producers is assumed to be very slightly downward sloping. As can be seen below, the aggregate quantity of exports of commodity c (ignoring the quantity demand curve shifter *F4Q(c)* and the price demand curve shifter *F4P(c)*) is proportional to the export price divided by the exchange rate. The typical value chosen for the export elasticity is –20, as it is assumed that Ireland is virtually a price taker in most markets due to our size. However in relation to certain livestock products (namely dairy output and cattle) it is assumed that Ireland has a significant market share, and the export elasticity is set at –5.

2.3.6 The Price System

The price linkage system specifies the bridge between input and output prices, with the latter being formed as a function of the former, the use of margin commodities in getting the goods to market, indirect taxes and subsidies. Given that the model incorporates subsidies to factors of production, the system is somewhat more complex than typical CGE models. Its structure is represented in figure 2.4.

Figure 2.4:

The Price Linkages in the Model



As we can see from figure 2.4, there are three 'levels' of prices. When we talk of basic prices we mean the producers' prices represented by the middle block in figure 2.4. This consists of the cost of raw materials plus the cost of the (subsidised) factors or production. The purchasers' prices are represented in the right hand block, and

consist of the basic cost of the good plus the cost of margin commodities in getting the goods to market plus the cost of indirect taxes minus any subsidies for selling to final demand markets. Finally, the rent received by the owners of factors of production is represented in the left hand block as the amount paid by users of the factors of production plus any subsidies. The price linkages in the commodity markets and factor markets are now dealt with in turn.

2.3.6.1 Zero Pure Profits in the Commodity Markets

This section deals with the relationship between the middle block in figure 2.4 and the right hand block. In effect, each equation says that output price must equal input prices to ensure zero pure profit. Excerpt 26 defines purchasers' prices for each of the five user groups. These are essentially zero-profit equations (as they are actually called for exporting and other) as the price a purchaser pays must equal the various costs associated with taking delivery of the goods. The purchasers price is therefore equal to the basic price plus any sales tax due plus margin costs. Note again the use of the TINY variable to ensure that the right hand side variable is never indeterminate.

The first equation, *E_p1*, represents the main production price and says that the price received by producers is less than the price paid by purchasers due to margins and tax. The power of the *ad valorem* tax is equal to the ratio of the tax and the market price, or V1TAX/V1PUR, and the rate of change of the *ad valorem* tax is *t1*, which from excerpt 28 we can see can be shifted by a rate independent of which market[2] the good was being sold and which commodity it was (*f1tax_csi*), or by a commodity specific, market independent rate (*f0tax_s(c)*). An example of a use of the former might be if we wish to model the government raising VAT revenue by way of compensation for a less of revenue/increase in expenditure elsewhere in the economy. we might use this shifter to indicate that this revenue is being raised from all commodities. An example of a use of the latter would be if we wished to raise the tax on beverage and tobacco, while leaving all other VAT rates unchanged.

[2] By 'market' we mean the various components of final demand and intermediate sales to other companies.

Equations *E_p2*, *E_p3* and *E_p5* show the corresponding equations for investment, household expenditure and public expenditure respectively, with similar definitions for the rates of change of the power of the *ad valorem* taxes, *t2*, *t3* and *t5*. Note that *t3* is household independent, so the government must charge urban households the same rate of indirect taxation as rural households. This is likely to be violated in so far as a particular commodity is in fact a composite of a number of commodities that face a different tax rate depending on household. So, for example, increased expenditure on alcohol might be weighted towards spirits that have a very high marginal tax rate in (say) rural households while might be weighted towards (relatively) low taxed beer in urban areas.

Equation *E_p4* in a simplified version (excluding margin flows) is shown below. It shows that the purchasers' price (in IR£) for each commodity going to each destination[3] is equal to the basic price plus the export tax minus the export subsidy. Therefore the price wedge between the purchaser and the producer is an *ad valorem* tax and *ad valorem* subsidy, with associated rates of change, namely *t4*(c,d) and *t4exp*(c,d).

The tax rate change variable has the facility to change by commodity, while also allowing a uniform tax shifter. The subsidy rate variable allows shifts that are commodity specific and independent of destination, destination specific and independent of commodity, both destination and commodity independent, and finally a shift variable that is both commodity and destination specific.

The reason that the subsidy rate of change variable is constructed with so much flexibility is that subsidy payments are of central concern to the model. More specifically, while ordinarily we will be happy to keep the tax rate unchanged, the same is not true for the subsidy rate. The reason for this is that, in the common agricultural policy, the rate of the subsidy is usually set so as to ensure that the domestic producer can sell at world prices. Therefore, when the domestic price falls,

[3] The destinations are the UK, Continental Europe and the Rest of the World.

the rate of the subsidy will also fall by the same amount, and the producer will still be selling at the world price.

2.3.6.2 Zero Pure Profits in Factor Markets

This section deals with the relationship between the middle block in figure 2.4 and the left hand block. In effect, each equation says that the owners of each of the factors of production get the rent accruing to land plus the subsidy that accrues to it.

Equation *E_p1cap* says that the difference between the rate of change of *p1cap(i)*, i.e. the actual rent that accrues to land from farming activity, is equal to the total rent minus the rate of subsidy payment. Therefore, where there are no tax rates and subsidies are strictly positive, the basic (owners) price will always be greater than the purchasers (land users) price. The equations *E_p1lab(i,o)* and *E_p1lnd(i,l)* have a similar definition but are extended to allow for the fact that there are nine different occupation types and three different land types.

As with indirect subsidies, factor subsidies are modeled to allow for a lot of flexibility. Consider land subsidies. They are allowed a land type specific change independent of industry, an industry specific change independent of land type, a shift which is both independent of land type and industry and finally a shift variable which is both specific in the land type and industry.

2.3.7 Other Equations

Excerpt 27 contains five equations, the first three of which are market-clearing conditions, while the last two define percentage changes for the aggregate demand for imports and labour. Equation *E_p0_B* ensures that demand equals supply for non-margin commodities. The right hand side of this equation includes a *Δx6* term, which measures any (by necessity, exogenous) change in the level of inventories.

Equation *E_x0imp* defines the variable x0imp, which is a measure of the (change in) aggregate import use. Similarly equation *E_x1lab* defines aggregate demand for occupation-specific labour. The final section incorporates numerous Excerpts that

are included in the model. Many of these excerpts don't actually do any work, in the sense that they don't actually change any of the calculations. However they are very important to aid the interpretation of the results of any simulation and as a diagnostic tool to ensure the model is doing what you expect it to.

GDP from Income and Expenditure Side

Excerpt 30 calculates the percentage change of the nominal aggregates, which make up GDP from the income side. The first three equations calculate returns to the three factors of production, namely land, labour and capital.

There are three further equations. The first relates to Other Cost Tickets that are all zero in this model. The change in indirect taxes must also be included as this is the government's share in value added, and thus forms part of GDP. Finally, pure profits exist for the returns to scale simulations and must be included. For the perfectly competitive core model, these will be zero.

Excerpt 31 calculates the percentage change of the nominal aggregates that make up GDP from the expenditure side. This will be calculated by reference to the familiar identity:

$$Y = C + I + G + In + (X - M) \tag{13}$$

where *In* is inventory.

Trade balance and Other Aggregates

The balance of trade is calculated in Excerpt 32 and is calculated as a percentage of GDP. It is not calculated as a percentage change as zero is a feasible value. The other equations of this excerpt define various volume, price and value indexes for imports, capital and labour.

Rates of Return and Investment

In the model, the creation of new units of capital is determined by the rate of return in that industry. The higher the rate of return the more capital that is created in that industry. Note that the rate of return is defined as twice the rate of change in the return on capital minus the change in the cost of a unit of capital. Therefore, if the cost of a unit of capital increases by as much as the increase in the return on capital, there will no increase in the return on capital. The reason for multiplying by a factor of 2 is in recognition of the fact that a lot of investment is needed simply to replace depreciated capital goods.

The equation *E_x2tot* relates the change in capital/investment ratio to the net rate of return minus the economy wide rate of return. The variable finv(i) allows for exogenous shifts in investment in each industry *i*.

2.4 Choosing the Model Closure

The model as specified will contain more variables (n) than equations (m), and will thus require a number of variables (n-m) to be set exogenously. From a purely mathematical perspective we must ensure that we choose the (n-m) variables appropriately to ensure that the coefficient matrix is invertible. Thankfully, economic intuition provides much guidance as to what constitutes a mathematically appropriate closure. For example, if we hold the price of (say) an imported good constant, chances are we will have to endogenise the quantity imported. If we were then to try and exogenise both variables, then elementary economics would tell us that we would need to allow demand or supply curves to shift appropriately – therefore we would need to endogenise taste and/or technology variables.

In each particular market the choice of closure depends primarily upon three not entirely mutually exclusive considerations.

Firstly, the choice depends upon the nature and availability of the data and the underlying phenomena that determine them. So, for example, in most traditional 'forward looking' modelling, the taste and technology parameters are held

exogenous, as we as economists have little to say about the former, and are pretty vague at best in relation to the latter. Where these variables are not held exogenous, they are frequently used as a 'mop up' of any residual real movements left over after consideration has been made for relative price movements. Given that in most comparative-static experiments we are abstracting from time, it seems reasonable in these circumstances to hold technology and taste constant[4].

Secondly, it depends on the assumed economy wide responses. A classic example of this is that for many short-term simulations, the real (or perhaps nominal) wage rate is held constant in recognition of the assumption that the presence of such institutional rigidities such as unions prevent a quick response to a shock. Adjustment comes via the total numbers employed, which, it is argued, is much more sensitive to short run fluctuations. This sticky wage assumption can then be eased in a long run simulation, with real wages adjusting.

Finally, it depends on what you want to find out. So, if you were interested in the impact of a change in a tax rate, then this would be held exogenous and shocked by an appropriate amount. However, if the government wanted to target an employment level in a particular industry, we would allow the tax rate to vary endogenously so that the exogenous employment target is satisfied.

We can take a step towards the automation of the construction of an appropriate closure by use of a table of variables and equations as illustrated in Horridge *et al* (1998) (see table 2.1 below). There are five columns in this table. The first column indicates the dimension. The 'Macro' dimension might more properly be called the scalar dimension, as it refers to all scalar variables. The second column indicates the variable count in the entire model, while the third column indicates the equation count. So, for example, the version of the model presented below had 126 scalar variables and equations that explained 94 of these variables.

[4] A notable exception is the 'Transmission via Trade' school, worked examples of which in a GCE context can be found in Lee et al (2000) and Lejour et al (2000).

Table 2.1:

Tally of Variables and Equations

1 Dimension	2 Variable Count	3 Equation Count	4 Exog. Count	5 Unexplained Variables
MACRO	126	94	32	Phi q_h omega f4pgen f5tot2 f3tot_h ffinv_l fgostax a1Ind_il f1lab_io f1prim_l f3tax_cs f5tax_cs f1tax_csi f2tax_csi f_t1cap_l f_t1lab_io f_t1Ind_il f_t4exp_cd x4_ntrad_d f4p_ntrad_d f4q_ntrad_d w0cif_adj_c f4tax_trad_d ff_subsidy_l f_twist_lk_l f4tax_ntrad_d ff_subsidy_ia ff_subsidy_im ff_subsidy_is twist_src_bar f_inctaxrate_h
COM	19+(1)	12+(3)	7	Ac f4p_d t0imp f0tax_s f_t4exp_d a1_si_agri ftwist_src
COM*IND	7+(1)	5+(5)	2	a1_s a2_s
COM*HOU	6	4	2	a3_s f3_s
COM*SRC	11+(1)	9+(3)	2	f5 fx6
COM*SRC*IND	9	7	2	a1 a2
COM*SRC*IND*MAR	4	2	2	a1mar a2mar
COM*SRC*MAR	5	3	2	a3mar a5mar
COM*SRC*HOU	1	0	1	a3
IND	37+(1+1+1+1)	20+(2+3+3+3)	17	a1oct f1lab_o a1cap a2tot f1oct f1tot ffinv p0cap a1prim a1lab_o a1Ind_l f_t1cap f_t1Ind_l f1tot_obs f_t1lab_o ff_subsidy f_twist_lk
IND*OCC	6	4	2	f_t11lab f1lab
IND*LND	5	3	2	f_t1Ind x1Ind
OCC	7	5	2	f1lab_l f_t1lab_i
HOU	18	15	3	f_inctaxrate a3_cs f3_cs
HOU*HOU	1	1	0	
COM*DES	6+(1+1+1)	3+(3+2+2)	3	f4p f4q f_t4exp
OCC*HOU	1	1	0	
COM*FANCAT	(1)	(4)	0	
I1AGRI	2	1	1	fitot_agri
I2MANU	6	3	3	f1tot_manu a1_manu_manu a1_manu_serv
I3SERV	2	1	1	f1tot_serv
LND	3	2	1	f_t1Ind_i
COM*MAR*DES	2	1	1	a4mar
TOTAL	284	196	88	

This leaves us with 32 variables that must be set exogenously. Given the convention of assuming that the equations named (for example) *E_delB* explains the variable *delB*, we can round up the 32 variables that have no matching equations and list them in column 5. In essence, this column suggests these variables as obvious candidates

for setting as exogenous. Looking down the columns we can see that this procedure is done for each of the dimensions present in the model.

There is one final aspect of table 2.1 that requires explanation, and that is the numbers in brackets in the variable and equation counts. Looking at, for example, the COM variables, we see that the variable count is 19 + (1), while the equation count is 12 + (3). The variable in brackets - denoted by (1) - is in effect explained by three equations – denoted by (3). So, for example, the COM equation that defines industry use of commodities has three different forms depending on whether the purchasing industry is agriculture, manufacturing or services. This is to allow for a technology shift away from (say) electricity in all agricultural industries, in all manufacturing industries or in all service industries. Note that these variables and equations all cancel each other out. So, in the COM case, the exogenous count is 19 – 12 = 7. The (1) in the variable count and the (3) in the equation count automatically cancel each other out. Through this method we can greatly simplify the process of identifying a mathematically adequate closure.

2.5 Approach to Solving the Model

Because of the size and structure of CGE models, the limited processing capacity of computers until recently has presented modellers with a difficult computational task (Bautista, 1992). A major stimulus to early CGE modelling was provided by Scarf's (1967) algorithm, based on Brouwer's fixed-point theorem, for the computation of a Walrasian equilibrium system. According to Shoven and Whalley (1984), the recent advances, particularly in relation to the Scarf algorithm, mean 'that it is no longer the solution methods that constrain model applications, but the availability of data and the ability of modellers to specify key parameters'. By way of a worked example, a fixed-point algorithm is used in solving for equilibrium prices in Clarete's (1984) study.

One major drawback of the fixed-point algorithm, however, is that it does not take full advantage of the fact that our base data represents an initial general equilibrium solution. Using Johansen's (1960) procedure of taking total differentials of the

logarithms of non-linear equations, the non-linear equation system is transformed into a linear one and a simple matrix calculation can be applied. This method is discussed in section 2.5.1. Of course, the solution obtained this way is an approximation, and the method gives no measure as to how large these approximation errors might be. These linearisation errors can be reduced or eliminated by using a procedure developed by Dixon et al. (1980) that combines Euler's method extended by a simple extrapolation exercise (see section 2.5.2). Finally we discuss Gragg's method, which is the default GEMPACK method, in section 2.5.3.

2.5.1 Johanson Solutions

Consider the general form of CGE models, in which an equilibrium is assumed to be observed at a vector, V, of length n. The vector satisfies the system of equations:

$$F(V) = 0 \qquad (14)$$

In the IMA*GE* model the function F is assumed to be differentiable, and is represented by m equations, the assumed functional forms of which are discussed in section 2.3. The number of variables n in the model will always be greater than or equal to the number of equations, otherwise the system would be over-determined. Hence we require n-m exogenous variables to close the model, and will solve the model for the remaining m endogenous variables.

To obtain the linearised form we must assume that the coefficient matrix is constant, so (21) above can be expressed as the product of a constant m * n matrix and the n * 1 vector of percentage-change in V:

$$Av = 0 \qquad (15)$$

Partitioning v into its exogenous (v_x) and its endogenous (v_n) components results in:

$$A_1 v_x + A_2 v_n = 0 \qquad (16)$$

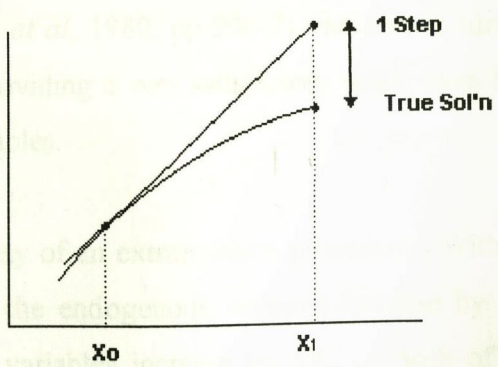
Finally, we can rearrange to give:

$$v_n = -A_2^{-1} A_1 v_x \qquad (17)$$

The typical ij^{th} component,$[- A_2^{-1} A_1]_{ij}$, represents the elasticity of the i^{th} endogenous variable with respect to the j^{th} exogenous variable calculated at the initial base data set V^I. As we move away from this initial solution, if the model is to be accurate, we need to update the A matrix to reflect the new elasticities. For example, as the amount of labour in the economy rises relative to capital, then so will the values of the share parameters used in A (e.g. labour's share in total factor usage) which are used to derive the optimal use of factor resources given a CES technology. By employing Johanson's technique we choose not to update the matrix at all. The solution produced is as in figure 2.5.

Figure 2.5

The Linear Johanson Solution

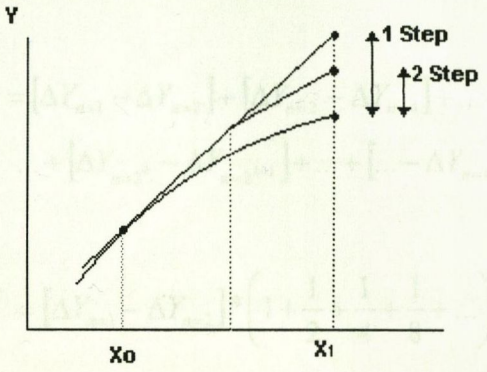


2.5.2 Euler's Method

Consider figure 2.5 again. If we bisect the exogenous shock (which is represented on the horizontal axis), apply half of the exogenous shock, recalculate the $[- A_2^{-1} A_1]$ matrix and then apply the remainder of the shock, we reduce the error in the simulation by $(\Delta Y_{n=1} - \Delta Y_{n=2})$. We can then repeat this process by bisecting each of the new intervals again so that the entire shock has been subdivided into four

sections (so n=4), with the result that the error is further reduced. In fact, as $n \rightarrow \infty$, the number of intervals approaches infinity and therefore the width of the interval tends to zero, so we are in effect recalculating the coefficient matrix continuously, producing an exact solution. For a more rigorous mathematical discussion of Euler's method, see Dixon *et al*, 1980, pp 202-8.

Figure 2.6
Solution Using Euler's Method



Given all of the above, it is natural to ask, how large does n have to be to ensure that the linearisation errors are reduced satisfactorily? Using a simple extrapolation procedure (see Dixon *et al*, 1980, pp 206-7), the answer turns out to be very small, with n=2 generally providing a very satisfactory result, even for very large deviations in the exogenous variables.

This is achieved by way of an extrapolation procedure. With a value of n=1, namely a Johanson solution, the endogenous variables increase by $\Delta Y_{n=1}$. With a value of n=2 the endogenous variables increase by $\Delta Y_{n=2}$. Both of these are illustrated on figure 2.6. The improvement[5] in accuracy is $(\Delta Y_{n=1} - \Delta Y_{n=2})$. Continuing and bisecting the 'leap' in exogenous values again gives us $\Delta Y_{n=4}$, which is a further improvement in accuracy of $(\Delta Y_{n=2} - \Delta Y_{n=4})$. Dixon *et al* comment that the simple rule, which works well in practice in the ORANI model, is that each bisection of the

[5] We must be careful – we cannot necessarily be sure that these are improvements in model accuracy at all. However, assuming that the functional forms could be closely approximated with a quadratic function is sufficient reassurance. The reason for this is that the derivative of a polynomial of degree (say) 3 will be of degree 2, while our approximation is linear so it will be at most of degree 1.

'leap' in exogenous values implemented results in an accuracy improvement of half the improvement to the previous leap. So, for example:

$$\Delta Y_{n=1} - \Delta Y_{n=2} = 2 * (\Delta Y_{n=2} - \Delta Y_{n=4}) \tag{18}$$

We can take advantage of this shortcut and sum the series of errors, remembering that $\Delta Y_{n=\infty}$ is the true answer. The difference between the 1-step Johanson and the true solution is as follows:

$$\begin{aligned} \Delta Y_{n=1} - \Delta Y_{n=\infty} &= [\Delta Y_{n=1} - \Delta Y_{n=2}] + [\Delta Y_{n=2} - \Delta Y_{n=4}] + \ldots \\ &\ldots + [\Delta Y_{n=2^k} - \Delta Y_{n=2^{k+1}}] + \ldots + [\ldots - \Delta Y_{n=\infty}] \end{aligned} \tag{19}$$

$$= [\Delta Y_{n=1} - \Delta Y_{n=2}] * \left(1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \ldots\right) \tag{20}$$

$$= [\Delta Y_{n=1} - \Delta Y_{n=2}] * 2 \tag{21}$$

Finally, rearranging the above gives:

$$\Delta Y_{n=\infty} = 2 * \Delta Y_{n=2} - \Delta Y_{n=1} \tag{22}$$

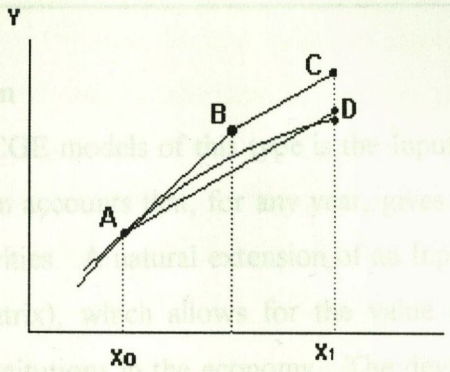
Hence by simply performing Euler up to n=2 and extrapolating, we can derive a very simple procedure for eliminating much of the linearisation error.

2.5.3 Gragg's Method

A further improvement in accuracy can be achieved by employing Gragg's method, which is in fact the default method assumed by GEMPACK. While both the Euler and Gragg method calculate the slope at B, the Euler method continues from B to C, while the Gragg method returns to the previous point. Generally, the Gragg method converges much more quickly than the Euler method, though for highly non-linear

simulations, it has a tendency to diverge. In such a case, the Euler should be used, though this of course might also diverge.

Figure 2.7
Solution using Gragg's Method



Problems would only arise if more complex functional forms modelling more complex behavioural characteristics such as a backward bending labour supply curve were introduced. In essence, any function with significant 3rd order (or higher) derivatives may cause problems, though we can be fairly sure that even these would not cause problems in the fairly limited absolute deviations that are likely to be of concern to us in most simulations. Using this procedure with n=2 and employing the extrapolation procedure on a computer with a Pentium II 300MhZ processor on the full version of the model takes about three minutes. As such, model size or complexity is no barrier to us in deciding which simulations to run or what aspects of the economy to model.

2.6 Conclusion

This chapter has discussed the form of the model code, the technology assumptions, i.e. functional forms, underlying the model and the method used for solving the model. While an understanding of the full model code is only necessary for economists who wish to develop the model further or to investigate its properties in detail, it is useful to have a broad understanding of the coding conventions as important excerpts from the TABLO file are introduced later where relevant. The full TABLO code is shown in appendix 1 at the end of the thesis.

CHAPTER 3

CONSTRUCTION OF THE DATABASE

3.1 Introduction

The core database for CGE models of this type is the Input-Output table, which is a unified set of production accounts that, for any year, gives the flows between all the various productive activities. A natural extension of an Input-Output table is a SAM (Social Accounting Matrix), which allows for the value added in an economy to accrue to one of the institutions in the economy. The development of this matrix is one of the key elements in the modeling process. The SAM is necessary so as to provide a link between economy wide incomes and expenditures.

The model distinguishes 34 industries (the first eight of which relate to farm level production, plus a separate industry for each of forestry and fishing) and 34 corresponding commodities, making it by far the most disaggregated CGE model for Ireland thus far. There are two sources of commodities, namely domestic and overseas. There are nine occupational groups and three household types, namely urban, rural farm, and rural non-farm.

The model is based on the most recently published Irish Input-Output table from 1993 (CSO, 1998). This has been further disaggregated so as to give a more detailed representation of agriculture forestry and fishing, which is traditionally treated as one sector in published Irish Input-Output tables.[1] A full list of the sectors used is shown in the Appendix 2. Ancillary data sources used to develop the SAM are the Household Budget Survey which is based on 1994-1995 and which incorporates household types also included in the National Farm Survey.

[1] See O'Connor and Matthews, 2000 for full details.

This chapter begins with an overview of the components of the model database followed by a discussion of the steps behind the construction of the base data set. Section 3.2 concentrates on the domestic and imported inter-industry flow matrices at both basic and purchasers' prices. Section 3.3 discusses the factoral distribution of income, while section 3.4 gives the alternative institutional distribution. Section 3.5 details the construction of the final demand column vectors, while 3.6 discusses the construction of each of the margin matrices. Given the model's agricultural focus, data issues relating to the modeling approach used for the Common Agricultural Policy is discussed in a separate section (3.7) to other taxes and subsidies. Each of the model's parameters is discussed in section 3.8, while the chapter concludes with section 3.9.

Finally, use is made throughout this chapter of a number of key statistical sources, which, for the sake of brevity, are referenced with acronyms followed by the appropriate table number where appropriate. For example, NIE12 refers to Table 12 in the National Income and Expenditure accounts for 1998. A full list of the acronyms with the relevant publications is listed below.

Table 3.1: Acronyms Used In Chapter 3

Acronym	*Full Name*
CIEAS	Compendium of Irish Economic and Agricultural Statistics, DAFF (1997).
NIE	National Income and Expenditure 1998, CSO (1999).
A1-A2	National Input Output Accounts 1993, CSO (1998).
Agro_IO	Agricultural Input-Output Table, O'Connor and Matthews (2000)
SA	Statistical Appendix, CSO various years.
RFTS	Road Freight Transport Survey, CSO (1996b).
REV	Statistical report of the Revenue Commissioners, Revenue commissioners (1993).
ASI	Annual Services Inquiry, CSO (1996a).
LFS	Labour Force Survey, CSO (1994).
HBS	Household Budget Survey 1994/95, CSO (1997)
DSESFC	Demographic, Social and Economic Situation of the Farming Community in 1991, CSO (1993).

Figure 3.1

A Simplified Representation of a Social Accounting Matrix

		Expenditures						
				Institutional Accounts				Total Receipts
		N	O + 2	1	H	1	1	
		Production Activities	Factors of Production	Government	Other Institutions	Rest of World	Investment	
Receipts								
N	Production Activities	1BAS(dom)		5BAS	3BAS / PO44	4BAS	2BAS, 6BAS	Gross Demand
O + 2	Factors of Production	1CAP, 1LAB, 1LND						Factor Income
1	Government	0TAR, 1TAX		5TAX	VHTG, 3TAX	4TAX	2TAX	Income to Government
H	Other Institutions		VLTH, VCTH, V1OH	VGTH				Income to Institutions
1	Rest of World	1BAS(imp)						Total Foreign Exch. Out
1	Investment							Aggregate Savings
	Total Expenditures	Gross Output	Expenditures by Factors	Expenditure by Government	Expend. by Institutions	Total Foreign Exch'ge Inflows	Aggregate Investment	

3.2 The Input Output Database

Figure 3.1 above is a schematic representation of the model's Input-Output database. Each column represents a source of domestic demand. So, reading along the row beginning with 'Production Activities' we can see that each industry supplies 1BAS(dom) by way of intermediate inputs, 2BAS and 6BAS to other industries as a capital input, consumed by one of the household types (3BAS/P044), used by the government in providing public goods (5BAS) or exported (4BAS). Further, the 1LAB, 1CAP and 1LND matrices show the use of each of the factors of production in the production of each industry. A fourth matrix PERS (not shown) shows the number of workers in each industry and corresponds to the O*N 1LAB matrix.

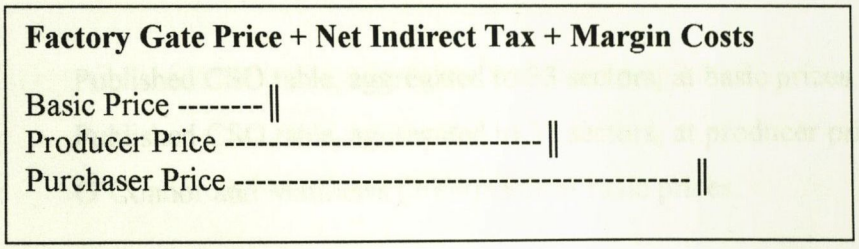
There is further information needed that is not illustrated here. Firstly, there is the incomes matrix which maps the income household types receive for the provision of labour, capital and land, while also receiving transfers from the government (VGTH). To calculate disposable income, the amount of income tax paid by each household is also calculated. There are two more matrices, namely the Make matrix (C*N) and the MPC (C*2) matrix. The former relates the production of commodity to industry. For example, electricity would largely be produced by the Electricity, Gas and Water industry, though others might produce (and use) small quantities of electricity as a by-product. In the model it is assumed that there is a one-to-one correspondence between industries and commodities. Based on this assumption, the Make matrix consists of the aggregate output for industry/commodity g on the diagonal element m_{gg} and zero for all off diagonal elements m_{ij}, i not equal to j. The latter MPC matrix refers to the marginal propensities of consumption for each of the household types concerned.

Input-output tables for the Irish economy has been produced since 1956 and published since 1964. They are produced at relatively irregular periods, namely 1956, 1960, 1964, 1969, 1975, 1985 and 1990. 1990 was the last time a full set of tables providing both the domestic and imported flows of intermediate goods at both basic and producers prices was compiled. The principal input-output database used in the model is an amalgamation of two related sources. The first is the published

41*41 input-output tables from the CSO for 1993 (CSO 1998), which provided tables of *combined* domestic and imported flows at both basic prices and producers' prices. The second is the O'Connor and Matthews (2000) 33*33 domestic input-output table for 1993 at basic prices that disaggregates the agriculture, forestry and fishing sector into ten distinct groupings.

As discussed in chapter 2, in the main industry-by-industry section in the input-output tables, it will suffice to produce four 34 * 34 matrices. These are, namely, a matrix of domestic intermediate flows at basic prices, a matrix of domestic intermediate flows at producer prices, a matrix of imported intermediate flows at basic prices and a matrix of imported intermediate flows at producer prices. Figure 3.2 is a representation of the relationship between various price measures.

Figure 3.2: The Relationship Between Various Price Measures



In sections 3.2.1 and 3.2.2 we give a short description of the main features of the Input-Output data available for Ireland, and describe the adjustments required to ensure that they are appropriate in relation to the structure described in this section. In section 3.2.3 we discuss the steps taken to reconcile the two tables to form a consistent dataset.

3.2.1 1993 published IO accounts of Ireland

The published 1993 tables are less detailed than usual and consist of only two tables, namely a 41 branch transaction table at basic prices for domestic and imported flows combined, and a 41 branch transaction table at producer prices for domestic and imported flows combined. All imports in the first table are valued at c.i.f. prices.

The difference between the two valuations is the net taxes on products (taxes on products less production subsidies) for domestic production and net taxes linked to imports (taxes less subsidies) for imported goods. Hence, for basic prices, taxes (and subsidies) are distributed along the indirect taxes row and shown as a cost to the branch purchasing the good (which of course includes final demands). The alternative is the producers' prices valuation, where there is no distribution of indirect taxes or subsidies as separate rows. All indirect taxes are added into the valuation of total supply.

The approach taken was to sum the 41*41 table to 23 sectors matching those used in the O'Connor and Matthews (2000) tables, and then to disaggregate the agriculture/forestry/fishing sector into the 10 industries as classified by O'Connor and Matthews as well as separating out 'farm animal feed' from the 'other food' industry. These aggregated tables are referred to by the following names for the sake of brevity. Agro_IO is shown in full in Appendix 2.

A1: Published CSO table, aggregated to 33 sectors, at basic prices.

A2: Published CSO table, aggregated to 33 sectors, at producer prices.

Agro_IO: O'Connor and Matthews (2000) table at basic prices.

3.2.2 1993 IO accounts for Ireland (Agro_IO)

The 1993 O'Connor and Matthews (2000) set of input-output accounts (from here on referred to as Agro_IO) were produced with the expressed purpose of developing more detail in relation to agricultural production. In all previous tables, agriculture forestry and fishing were amalgamated into one sector, while in this table, there are four livestock sectors (dairy, cattle, sheep & wool and pigs, poultry & horses four crop sectors (wheat, barley & oats, fruit & vegetables, root & green and other crops) , one sector for fishing and one sector for forestry. A *farm animal feed* sector was also incorporated, a sector which usually appeared in '*other foods*', amalgamated with flour milling. Another important feature to note in relation to agriculture is that all flows are treated on a net basis, so flows between farms are not considered.

The gain of ten sectors (10 + 1 –1) in terms of agriculture was at the price of the loss of a number of sectors. Table 2.4 in the appendix shows the list of 18 sectors in the 41 that were amalgamated, along with their new group name. The flows that do not relate to agriculture (or forestry or fishing) in the 1993 tables are in fact based on 1990 input-output flows, and were updated to 1993 using the RAS procedure (Bacharach, 1970). The original table is shown in appendix 2, and relates to domestic flows, with all imports aggregated into one row. One large advantage of this set of tables over the CSO figures is that the table has already been extended to form a rudimentary SAM. Hence there is already an institutional breakdown of income.

3.2.3 Reconciling the two sets of IO accounts

The process of reconciling the two sets of IO accounts (or more specifically the Agro_IO table and the Basic Prices table in CSO, namely A1) is a necessarily messy affair, with numerous steps. What follows is a discussion of the main steps that were followed in reconciling the data. We generally adhered to the following rules:

- In general, where a disagreement in relation to data arose, the Agro_IO figures were taken as correct.
- Secondly, where uncertainty exists as to the correct treatment of an import flow, the figure is put in the diagonal. This has the implication that the import composition of inputs is in effect assumed to be the same as the domestic composition of inputs.

Creating the imports matrix (basic prices): We calculate the import matrix by subtracting Agro_IO from A1 to give matrix (A1-Agro_IO). The main problems to overcome were to provide estimates of imports used by farms, industry wide imports of farm level produce, the division of '*other foods*' to create a separate '*farm animal feed*' sector, making sure that the import figures made sense and finally making sure the column totals for imports equal the Agro_IO import totals.

Firstly, Agro_IO provided the 33*8 matrix of estimates for import use of 8 of the agricultural sectors, and these estimates are incorporated here. The next step is to estimate the 8*23 matrix of industry wide imports of farm level produce. We have some guidance in that we know the column totals for these imports for each of the 23 industries in question, and can immediately identify 15 as being zero. The remaining industries are shown below in table 3.2 along with the amounts involved, and how they were eventually allocated.

Table 3.2:

Allocation of Imports of Farm Produce

Industry	*Imports of Farm Gate Produce IR£ m*	*Industry Attributed to*	*Comparable 1990 Import IR£ m*
Chemical	1.56	1.56 to Other Crops	1.96
Meat processing	42.24	3.6[1] to Cattle, 0.7[2] to Sheep 17.9[3] to Pigs & Poultry	9.31
Milk Processing	1.02	1.02 to Dairy	1.08
Farm Animal feed	114.34	Pro rata based on the proportions used of domestic agri-output.	150.02
Other Food			
Beverage & Tobacco	14.66	14.66 to Wheat, Barley & Oats	11.42[4]
Textiles	28.75	28.75 to Sheep & Wool	27.84[5]
Other Market Services	11.86	2 to Cattle	1.66

1 Based on CIEAS 83

2 Based on CIEAS 88

3 Based on CIEAS 92 and 103 respectively

4 In 1990 this consisted entirely of beverages

5 In 1990 this consisted almost entirely of textiles/clothing

In disaggregating farm animal feed and other foods from the single IO figures, two stages must be completed – namely a disaggregation of the other foods row and a disaggregation of the other foods column. The former is quite straight forward if we assume (not unreasonably) that - generally - non-agricultural industries have no use for imported inputs of farm animal feed. Firstly we know how much each sector imported of merchandise goods, and how much was invisible imports, so the latter can immediately be allocated to the 'Other Market Services' sector. In terms of merchandise goods, the methodology is somewhat subjective. If SA167 is to be

believed, 248.1m of *farm animal feed* (the commodity) were imported in 1993. However it is impossible to both reach this target and keep imports for the industry *farm animal feed* at its Agro_IO target of 147.94. Eventually we allocated the maximum possible amount of imports of *farm animal feed* to the *farm animal feed* sector of 116.68. The remainder of the diagonal term is assumed to be imports of the commodity 'other foods' by the industry 'other foods'. The import by *farm animal feed* and *other foods* of other industries output is calculated on a pro-rata basis with domestic inputs.

Along with these problems of filling in missing data, it is necessary to apply some care in ensuring that the imports produced directly from the A2-A1 operation make sense. Firstly, we assume that any cell worth equal less than 0.1 is zero. However the predicted imported figures by industry do not all match up with Agro_IO row of import totals. By assuming zero imports of credit and insurance, the problem automatically disappears. This would seem to indicate an error in the compilation of one of the tables. Unfortunately, historical input-output tables for Irish imports only cover merchandise imports, not service imports, so we have little guidance for the source of the error.

Finally, even after all these alterations have been made, there remain a few negative entries for imports. All but one is small enough (<2m) to discard. The large one (over 18m) is the amount of imports of the meat processing industry used in the meat processing industry itself. It can be assumed that this reflects differences in estimates of the value of domestically processed meat that is used within the industry, and has nothing to do with imports. Therefore, we set this to zero.

It was decided at this stage to add an additional sector, namely *dwellings*. The Irish IO tables take no separate account of the existence of dwellings. Why might this omission be a loss?

- The availability and price of dwellings has a large impact on the flexibility of the labour force to migrate internally and externally.

- The construction of dwellings has a very particular input structure.
- A separate Dwellings sector would allow a transmission mechanism whereby high economic growth could influence the price of farmland.
- The price of housing is an important feature of the evolution of Irish economic performance over the 1993 – 1998 period.

Crucially, an increase in household income, an increase in the number of households or a dramatic change in the price of land currently has no direct impact on the demand for houses. So how is house building currently incorporated into the model? In terms of output it is treated as part of gross fixed capital formation and in terms of cost it is accounted for in the repayment of mortgages.

We can solve many of these problems by incorporating a Dwelling sector. To avoid 'unsettling' the balanced matrices that have already been calculated, we will make this as simple as possible. In particular, our Dwellings sector has the following features:

- It will only use the commodity 'Construction' in intermediate production.
- It will only use land as a factor of production.
- Households are assumed to be the only source of demand for housing. While government, and indeed businesses, can in reality also demand dwellings, these demands are not included in the model.

In essence what we are doing is relocating a proportion of GFCF so as to give us flexibility in how we handle it. Therefore any taxes or margins currently imposed on GFCF will be transferred pro-rata to the new sector.

In the actual simulations reported in this thesis, we do not allow for changes in the price of housing to influence migration nor do we allow the high price of land for residential use to influence the price of farmland. However, the change in the price of housing is explicitly incorporated in both the historical and forecast simulations,

therefore influencing both the updated 1998 model and the baseline simulation as presented in Chapter 7.

3.3 The Factor Income Rows

3.3.1 Labour Income

The labour costs are gross figures, thereby including any direct income taxes and also employer's contribution to social insurance. The total figure of IR£16,022.53 across all industries in both A1 and Agro_IO can be derived from NIE12 as the remuneration of all employees, excluding foreign employees. The total figure for Agriculture, forestry and fishing of IR£217.09 in A1 is very close to the corresponding total of 219.7 in NIE2, which only lists this figure for four major production classifications. This consists of IR£197.9 of wages to farm employees and to employees of forestry, and IR£21.8 of employer's contribution to social insurance.

In the Agro_IO data set, in terms of employment numbers, we have for each industry total man-hours. Further, LFS23 provides a breakdown of estimated people at work classified by 9 economic sectors, sex and 9 occupation groups. To go from LFS23 to Appendix 2 in the appendix requires that we first provide a industry-to-industry mapping from the LFS classification to the IO classification. This mapping is shown in Appendix 2. This mapping caused little problems for five sectors. However total employment in the other three industry groups differed significantly (by 10% - 15%) from the level predicted in the Agro_IO figures. In calculating Appendix 2, the employment figures from LFS23 were scaled up to match the Agro_IO figures, and occupation proportions per LFS industry grouping were applied uniformly to each IO industry within that grouping.

We believe that this approach will be satisfactory for most of the industries. However, given our focus on agriculture, it would be preferable to give a closer examination of the 10 primary sectors. Particularly, LFS25 estimates an unemployment rate for farmers of less than 3%, which clearly fails to capture the extent of underemployment in Irish agriculture.

Fortunately, as a check on some of our figures for farming we have DSESFC20 which lists - in terms of the same occupation listing used in LFS25 - the amount of employment by farm type. We will just examine the first three sectors, namely dairy, cattle and sheep, as these sectors most closely correspond to one of the IO sectors[2]. A cursory examination of the DSESFC20 table indicates that this process will be worthwhile – dairying employs a very low number of workers who classify themselves in industries other than agriculture/forestry/fishing, while sheep and cattle producers are much more likely to classify themselves as having some other occupation. This probably arises from the fact that dairy farming is a full time commercially viable industry, while cattle and sheep farmers often work (effectively) on a part-time basis.

We use the RAS technique to adjust the DSESFC20 table to make sure it matches the column and sum totals for the three sectors combined derived from the LFS estimates as discussed above. The results (see appendix 2) estimates that in total 500 people classified in occupations other than agriculture/forestry/fishing are in dairy farming, which compares with the original unadjusted estimate of 1,100. To put this in perspective, there are around 35,000 dairy farm workers. Conversely, the number classified in occupations other than agricultural/forestry/fishing in cattle and sheep farming rises from the unadjusted estimate of 2,500 to the RAS estimate of 3,100.

3.3.1.1 Industry-by-Occupation Wage Bills

Next we must move from an industry-by-occupation matrix of numbers employed to a industry-by-occupation wage bill matrix for each industry by occupation. As well as the 'numbers employed' matrix, we have as a control total the total wage bill for each industry. We have little additional information as to how wage rates should be calculated, so we must assume constant wage relativities as gleaned from the HBS, Volume 1, Table 5, p 67. Based on a state average of 100%, the wages and salaries of the 6 socio-economic groups are shown in table 3.3 below, which were in turn derived from the 12 socio-economic groups used in the 1991 census. The jobs

associated with each socio-economic group are listed in Appendix 4 of Volume 6 of the 1991 census.

Table 3.3:

Relative Wages and Salaries by Socio-economic Group, based on Household Budget Survey 1994/95

	Number in Workforce	*% of Average State earnings*
Professional, employer or manager	176.4	213%
Salaried & Intermediate non-manual	180.3	134%
Other non-manual worker	122.5	101%
Skilled Manual Worker	191.7	113%
Semi-skilled manual worker	119.6	75%
Agriculture/Farm/fishery	177.9	45%
Unknown	167.9	5%

So, for example, professionals, employers or managers receive over double the state average pay, and almost three times (213% / 75%) semi-skilled manual worker. These relative pay rates were then applied to employment numbers matrix to derive 'labour units' which are assumed to be of the same value within each industry, allowing us to calculate a full occupation*industry matrix of wage bills.

3.3.1.2 Occupation-by-Household Wages

Our final task is to calculate the (9+1)*3 LINC matrix which maps the wages received by each occupation (plus those on unemployment benefit) to each of the three household groupings. We know the sum total by occupation and can derive the total by household from the HBS data. Next, while exact figures for a rural/urban breakdown are not available, we can approximate by dividing up total (say) urban household income into the different occupations by taking a representative geographic area. So for urban households, the representative area was the sum of Dublin County and County Borough, Cork County and County Borough and Galway

[2] Note that these three sectors account for 85% of Ag/forestry/fishing employment.

County and County Borough[3]. Based on the total occupational structure of these areas, we apply a proportionate breakdown of total urban household income (estimated from HBS). Finally, given control totals for the 9*3 matrix, and estimates of the coefficients derived as described, we use the RAS technique to match the coefficients with the control totals. While ideally this would have been done for the Urban/rural farm/rural non-farm breakdown, in practice it is too difficult to separate rural farm and rural non-farm, so the underlying coefficients were assumed the same, except for agricultural workers who were assumed to be predominantly from farm households.

Table 3.4: Total Household Off Farm Employment

Occupation	*Share*
Labourers & Unskilled	3%
Transport & Communication	4%
Clerical Workers	8%
Commerce, Insurance and Finance Workers	15%
Service Workers	13%
Professional and technical workers	22%
Others	7%
Producers, Makers and Repairers	28%

One of the key features that this approach will hope to capture is the importance of off-farm employment in Irish farm households, and the nature of that employment. Given the approximations that have had to be employed, it is useful to compare the figures returned with a study of rural Wales (Bateman et al 1993) which found that for principal farmers among farms with off-farm income, almost 40% were classified as professional - technical - administrative - management, with half of these comprising of teachers. Of the remaining 60%, half classified themselves as clerical - sales - services while the other half were classed as construction-production-transport-labourer. A similar structure was found for other members of the household, albeit with a slightly higher weighting in clerical - sales - services. The results of the model calculations for total household off farm employment are shown

[3] The only manual adjustment was to reclassify 30,000 agricultural workers in Dublin, Galway and

below. While mismatches in terms of category will explain some of the differences, it is heartening to note that Professional and technical workers are fairly highly represented in the model results as in the Welsh investigation.

3.3.1.3 Note on Labour Usage in the Irish Economy

In order to understand many of the simulation results, it is helpful to keep in mind some of the more salient features of the production structure of the economy, not only between particular commodities, but also between different sources of final demand. We do this by fixing industry capital and land, and shocking aggregate employment by 1%. In this way we can capture not only the labour intensity of the industry in question, but also the labour intensity of the intermediate inputs used in the production of the commodity in question.

The results shows that, in aggregate, farming industries are the least labour intensive of all the three industry groupings, with services the most labour intensive. As well as this grouping of industries by type, we can also group them by final demand classification. This way, we see that investment demand is very labour intensive, which is not surprising given the importance of the construction industry in investment. Exports and consumption show an equal rise, though consumption in this sense includes public consumption, which is very labour intensive. Therefore, private consumption is the least labour intensive of the final demand categories.

In the model results, no industry showed a decline in output, with the ratio of price of each capital/land intensive industry to all other industries decreasing sufficiently to compensate for the shift in endowments. Table 3.6 below shows the ranking of each industry by labour intensity, with (1) denoting the least labour intensive, and (34) the most labour intensive.

The three least labour intensive are forestry, milk processing and farm level milk production, while the most labour intensive are wood and paper transport and non-metallic minerals.

Cork 'city' regions as rural workers.

Table 3.5

Calculating Labour/Capital Intensity Of Final Demands

Real Variable	*Result*
Exogenous Variables	
Labour	1.0%
Capital	0.0%
Land	0.0%
Endogenous Variables	
GDP	0.6%
Farming	0.2%
Manufacturing	0.5%
Services	0.7%
Consumption	0.5%
Investment	1.3%
Exports	0.5%
Imports	0.6%

Table 3.6:

The Ranking Of Industries by Increasing Labour Intensity

Industry	*Ranking*	*Industry*	*Ranking*
I9Forestry	1	I2Cattle	18
I17MilkProds	2	I23RubPlas	19
I1Milk	3	I12ElecGas	20
I6FruitVeg	4	I21Textiles	21
I8OtherCrops	5	I30Credit	22
I11PetCoal	6	I24Construct	23
I10Fishing	7	I32Govment	24
I4OtherLive	8	I29Commun	25
I14Chemicals	9	I19OtherFood	26
I7RootGreen	10	I25TradeMarg	27
I3SheepWool	11	I15Metal	28
I5Cereals	12	I34Dwellings	29
I20BevTob	13	I16MeatProds	30
I18AnimFeed	14	I26LodgCater	31
I28Sheepmeat	15	I13NonMet	32
I33Animmeat	16	I27Transport	33
I31OtherSers	17	I22WoodPaper	34

3.3.2 Capital Income

The figures for capital income by industry are provided in Agro_IO. The only change required is to subtract the calculated return to land for agricultural industries.

3.3.3 Land Income

The typical valuation method used in calibrating CGE models is by defining quantity as that amount of the good or service that in the base year is worth £1. The reason for this is obvious in that only the value of a flow is needed, with the price being set automatically at unity. So, for example, we would say that £440m of computer purchases consists of 440 million 'units of computers', each with a value of £1. The obvious alternative would be to actually breakdown a flow into physical quantities, with a matching quantity and price measure. So, we would find from sales data that 120,000 PCs, 500 advanced database centers and one supercomputer were sold. We would then try to find appropriate price data (whether basic, producers or purchasers) and sum over all values, using the known total valuation of £440 million as a control total.

While the advantages of the former method are clear, one possible area where the disadvantages outweigh the advantages is in the valuation of flows that accrue to land. The reasons for this are as follows:

- Firstly, we have no valuation of flows to land as a starting point anyway, so the only real guidance is matched data on land price and quality
- Secondly, the amount and (roughly) the quality of land available is known, and in terms of quality is more or less fixed.
- Thirdly, many EU subsidies, (for example extensification premia and set-aside payments), relate to physical amounts of land, not to the value of rents that accrue to that land.

Therefore the method that will be employed will be to calculate the amount of land of each type by use and, using published price data, to try to infer the flows to each

type of land in the base year. Firstly, however, we will calculate the quantity of land of various qualities available.

Quantity and Quality of Irish Land

The definition of soil quality adopted in the published data is as identified by Gardiner and Radford (1980):

- Class 1: Wide Use Range, no limitations on Use. (23.4%)
- Class2: Moderately wide use range. (11.7%)
- Class 3: Somewhat limited Use Range. (15%)
- Class 4: Limited Use Range. Permanently unsuited to tillage but suited to a permanent grassland system. (21%)
- Class 5: Very limited uses. Much is suitable for forestry. (25.5%).
- Class 6: Extremely limited use range. This contains soils whose productive potential is virtually zero. (3.1%).

Based on the descriptions of each class given above, we can estimate a rough breakdown of land by potential use. Further, as can be seen in table 3.7 below, Class 1, Class 2 and Class 3 can be identified as the areas where tillage farming is possible. The bulk of Class 3 land (920,000 ha) is referred to as 'marginally suitable' land. We can immediately ignore class 6, where not even forestry is commercially viable. Table 3.7 is derived from the percentages in each land class as listed in Barrett and Trace (1999) multiplied by a total land base of 6,829 thousand hectares.

For our purposes, this breakdown is too detailed, with a three-sector breakdown being sufficient. In particular, we would like to estimate the available area under the following titles:

Class A: Land suitable for tillage, pasture and forestry

Class B: Land only suitable for pasture and forestry

Class C: Land only suitable for forestry.

Table 3.7:

Hectares of Soil Types In Ireland

	Tillage	*+ Pasture*	*+ Forestry*
Class 1	1,598	1,598	1,598
Class 2	799	799	799
Class 3	1,024	1,024	1,024
Class 4	0	1,502	1,502
Class 5	0	0	1,741
Class 6	0	0	0
Total	3,421	4,923	6,664

The summation of table 3.7 into these new classes is shown in table 3.8 and can be interpreted as the total potential land base.

Table 3.8:

Potential Land Use

	Class	*Tillage*	*+ Pasture*	*+ Forestry*
Class A	1, 2 & 3	3,421	3,421	3,421
Class B	4	0	1,434	1,434
Class C	5 & 6	0	0	1,741
Total		3,421	4,855	6,596

The next step is to try and estimate the total actual usage of land by type in 1993. To aid this, we assume that no land of Class A is used for forestry, and that tillage is cultivated on Class A land. Finally, we assume that one-third of forestry land is of Class B, with the remainder treated as Class C. Finally, given the price of each of the classes of land[4], we can calculate a total price for the entire stock of each class of

[4] Barrett and Trace, (1999), provide land prices up to 1997 for the six land classes listed above. These are then converted into Classes A, B and C by an appropriate area weighting.

land. Then, by applying a rate of return of 2%[5] we can calculate the expected flows from land in each of the individual industries.

Table 3.9:

Actual Land Use

	Tillage	*Pasture*	*Forestry*	*Maximum Availability*
Class A	404	3,017	0	3,421
Class B	0	983	170	1,434
Class C	0	0	341	1,741
Total Ag Use	404	4,000	511	4,915

3.4 Institutional Distribution Rows

These factor payments are subsequently distributed to the institutions, namely government, households and savings.

3.4.1 Household Income

Household income incorporates wages and profits distributed to each household as well transfers to households. It is exclusive of direct taxes.

The household income figure in A1 includes IR£6,208.20 which accrues from government current expenditure. This comprises of all the various transfers to households, a detailed list of which can be found in NIE24. The IO figure can be reconciled with the NIE24 total of IR£7,228.71 by subtracting national debt interest payments to non-residents of IR£1,020.55. Capital grants to households (also in NIE24) will be included in transfer payments. These comprise mainly of education and disability grants, and the total for this category as a whole is IR£94.4 which is

[5] This is purposely set quite low to ensure that other factors of production do not record negative value added. It can be justified on the basis that landowners expect future capital gains and are, therefore, willing to accept a lower current rental return.

included in the 'other' section, giving a total in table 3.10 below of IR£7,322.9 for 1993.

Table 3.10:

Breakdown of Government Transfer Payments, 1993[6]

	Domestic			*Foreign*
	UE/Pay Related	Other Social	Accumulated Liabilities	
National debt interest:				
paid to residents			1,121.8	
paid to the rest of the world				1,020.5
Unemployment benefit	240.0			
Unemployment Assistance	788.8			
Income Related Payments	613.9			
Old Age Payments	426.85	1280.55		
Transfers to the rest of the world				154.8
Child benefits		425.6		
Health benefits		357.7		
Housing Benefits		202.7		
Education Expenditure		597.4		
Other		92.3		
Total	2069.6	2956.3	1121.8	1175.3

Source: CSO, NIE24

Care must be taken to model these transfers appropriately. First of all the model will distinguish between social transfers and transfers which relate to the meeting of accumulated liabilities. Within the former, we should also distinguish between payments that vary with unemployment/low-pay and those that do not, and between domestic and foreign recipients. We assume that unemployment benefit, unemployment assistance and income related payments all vary with unemployment/low-pay. Some amount of Old Age Payments should also be included, reflecting the fact that the going wage rate/ level of unemployment can induce workers to take up these various schemes. Rather arbitrarily, we assume that one-quarter of all old age payments vary with unemployment/low-pay.

This disaggregation of transfer payments will allow us the possibility to hold social transfer payments exogenous, while allowing UE benefits to vary. It will also allow the possibility to explicitly model the accumulation and repayment of the national debt.

3.4.2 Calculating Marginal Propensity to Tax

Income tax in Ireland is charged under four schedules, with Schedule E accounting for the taxation of wages and salaries. The tax is charged for a year of assessment beginning on 6 April, at graduated rates. For individuals, various allowances, deductions and reliefs also graduate income tax. An important feature of the tax code for married couples was that if only one spouse is working, the two spouses' allowances could be combined. This feature was phased out beginning with the 1999 budget as it was felt that non-working spouses (usually women) were discouraged from returning to work because of being charged their husband's marginal rate of tax. The standard rate of tax (payable on the first £7,675 of tax) was 27% in 1993, while the higher rate was 48%. The first £3,600 of income was untaxed. The tax rates were the same in 1993/94 as 1992/93, though the bands and allowances were increased broadly in line with inflation.

Table 3.11: :Tax Schedule for Personal Income (1993/1994)

Actual Tot Inc	*Single Person*		*Married Couples who elect for Joint Assessment*			
			One Spouse Working		Both Spouses Working	
	Amount Tax: IR£	Effective Rate: %	Amount Tax: IR£	Effective Rate: %	Amount of Tax: £	Effective Rate: %
5,000	469.53	9.39	0	0	0	0
10,000	1,939.53	19.20	1,332.28	13.32	939.06	9.39
15,000	4,172.97	27.82	2,732.28	18.22	2289.06	15.26
20,000	6,622.97	33.11	4,132.28	20.66	3839.06	19.20
50,000	21,322.97	42.65	18,667.22	37.33	18145.94	36.29
75,000	33,572.97	44.76	30,917.22	41.22	30395.94	40.53

[6] Appendix 2 for a full definition of transfer payments.

The incorporation of income tax into the model can be done with varying degrees of sophistication. At the simplest level, the effective marginal rate of tax could simply be taken as either the upper or lower legal tax rate, depending on the average industry salary rate. At the other extreme, a full micro-simulation exercise based on the HBS database could be conducted which examines in detail the financial circumstance of each member of the household. This would allow the provision of marginal tax rates for virtually any categorisation – profession, demographic profile, family circumstance etc. A compromise will be made by the construction of a rough micro-simulation that will take account of the principal taxation rates, allowances, bands and exemptions. This exercise can be broken down into two steps. Firstly, the marginal rate of tax for each tax-unit is determined. Secondly, these figures must be re-weighted to ensure that the sample is representative of the population as a whole.

The tax unit usually chosen in such investigations comprises of an adult or married couple together with dependent children, if any. The definition of dependent children is any child under the age of 15 or still in full time education. So a household consisting of a married couple and four children under the age of 15 is one tax unit, while a married couple with three children aged 16, 18 and 19, none of whom are in full time education would be considered to comprise of four tax units. The figures presented below were calculated on the basis of the total taxation impact (including PSRI) of an increase in earned income and non-transfer related unearned income of 1%[7]. The reason for calculating these marginal and average rates is that, depending on the purpose of the simulation, we may think that particular opportunities are available only to the head of household. At the lower[8] and higher ends of the scale the difference in marginal rate of taxation is substantial.

[7] This is done by way of a simple tax model that calculates the appropriate allowances and bands applicable for each household based on the information provided for that household of the amount and type of incomes received, and the number and status of household members. So, for example, a one-person household will received the basic allowance plus (possibly) the Schedule E PAYE allowance. Given her total taxable income, we can therefore calculate whether she pays the higher or lower rate. A more complex family may received pensions, child support, non-PAYE earnings etc. A family may also contain a number of workers paying different marginal rate, resulting in a household marginal taxation rate that is between the 'legal' rates.

[8] The lowest income decile is 1, and the highest income decile is 10.

Table 3.12: *Simulated Marginal Taxation Rate by Household type Member*

Household Income Decile Ranking	*Head of Household*		*Other Household Members*	
	Average	Marginal	Average	Marginal
1	7%	27%	0%	0%
2	9%	26%	0%	0%
3	9%	25%	7%	26%
4	11%	25%	9%	26%
5	14%	27%	11%	27%
6	17%	28%	15%	29%
7	19%	28%	14%	30%
8	22%	38%	17%	31%
9	27%	43%	19%	33%
10	32%	45%	20%	33%

For the purposes of the simulations reported on in this thesis, the only figures required were the average and marginal rates of taxation for each household type independent of which member of the household earns the income. The average figures were 16.3%, 13.3% and 13.2% for urban, farm and rural non-farm respectively, while the marginal figures were 28.2%, 27.0% and 26.9% respectively.

3.4.3 Government Income

Government income is the sum of direct and indirect taxes. The former can be subdivided into personal and company taxation, the first of which is dealt with in section 3.4.2. The marginal rate of company taxation is assumed to be equal to the average rate. Indirect taxes are dealt with in section 3.5.5.

3.4.4 Company Income

Company income is not calculated directly, but rather can be deduced as the remainder of value added flows when households, government and overseas have taken their share.

3.5 The Final Demand Accounts

3.5.1 Household Expenditure

Calculation of the household expenditure figures consisted of two stages. Firstly, the total household expenditure column was calculated and then this was subdivided into the three household types, namely urban, farm and other-rural. A brief description of the steps taken follows.

The first task is to reconcile the Agro_IO (basic prices) and A2 (producers prices) tables with each other, and with table NIE13 which shows the cost of consumer goods at purchasers' prices. Unfortunately, the aggregation of NIE13 precluded a complete comparison. Here we begin with the Agro_IO figures for domestic consumption at basic prices, and compare them with the IO figures at basic prices. Hence, if we had a perfect match up of industry classifications, we would expect the difference between the two sets of figures to represent imports at basic prices. There are, not surprisingly, some mismatches.

For farm gate industries 1-10, the subtraction of the two tables leaves 250.7 of imports that must be allocated as farm gate food imports. Most of this can be accounted for by the 245.4m of fruit and vegetable imports which, when intermediate use of 6.73 has been subtracted, leaves 238.37m for household consumption.

One of the main difficulties now is the implied imports of processed meat and processed dairy products, which are –26.68 and 29.23 respectively. Unfortunately, the 1990 SA6.4 figures for Meat and meat preparations figures do not match up – understandably given the different aggregations. Therefore the route chosen was to apply the rate of increase of meat imports from 1990 to 1993 in SA6.4 (1991, 1994) (-7%) and applying this increase to the IO meat import figure for 1990.

For all other industries, namely 11–33, there are five industries with very small imports, which are assumed to be zero. Relative to 1990 imports, the movement between the two IO data sets were relatively small, with the exception of Non-metallic metals, which fell by 32% p.a. and petrol, and coal, which rose by 12% p.a.

A direct comparison with 1990 is not possible for the various services industries. The net effect of these changes is to increase household consumption of imports by 71.51m, which should not affect the results significantly.

Given this total of household expenditures, the next step was to subdivide this into the three household types. This was done by categorising each commodity as one of the ten listed in HBS-B - which lists average weekly expenditure classified by household type – and dividing the IO expenditure pro-rata between each of the household types. A full list of this commodity mapping can be found in appendix 2.

3.5.2 Marginal Household Budget Shares

The method used to calculate the household elasticities was to calculate the appropriate elasticity for each commodity listed in HBS-B and using the commodity mapping in appendix 2 to apply these elasticities to the 34 sector IO commodity group. There are two salient features of the figures that are of particular relevance to the model. Firstly, Dublin households allocate £42 a week to housing, while farm households allocate a mere £13. The widely noted empirical regularity that low income households tend to spend more as a percentage of total income on food than high income households is clearly shown, and seems to be independent of household type.

To calibrate the LES (Linear Expenditure System), three sets of data are required. Firstly, the average budget share of each good per household that is easily calculated from the expenditure data is required. Secondly, the 'Frisch' parameter, or 'money flexibility,' of each household is also required. In the LES, the income elasticity is equal to the ratio of income to supernumerary income, and is referred to here as the Frisch parameter. The larger are subsistence expenditures, the smaller is supernumerary income and thus the larger is the absolute value of income elasticity. Frisch (1959) suggests the following values:

$\omega = -10$	for an extremely poor and apathetic part of the population.
$\omega = -4$	for a slightly better off but still poor part of the population with a fairly pronounced desire to become better off

$\omega = -2$	for the middle income bracket, 'the median part' of the population.
$\omega = -0.7$	for the better-off part of the population
$\omega = -0.1$	for the rich part of the population with ambitions towards 'conspicuous consumption'.

Finally, the expenditure elasticities of each household type for each good must be estimated. The elasticities were calculated for each group by taking a point estimate of the elasticity based on the change in expenditure in moving from one decile to the next, and than averaging these nine point estimates. This implied Frisch parameters of –1.79 for urban households, -1.45 for rural farm households and –1.60 for rural non-farm households.

3.5.3 Gross Fixed Capital Formation

The available IO tables for Ireland give the nominal expenditure on Gross Fixed Capital Formation (GFCF) of each commodity. From these figures, the amount of domestic versus imported GFCF can be derived. However, we need these figures by industry, so that we have (say) the amount of investment by industry *i*, using commodity *j* which is sourced from *s*. Given that the model is static, this capital investment has no direct implications for production in the investing industry, so the figures are not of critical importance.

This first 34*34 matrix is formed on the basis of total investment flows, therefore excluding tax and excluding margin flows. It takes the amount of additions to capital assets in CIP1993, Table 19, in each of the two sectors Plant, machinery, equipment & vehicle and Buildings & other construction work, and applies the proportions of investment by industry implicit in these figures to distribute investment in machinery and construction. Other investment is distributed on the basis of an average of the two. The reason why the total figures from CIP19 exceed those in the IO tables is that CIP19 includes purchases of second hand goods, such as buildings, while IO only considers the formation of new units of capital. Therefore the method implicitly assumes that new (say) buildings are bought in the same proportion as second hand buildings by all industries.

3.5.4 Export Demand

The total exports vector is subdivided into merchandise and invisible exports in Agro_IO. A slight modification was implemented by dividing exports into three destinations, namely UK, EU excluding the UK, and the rest of the world. This was only done for relevant agricultural exports to allow for a correct treatment of agricultural supports. In particular, the sectors that were disaggregated were cattle, sheep & pigs, poultry & horses, dairy exports and total processed meat. The aggregate export figures as taken from the Compendium of Agricultural Statistics were substantially lower in each of the sectors than the corresponding Agro_IO entries. It is not particularly clear why this might be the case.

3.5.5 Indirect Taxation

This section discusses how taxes were apportioned. First, note from Agro_IO that the sum of the totals for Taxes Linked to Production (ex. VAT), Net Taxes Linked to Imports (ex. VAT) and Vat on Products is IR£4,900.87m, the same as the total for indirect taxes for intermediate and final demand in A1. A large portion of this is accounted for by indirect taxation on household consumption of IR£2,791.20m which includes a significant portion of total custom and excise revenue. Further, the total tax linked to production in A1 of IR£1,396.59 is broken down into the full 33-industry list.

The initial approach taken to try and solve for the various tax matrices was in isolation with the aid of various data sources. Then numerous target values were compared with the result of the estimation procedure to check how reasonable the results were. For example, in the estimate of household expenditure tax, various VAT estimates from the ASI and estimates of household expenditure contained in NIE13 were used. Generally, it proved extremely difficult to come close to some of the targets.

For the most complex table, the taxes on intermediate flows, perhaps the most obvious approach was to get the difference between the flows at basic prices and

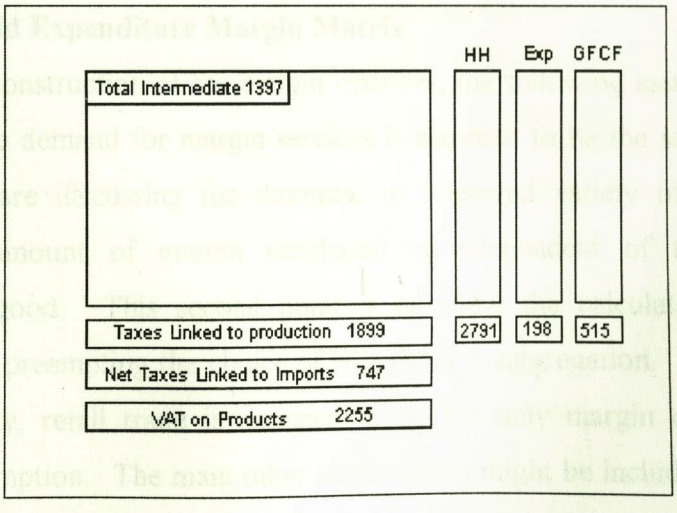
producer prices. In practice, however, this resulted in two large problems, namely the existence of numerous negative entries, and row and column sums that seemed to bear very little relation with any total figures provided in the IO tables themselves.

The approach that was finally used was more mechanistic but has the great advantage that it satisfies the appropriate column and row sums. A brief description of the steps is as follows:

- **Step 1:** From figure 1, we firstly note that the sum of the four columns Taxes linked to production, net taxes linked to imports, Vat on products *by industry* and intermediate production will equal the corresponding row sums for all intermediate and final demand by industry.

Figure 3.3:

Representation of 1993 Input-Output Flows



Source: Input-Output Tables, 1993, CSO.

- **Step 2:** A RAS procedure was implemented to arrive at the 33*4 matrix consisting of industry-by-final demand usage. It was based on the column and row sums and used the underlying 'basic' flows as the initial coefficient matrix. So, for example, the answer ensured that taxes paid by sales of (say) dairy were correct, and that the amount of tax paid on exports was correct at 198.

- **Step 3:** Step 2 provides a 33*1 column of intermediate industry tax. We have from Ag-IO the corresponding 1*33 row vector. To reconstruct the 33*33 intermediate tax matrix, we again apply the RAS procedure based on these column and row sums and use basic intermediate flows as our initial coefficient matrix.
- **Step 4:** Finally, where appropriate, these various tax matrices were divided into import/domestic flows on a pro-rata basis.

3.6 Margin Matrices

We will restrict attention for the purposes of margin matrices to two final demand sectors, namely household consumption and exports. Government demand does not contain any margin commodities *per se*, as margin sectors are all catered for in the inter-industry matrix. It is also assumed that changes in inventories do not require margin commodities.

3.6.1 Household Expenditure Margin Matrix

To simplify the construction of the margin matrices, the following assumptions were made. Firstly, the demand for margin services is assumed to be the same regardless of whether we are discussing the domestic or imported variety of the product. Secondly, the amount of margin purchased is independent of the household purchasing the good. This second point is to allow the calculation of margin matrices without preempting the choice of household disaggregation. Finally, for the sake of simplicity, retail trade is assumed to be the only margin commodity for household consumption. The main other sector which might be included as a margin commodity would be transport, both internal and overseas. It would be difficult to disentangle personal travel from margin demands for these commodities.

The total of IR£2,249.97 for wholesale trade in matrix A1 consists entirely of retail trade as consumers are assumed not to buy *wholesale and repairs*, which can be seen to have zero household consumption from the IO table.

While data on gross retail trade are available for 1993, they are not provided in the sectoral detail that is required. The next best set of figures comes from the 1991 Annual Services Inquiry. A table of gross margins from this survey is shown in table 3.13 below. Note the gross margins figures are expressed as a percentage of 'Purchases of Goods for Direct resale excl VAT' as this corresponds to our figures for total household consumption. So, for example, the margins associated with petrol stations are relatively low (13%). On the other hand, it should also not be surprising that Public Houses margins are the highest at 48%. To understand why this is the case, think of £20 of petrol sold to one individual - the transaction takes place within minutes by self-service in a drive by station. On the other hand the publican, for every £20 of alcohol sold per person, must also provide a few hours worth of communal area to consume the alcohol that incurs a high cost in terms of staff, rent and fittings.

Table 3.13:

Retail Trade Gross Margins 1991

	Turnover (ex VAT)	*Purchases of Goods for direct resale (ex VAT)*	*VAT*	*Turnover (incl VAT)*	*Purchases of Goods for direct resale (ex VAT)*	*Gross Margin*	*Gross Margin as a % of (2)*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Grocery	2859	2311	248	3107	2511	558	22%
Grocery with Pub	147	117	22	169	135	30	22%
Pub With Off-License	916	580	181	1097	695	336	48%
Tobacco, sweets and newspapers	285	227	41	326	260	59	23%
Fresh Meat	277	204	2	279	205	73	36%
Other Food, drink & Tobacco	294	234	15	309	246	62	25%
Garages/Filling Stations	2054	1774	389	2443	2110	270	13%
Chemists	304	215	22	326	231	90	39%
Hardware	252	189	47	299	224	66	29%
Electrical Goods	197	145	39	236	174	52	30%
Drapery and Apparel	797	548	96	893	614	260	42%
Footware	107	74	11	118	82	34	42%
Other Non-Food	867	622	140	1007	722	255	35%
Total	9356	7240	1253	10609	8208	2145	26%

Source: SA7.1

Table 3.14 below gives the allocation of these margins to the total household consumption in 1993. Firstly, no retail margin is present with services industries, food consumed on farm and the sector 'electricity, gas and water'. We can be fairly confident in our allocation of retail margins as the figures display quite a clear pattern. Firstly, food and drink margins represent around 22% of sales except in specialist shops like butchers (36%), pubs (48%) and chemists (39%). Non-food items display higher margins of around 40% with the exception of petrol (13%).

The resultant figures for margin use were then summed to get IR£2,982.6, well in excess of the target value of 2,249.97. The figures were then compared with the more aggregated published figures for 1993 that seemed to indicate that the estimate for beverage and tobacco was too high.

Table 3.14:

Application of Gross Margins to IO Sectors

IO sector	*Sales*[3]	*Margin Sector*	*% of Total Sales*	*Margin use*
Fruit + Vegetab.	352.0	Grocery	22%	77.4
Petrol.+Coal	750.2	Garages/Filling Stations	20%	150.0
Non-Met.Min.	77.4	Other non-food	35%	27.1
Chemicals	370.6	Other non-food	35%	129.7
Metal,Eng.,Veh.	961.7	Hardware, Electrical & Cars[1]	32%	307.8
Meat	600.8	Fresh Meat, Grocery	26%	156.2
Milk Prods.	471.4	Grocery	22%	103.7
Other Food nes	1140.3	Grocery	22%	250.9
Beverag.+Tobac	2117.4	Pub	48%[4]	386.0
Textil.Cloth.Lea.	1057.8	Drapery & Apparel, Footware	42%	444.3
Wood+Paper	618.8	Other non-Food	35%	216.6
Rubb.Plast.,O.M	293.2	Other non-Food	35%	102.6
Total	8811.6		36%	2982.6

1 It is assumed that car sales margins – which are not accounted for in table SA7.1 - are 35%.

2 A weighted average of 15% for petrol and 35% for coal.

3 Taken directly from IO3

4 Not used.

This figure was then replaced by the 1990 figure, with an appropriate allowance for inflation. With this change, the total falls to 2,352.3, very close to the required total. The figures in Table 3.14 were then proportioned downwards to satisfy the IO total, and these margins were then applied proportionally to domestic and imported to arrive at household margins for each flow.

3.6.2 Gross Fixed Capital Investment (GFCI) Margin Matrix

For the GFCI Margin Matrix we assume that the amount of margin purchased is independent of which industry is investing. Wholesale/Retail trade, and Marine, air & auxiliary transport are assumed to be the two margin commodities used. Both are zero for imports, so we assume that they only apply to domestic use of GFCI.

In terms of the distribution of Wholesale/Retail trade, the approach followed will closely match the methodology in relation to Household margins, with the exception of course that the relevant comparison is with wholesale trade, not retail trade. These figures (which correspond with those in table 3.16) are shown in table 3.15. Note the limited number of sectors. This reflects the fact that GFCI is relatively concentrated – 90% of domestic demand is for construction. The results show that applying the wholesale margins leads to a gross over estimate of margin use (IR£834 compared to our control total of IR£282.1). Therefore, in the last column of table 3.16 our estimates are rescaled to equal IR£282.1.

Given that there is such a difference between our control total and our calculated total wholesale margin use, it is not unreasonable to question the reliability of our results. The reason that they are so 'off' is that most (say) construction materials will not come through traditional wholesalers, but will rather be purchased in bulk directly by the builders. Why retain these figures then? Firstly, because we have little other guidance as to what margins might be. Secondly, because we suspect that the *relative* margins implicit in the ASI figures (see table 3.15) do tell us something about differences in wholesale margins. The IR£7.4m use of *marine, air & auxiliary transport* in GFCI we assume to be linked solely to construction.

Table 3.15:

Wholesale Trade Gross Margins 1994

	Turnover (ex VAT)	*Purchases of Goods for direct resale (ex VAT)*	*VAT*	*Turnover (incl VAT)*	*Purchases of Goods for direct resale (inc VAT)*	*Gross Margin*	*Gross Margin as a % of (5)*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Builders' Materials	728	547	142	870	654	199	30%
Hardware and Electrical	528	405	102	630	483	124	26%
Motor & Non-Ag Machinery	1812	1454	347	2159	1732	422	24%
Agricultural machinery	173	145	32	205	172	34	20%
All Other Non-food	3530	2695	529	4059	3099	854	28%
All Business	11596	9147	1679	13275	10471	2583	25%

Source: ASI7

Table 3.16:

Application of Gross Margins to IO Sectors

Merchandise List	*Domestic*	*Margin*	*Margin % of*	*Predicted*	*Rescaled*
	Flows	Sector	Total Sales	Margin use	Margin Use
Non-Met.Min.(13)	7.2	All Other Non-food	28%	2.0	0.68
Metal,Eng.,Veh.(15)	253.9	Motor, Non-Ag Machinery	24%	60.9	20.54
Textil.Cloth.Lea.(21)	3.3	Clothing, footware	28%	0.9	0.31
Wood+Paper(22)	6.0	All Other Non-food	28%	1.7	0.57
Rubb.Plast.,O.M(23)	11.2	All Other Non-food	28%	3.1	1.05
Construction(24)	2551.1	Builders Materials	30%	765.3	258.06
Total	2832.7			834	281.2

3.6.3 Exports Margin Matrix

The margin commodities for exports are Wholesale/Retail Trade and Marine, air and auxiliary transport. The other obvious possibility, internal transport, is already incorporated into inter-industry flows, and as such as a zero entry in the merchandise export column. We are given in F1 the use of these two industries in merchandise exports.

The first simplification employed is to assume that Wholesale/Retail Trade margins are a fixed proportion to the value of export. However, this rule of thumb is clearly not satisfactory for transport costs which depend on the product's weight, its

perishibility and its fragility. Secondly, the transport figures reflect purchases of Irish transport services by export industries. Therefore we need to assume that Irish (as opposed to overseas) providers of transport services are not dominant in the transport of one product, with a relatively smaller share in other products. Thirdly, the only information we have is from RFTS8, which refers to road freight related to international journeys. We must therefore assume that the costs of intra-national transport are proportional to costs of inter-national transport, with both being determined by the 'bulkiness' of the product. Fourthly, RFTS8 does not distinguish between imports and exports. Therefore we must approximate transport costs based on a sum of imports and exports, and then proportionally allocate costs to exports. This will yield as a by-product the transport costs related to imports, which are discarded. Fifthly, following from the last point, we must assume that the 'bulkiness' of exports from an industry is the same as the 'bulkiness' of that industry's imports. Finally, we have no estimate of 'fragility' or 'perishability', so we must assume that transport costs relate only to weight.

The application of the method is shown in table 3.17. Each IO sector is matched with one of the five sectors shown below (see appendix 2 for this mapping). In columns (1) to (3) we have the value of exports, imports and total international trade from the IO table F1, summed into the five sectors. The recorded tonne-km million from RFTS7 are shown in column (4). Dividing value (3) by (4) gives the price of each category by tonne-km million. Ideally, this would be by tonne-million. We must assume therefore that the distance traveled by each commodity is the same. In column (6) we divide the previous column proportionally to separate out exports from total trade. Column (6) is translated into the column of transport margins in F1 based on a proportionate allocation of total transport costs from the IO table. Within sectors (which are aggregated in Table 3.17), the assumption is made that transport costs are proportional to value.

Given the plethora of restrictive assumptions employed in the calculation of column (5), it is reassuring to note that the figures are intuitively appealing. Our interpretation of them is that a tonne of Agri-products/Live Animals is only worth

one-tenth (or 10.84/101.31 to be exact) of a tonne of chemicals. Between these two extremes are Foodstuffs/Animal Fodder and Other which comprises of the bulk of exports.

Table 3.17:

Calculating the Tonnage of Merchandise Exports

	Export	*Import*	*Int'l Trade (Value)*	*Tonne-km million*	*Price per tonne-km*	*Tonne-km (exports)*
	(1)	(2)	(3)	(4)	(5)=(3) / (4)	(6)
Agri-products / Live Animals	436.91	311.37	748.28	69	10.84	40
Foodstuffs / Animal fodder	5064.86	911.76	5976.62	237	25.22	201
Chemicals & Fertilisers	3214.9	736.34	3951.24	39	101.31	32
Other	9021.78	6403.01	15424.79	529	29.16	309
No Transport Cost	0	163.01	163.01	0		0
Total	17738	8525	26264	874	30.05	590

3.7 The Common Agricultural Policy

The method for the modelling of the Common Agricultural Policy is dealt with in three different sections contained in different chapters. In Chapter 2 the structure of the underlying model was discussed, including the treatment of both direct and indirect subsidies. In the two simulation chapters, namely chapter 5 and chapter 7, the model closure for each simulation is discussed. So, for example, we might choose to hold the price of milk constant while letting the rate of 'subsidy rent' change as input costs vary. Or, we might choose to endogenise the rate of export subsidy to ensure that the export price falls by (say) an exogenous 29%. This section deals with the data required for implementing the direct subsidies and price subsidies.

In practice, a minimum price floor was achieved by the CAP via an import levy which prevented non-EU countries selling below the floor price, and export subsidies which ensured that farmers received the artificially higher internal EU price, even

when they sold to non-EU markets. This thesis ignores the allocation of import duties, for the simple reason that Ireland is a very large agricultural producer and is a large net exporter. Export subsidies are treated as a price wedge between the price actually paid by non-EU purchasers and the price that is actually received by farmers. The export subsidy figures are shown in table 3.18 and are culled from the Compendium of Irish Economic and Agricultural statistics (1997).

Therefore the difference between the producers' price and the purchasers' price is equal to margin costs plus indirect taxation (if any) minus subsidy (if any).

Table 3.18:

Allocation of Subsidies Among Sectors

	Export Subsidies	*Direct Subsidies*
Dairy	92.76	45.98
Beef	335.94	202.91
Sheep	0.00	181.24
Other Livestock	2.19	1.61
Cereals	5.62	0.39
Fruit & Veg	0.00	0.30
Root & Green	0.00	0.27
Other Crops	0.00	0.06

Source: Compendium of Irish Economic and Agricultural Statistics (1997)

Direct payments are dealt with as subsidies to land. As discussed in more detail in chapter 3, for each direct subsidy, the rent paid to the owner of land is greater than the rent that accrues from the farming activity to the extent of the subsidy. The figures provided in the Agro_IO tables do not actually match up with the corresponding figures in the published NIE tables because the Agro_IO table figures relate to flows actually received in the relevant timeframe while the figures given in NIE are calculated on an accruals basis. As mentioned at the beginning of the chapter, we will maintain the principle of assuming Agro_IO is correct for the purposes of consistency. No forestry subsidies are recorded in Agro_IO, so they are ignored.

3.8 The Model Parameters

3.8.1 Elasticities of Substitution Between Primary Factors

There are two sets of substitution elasticities that need to be specified. The first set of elasticities required for the model describes the degree of primary factor mobility, which describes the ease with which particular industries can substitute one primary factor aggregate (e.g. capital) for another (e.g. labour). Asuming that output in a sector is unchanged, if the elasticity is close to zero, then a change in price differentials for primary factors will not induce a large substitution from one factor to another within that industry. On the other hand, if the elasticity is large, then a small change in the relative price of (say) capital could induce a large change in the nature of factor supply to the sector, while maintaining the same level of output. The elasticities chosen were taken from Dimaranan, McDougall and Hertel (1998) for use in the GTAP model. They are shown below in table 3.19 for the 34 industries in the model.

It is important to note that specifying the elasticities of substitution between factors of production at the level of the production function is not the same thing as specifying the degree of factor mobility between sectors. This also depends on:

- Closure Rule: To the extent that capital, labour or land are fixed by sector in a simulation, factor mobility between sectors is reduced.
- Factor mobility between sectors also depends fundamentally on the make up of the primary factor aggregates of labour, capital and land. This in turn suggests an important potential role for the elasticity of substitution within primary factors. If the aggregate labour demand of (say) *lodging and catering* consists entirely of hotel workers, and the aggregate labour demand of *cattle farming* consists entirely of labourers, then the possibility of mobility between the two industries depends on the extent to which labourers can retrain to become hotel workers or vice versa. This could either be done via an elasticity of transformation of labour skills, completely free mobility, or specifying supply elasticities for each occupation.

Therefore the extent of factor mobility between sectors depends firstly on the degree to which factors are specific to sectors, and secondly to how easily these factors can morph into a form more suitable to a new industry if required.

3.8.2 Elasticities of Substitution Within Primary Factors

The next requirement is the specification of pair wise labour-labour substitution elasticities and pair wise land-land substitution elasticities. While there are a number of studies that attempt to measure the former, very little evidence exists to estimate the latter. Tinbergen (1975)[9] concludes that the evidence for pair-wise labour/labour substitution elasticities is not inconsistent with a unitary elasticity.

For land-land elasticities, the magnitude of substitution elasticities must reflect the fact that the classification adopted in section 3.3.3. already pools together land of quite differing quality. Class A incorporates land with no limitations on use to land with a 'somewhat limited use range'. Class B includes land that has a limited use range and in the wording is "permanently unsuited to tillage but suited to a permanent grassland system", while class C incorporates land with very limited uses and land with soils whose productive potential is virtually zero. In the model it is assumed that Class C is only used in forestry. Therefore the necessary parameterisation effectively is between Class A and Class B in each industry. On this basis, the following elasticity values were chosen:

Table 3.19: Pair wise Land-Land Substitution Elasticities

	Elasticity Value
Milk	0.5
Cattle	0.5
Sheep & Wool	0.5
Other Livestock	0.5
Cereals	0.0
Fruit & Veg	0.0
Root & Green	0.0
Other Crops	1.0

[9] Cited by Dixon et al (1980).

3.8.3 Armington elasticities

The so-called Armington elasticities measure the substitutability between domestic and imported goods. In the model, three such vectors of elasticities are required as there are three import competing uses of commodities – in intermediate production, in the production of investment goods and finally household consumption, and are assumed to be the same for all three sources of final demand. These elasticities are also taken directly from Dimaranan, McDougall and Hertel (1998) and are shown below in table 3.20. The elasticities of substitution between primary factors are denoted by σ_{VA} where VA stands for Value Added, while σ_D denotes the Armington elasticities.

Table 3.20: Substitution Elasticities

Industry	σ_{VA}	σ_D		σ_{VA}	σ_D
Milk	0.24	2.8	Animal Feed	1.12	2.2
Cattle	0.24	2.8	Other Food	1.12	2.2
Sheep & Wool	0.24	2.8	Bev & Tob	1.12	3.1
Other Livestock	0.24	2.8	Textiles	1.26	4.0
Cereals	0.24	2.2	Wood & Paper	1.26	2.3
Fruit & Veg	0.24	2.2	Rub & Plas	1.26	1.9
Root & Green	0.24	2.2	Construction	1.40	1.9
Other Crops	0.24	2.2	Trade marg	1.68	1.9
Forestry	0.20	2.8	Lodg & Cater	1.26	1.9
Fishing	0.20	2.8	Transport	1.68	1.9
Pet & Coal	0.20	2.8	Sheep Meat	1.12	2.2
Elec & Gas	1.26	2.8	Commun	1.26	1.9
Non-Met	1.26	2.8	Credit	1.26	1.9
Chemicals	1.26	1.9	Other Serv	1.26	1.9
Metal	1.26	3.2	Publ Serv	1.12	1.9
Meat Products	1.12	2.2	Anim Meat	1.12	2.2
Milk Products	1.12	2.2	Dwellings	1.26	1.9

3.9 Concluding Remarks

This chapter has explained the data requirements for CGE models of the type employed, and explains the process used to reconcile the (at times conflicting) data

from the various input-output sources. The chapter continued by explaining in some detail the methods used to extend the existing data set so as to arrive at a detailed breakdown by occupation type, by household type and by land type. A separate section was devoted to issues behind the allocation of subsidies to ensure an adequate modelling of the Common Agricultural Policy. Finally, the choice of model parameters was explained.

CHAPTER 4

THE MACSHARRY REFORMS OF THE COMMON AGRICULTURAL POLICY

4.1 Introduction

The main aim of this chapter is, in a comparative static, general equilibrium framework, to measure the impact of the MacSharry reforms on the Irish economy. In published CGE models, investigating the impact of a policy reform is usually approached by the construction of various scenarios, the results of which are then discussed. This is a very simple, effective device for explaining the key elements of a voluminous set of results, and its popularity is well merited. However, in the background of such a set of simulations must be the idea that the form of the original model was originally tested as a stand-alone set of results. As CGE models cannot be statistically tested, the credibility of the model results depends on an assessment of the 'reasonableness' of results. While this is not scientifically objective, it is currently the only workable performance criterion. The purpose of this chapter is to present a detailed representation of the model results as a way of illustrating how the model works.

The second aim of this chapter is in the separation of the partial equilibrium effects from the general equilibrium effects of the reform. The purpose is to identify the importance of general equilibrium transmission mechanisms not captured in partial equilibrium analyses. In this section, we explicitly decompose a general equilibrium elasticity into its component parts. The results indicate that the 'bounce effect' whereby changes in agricultural prices have an indirect effect on output in agriculture via a disturbance in non-agriculture factor and commodity markets can be very large.

Finally, the third aim of this chapter is to conduct a sensitivity analysis on the model results in an effort to ascertain how sensitive simulation results are to key parameter values and closures. This sensitivity analysis is done in the context of an examination of the impact on the economy of the 2001 Foot and Mouth disease outbreak which paralysed Irish tourism and agriculture for a brief period in 2001.

The chapter is constructed as follows. Section 4.2 discusses the MacSharry reforms in cereals and beef. Each commodity/industry is discussed in terms of the market background at the time of the reform, a discussion of the nature of the actual reform and a discussion of how the reform is implemented in the model including a brief discussion of the economic environment (i.e. closure) under which the simulations were run. The simulation results are discussed in some detail, both in terms of the macro results for the economy as a whole together with impacts on a sector-by-sector basis. Section 4.3 details the methodology and application of a numerical comparison of partial and general equilibrium methodologies, while section 4.4 discusses the sensitivity analyses conducted.

4.2 Modeling Reform of The Common Agricultural Policy

4.2.1 Introduction

The basic structures that would subsequently develop into the Common Agricultural Policy can be seen in the proposals in January 1962 of the following mechanisms for cereal support (Tracy, 1997):

- *Target Prices:* In practice these ceased to have significance other than as a stage in calculating the other elements.
- *Intervention prices:* Floor prices at which intervention agencies stand ready to buy produce.
- *Threshold Prices at the Common Frontier:* These are, in effect, minimum import prices, with variable import levies preventing imports from entering below the threshold prices.
- *Export Subsidies:* These refunds bring the price of exports down from the internal market levels to levels on export markets.

After the initial setting of prices, they were then subject to annual determination by the Council of Ministers. The inflationary background of the 1970s and early 1990s induced sharp price increases for agricultural products, resulting in a growing problem of overproduction in Europe. Technological advances on the farm exacerbated this problem. Consumption, however, grew much more slowly. At first this was not a problem, resulting merely in the EU's greater self-sufficiency, though soon afterwards market balance had to be attained through costly intervention and export refunds. One of the major resultant strains brought about by the CAP was on the EU budget. In 1988, with a view to greater budgetary discipline, an agricultural guideline that limited growth of agricultural expenditure to a maximum level, backed up be market stabilisers, were introduced.

4.2.2 MacSharry Reforms

Traditionally, all producers, regardless of size or volume of output, have benefited substantially from high levels of internal prices. In 1992, the MacSharry reforms broke the link between price support and production, levels of support were reduced and compensation was paid to farmers on a per hectare or per animal basis. Extensification and the use of production processes that protect the environment were also encouraged under the agri-environmental accompanying measure.

The 1992 cereals reform saw intervention price cuts of 29% over three years with compensation paid on a per hectare basis. This compensation was made available unconditionally to small producers. Commercial producers would only get compensation if they set aside part of their land, with the rate being set initially at 15%. The compulsory set-aside rate was subsequently reduced to 10% for the 1996 crop as a result of much firmer market prices, and subsequently to 5% for the 1997 crop.

For beef, the intervention price was reduced by 15%, while the scope of beef intervention was also restricted. By way of compensation, existing direct compensation was increased. A special premium for young male cattle became

payable twice in the life of each animal rather than at slaughter. A deseasonalisation premium was introduced in Ireland and Northern Ireland. The rate of the suckler cow premium was also gradually increased.

For milk, the quota system was extended to 2000, with the principal change being the abolition of the co-responsibility levy. A provision also existed for a 1% cut in milk quota but this was not implemented.

Before we begin, we must note a potential flaw on the current model structure – in the default closure all *ad valorem* subsidy rates (relating to both export and direct subsidies) are fixed exogenously. Thus, the *ad valorem* subsidy (in absolute terms) changes as the size of the nominal flow changes, whether due to price or volume changes. However in the CAP, subsidies are tied to real output, not to nominal output. For the purposes of the current simulation, this does not pose a problem. For direct land subsidies we target total subsidy amounts to be paid rather than a particular *ad valorem* or headage payment. For exports, prices are (more or less) set exogenously, so using an *ad valorem* rate to target a rate that varies with output does not require any change in the model or the closure.

It is difficult *ex-ante* to anticipate the model results. The level of direct aid was set so as to fully compensate farmers for changes in prices. Therefore output (with the exception of cereals) was expected to be largely unchanged, as the reforms did not seriously attempt to decouple support from production levels. The routes that influence is likely to come therefore are essentially general equilibrium in nature, and therefore hard to predict *a priori*. In the case of Ireland, there is a switch from payment of aid to farmers from consumers to tax payers, though since both groups are effectively outside Ireland, this is not expected to have a large impact. Also, the nature of aid from taxpayers is also switched from price supports for exports towards direct payments.

4.2.2.1 Modelling Reforms of Cereal Production

Modelling Price Movements

Intervention prices were maintained through a system of variable import levies and intervention buying. The measurement of the impact of the reforms is complicated by the fact that it was an EU wide reform but we have no EU model, only a model of Ireland. In the absence of a fully specified EU wide model we have to make assumptions regarding EU wide supply and demand curves. As a starting point, we assume that Ireland is too small in size relative to the rest of Europe to impact on output and input. Secondly, for the purpose of the simulation it will be assumed that the planned reduction in the intervention price of 29% is reflected in an actual reduction in the market price of the same amount. An alternative approach would be to "borrow" the result of a full EU model simulation such as by Meyers, W., Helmar, M. and Hart, C., (1998).

The reduction in price is imposed on cereal prices as follows:

Price Changes

```
shock     f_t4exp 73     =     -29.000;     !Change in Export Subsidy Rate
shock     pf0cif 5       =     -29.000;     !Change in Import Price
```

Modelling Direct Aids

Arable Direct Payments were introduced in the cereals sector to offset income effects due to support price reductions. There are two area constraints, firstly the base area constraint whereby payments were calculated on the basis of historical average yields limited to a historical base area, and secondly the set-aside constraint.

Compensatory payments are only granted for an area that does not exceed a regional base area. The regional base area is defined as the average number of hectares in the region devoted to arable crops in the base period. The base area can also be determined at the level of the individual farmer, but no country has taken up this option. If claims are made for an area of land greater than the base area, then the area for which subsidies is requested is reduced in proportion to the excess area. The

set-aside rate was to be fixed annually by the Commission, and was initially set at 15% for compulsory set-aside.

The system of direct aids is modelled explicitly in the model as a land subsidy whereby the optimal amount of land is determined as a function of the crop price, the market price of land minus the amount of the subsidy, and the cost of the various intermediate inputs. Given that subsidies account for around 100% of cereal farmers' incomes, non-participation is not really an option, and therefore is not incorporated in the model.

There are two further considerations when discussing the set-aside rate (which will be fixed exogenously). Firstly, the presence of the simplified scheme for small farms for which there is no requirement to set-aside land reduces the amount of land actually set-aside. Secondly, the 'slippage effect' of low quality land with relatively low yields being used for set-aside must be accounted for, although this is countered in the EU by the requirement to rotate the land set-aside. These are incorporated implicitly by implementing a rate of set-aside of 12% that is 3% lower than the 'legal rate'. This is implemented as a productivity shock for land in cereals. As can be seen in equation *E_x1lnd_l* (which is reproduced below) the technology shift variables are interpreted as meaning the amount of additional land that is required to produce each unit of output. Therefore a *positive* value implies more land is needed for each unit of output and is interpreted as a deterioration in technology.

Equation E_x1lnd_l # *Industry demands for land* #
(**all**,i,IND) x1lnd_l(i) - a1lnd_l(i) = x1prim(i)

shock a1lnd_l 5 = 12.000; !Cereals

The second element of the reform package is the direct payments that are received by way of compensation for the fall in price. The rate of subsidy is 207 ECU/ha, which given the land under cereals in the base year of 280,000ha, an ECU/IR£ conversion rate of 1.2517 and a base line flow accruing to land of IR£40.90m in cereals production suggests a rate of direct subsidy to land of 113.227%. In terms of the

model we actually impose the increase on the subsidy bill rather than flows to land, with the rate of subsidy moving endogenously to ensure our target is hit. Given that in the base year data there was only £1 of subsidies to land under cereals in the base data set, this translates into an increase of 4631% in the amount of subsidy.[1]

Targeting of Aggregate Cereals Subsidy Bill

```
swap      f_tllnd_l 1-9   =   wlsub_lnd 1-9;
shock     wlsub_lnd 5     =   4631;
```

4.2.2.2 Modelling Reforms of Beef Production

One problem that arises is that the commodity meat products are a composite of processed beef (supplied by industry 2), processed sheep meat (industry 3) and processed meat from other animals (industry 4). This presents obvious difficulty.

It was decided to disaggregate the data set so as to subdivide meat processing into three separate processing industries. This was done via a TABLO file, and is almost entirely mechanical in that inputs and outputs are divided pro rata as a proportion of the inputs of each of the primary sectors into the processing sector. The only deviation from this pro-rata rule is to assign intermediate supplies of the output of cattle farms to the cattle processing industry, intermediate supplies of the output of sheep farms to the sheep processing industry and intermediate supplies of the output of other livestock farms to the other livestock processing industry.

Table 4.1

Breakdown of Inputs into Meat Processing

1993	*£ million*	*Share*
Meat Processing	1,575.31	100.000%
Cattle	1,115.50	70.811%
Sheep	164.00	10.411%
Other Livestock	295.81	18.778%

[1] This method is not entirely accurate as it assumes that the area under cereals does not change in

Modelling Price Movements

We follow Weyerbrock (1998) in modeling trade policies as exogenous or endogenous price wedges. Variable export refunds are modelled as the gap between the actual price of a commodity and its world market price.

The price of cattle falls by 15% due to a fall in the export price both within Europe (due to a fall in demand curves) and outside Europe (due to a cut in export subsidies). As the beef processing industry is assumed to be perfectly competitive, it only earns normal profits, so the change in the cost of inputs must be equal to the change in the value of outputs. Given that 64.824% of the initial budget of the beef industry is spent on cattle, the fall in cattle prices of 15% translates to a fall in beef prices of 15% * 64.824% = 9.724%. Therefore we will assume the price of exports from the meat processing industry falls by 9.724% as a result of the reforms.[2]

Modeling Direct Aids

We treat all relevant premia as a land premium that can only be drawn upon by cattle farmers. The reason for this is that while many EU payments are headage payments which relate to the number of animals a farmer has, they are also tied to minimum stocking rates per acre, which means that they are in effect subsidies to land. When simulating a change in these payments, we need to assume that relative stocking rates per farm are fixed, as the extensification criteria are measured on the farm rather than the national level. In terms of deciding the rate of subsidy, we target the estimated bill of £141m. This is equal to 69.2657% of 1993 land subsidy levels.

The shocks are implemented as follows:

Export Subsidy Changes

shock	f_t4exp 70	=	-15.000;	!Beef Farms
shock	f_t4exp 84	=	-9.724;	!Beef Processing

---

response to the shocks in the scenario.

Export Demand Curve Shifts

shock	f4p_d 2	=	-15.000;	!Beef Farms
shock	f4p_d 16	=	-9.724;	!Beef Processing

Import Prices

shock	pf0cif 2	=	-15.000;	!Beef Farms
shock	pf0cif 16	=	-9.724;	!Beef Processing

Direct Payments

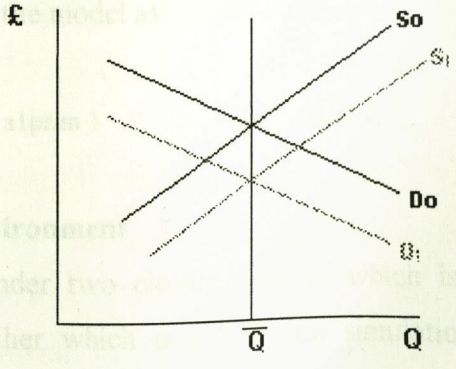
swap	f_tllnd_l 1-9	=	wlsub_lnd 1-9;
shock	wlsub_lnd 2	=	69.2657;
shock	wlsub_lnd 5	=	4631;

4.2.2.3 Modeling the Milk Quota

While reform of the dairy market was not on the agenda for the MacSharry reforms, the importance in an adequate modeling of the sector is clear given the importance of the dairy industry in Irish agriculture. The milk quota was introduced in 1984 to curb the growing cost of the EU's agricultural support budget. Since then the milk quota has remained virtually unchanged, though some alterations such as making access to a quota more 'tradeable' between farmers were introduced.

Figure 4.1

Modeling of Milk Quota



[2] This assumes that international beef plants have the same cost structure (i.e. cost of cattle as a proportion of total costs) as Irish plants.

The first point to note is that to correctly model the quota rent, we do not need to explicitly value that rent in the base year. It suffices to say that the primary factors in dairying produce an income flow – the fact that the value of this flow is higher than would otherwise be the case in the absence of the quota is irrelevant. Put another way, if we were to judge all (say) capital in all industries by their replacement cost, we would find in a perfectly mobile capital market that all capital would have the same return with respect to replacement value with the exception of dairying which would enjoy an artificially greater flow.

The approach taken to modeling the quota in the model as the demand curve for farm milk shifts is based on the same reasoning - we allow endogenous shifts in the supply curve to ensure that output remains at Q. In terms of the model code, this means endogenising *a1prim(i)* which is the technology shift variable for the use of primary factors in industry *i*. So, for example, a value of 10% implies that 10% more is needed of the primary factors of production to produce each unit of output. This can be seen from figure 4.1, which shows that the downward shift in the demand curve results in an endogenous deterioration in the quality of each physical unit of primary factor used in the production of milk such that the amount of milk output remains unchanged. Conversely, an upward shift in the demand curve results in an endogenous improvement in the quality of each physical unit of primary factor used in the production of milk such that the amount of milk output remains unchanged.

This is implemented in the model as:

```
swap      a1prim 1      =      x1tot 1;                    !Milk
```

4.2.3 Economic Environment

We run the model under two closures one of which is intended as a short run simulation and the other which is a long run simulation. As the names might suggest, the primary difference between the two lies in the ability of capital to move between industries in search of the highest possible return. In choosing an appropriate economic environment we must close both the supply and demand sides

of the model. In terms of the former, each of the primary factors has a different treatment reflecting their particular attributes. Assuming that technology is fixed, either factor quantity or factor price will adjust to clear the market, with fixity being determined on the basis of a specific industry or all industries that use that factor of production.

In terms of the labour market, the assumption is made that aggregate employment by occupation is fixed in the short run. However it is assumed that labour by occupation is free to move between industries so as to ensure that the real wage of each occupation is equalised across all industries. In the long run, it is assumed that aggregate employment can rise or fall by way of altered migration/participation to ensure that the labour market clears in aggregate at the fixed real wage rate. This assumption is based the fact that labour is highly mobile between Ireland and the U.K., suggesting that our wage rates are determined there rather than in Ireland. It follows that in the long run, the aggregate supply of each occupation is also allowed to adjust to ensure that wage relativities are maintained. This can be defended on one of two grounds. Firstly it can be thought that some workers in occupations facing downward wage pressure retrain into new occupations which have upward wage pressures. Alternatively, we can think that workers in occupations facing declining wages emigrate to the U.K., while workers in occupations with higher wages immigrate from the U.K. It could be argued that skilled labour has showed more mobility in Ireland's case, suggesting that skilled wages are set exogenously, while unskilled wages are endogenously determined. For the purposes of the simulations that follow, this is ignored.

Capital, on the other hand, is assumed to be fixed in the short run, while mobile in the long run. In the short run capital rents adjust to ensure equilibrium, while in the long run they are exogenously set. Finally, the quantity of land of each quality class is exogenously fixed in both the short and long term. This does not impact on the ability of farmers to substitute between land of different quality – however any increase in use of (say) land of class A for cereals must result in a reduction in use of land of this quality in some other farm activity.

The previous paragraphs discussed the mobility of the factors of production in the short term and the long term. In this paragraph we discuss the treatment employed of the main consumption variables. The balance of trade is exogenously fixed in both the short term and the long term, forcing any change in investment to be matched by some form of domestic saving. It is questionable whether this is actually true, in that the policy simulations considered may raise the returns to capital or lower the price of capital investment. However the main advantage of exogenising the balance of trade is that it internalises the welfare impact of a shock to the model.

As can be seen the latter part of this chapter in the sensitivity analysis, the model results - albeit for a different simulation - are very sensitive to a Keynesian closure, which allows changes from the employment rule to ensure that the required amount of domestic consumption is satisfied. We use a Kaldorian closure (forced savings closure) on the basis that any change in income or consumption is likely to come via households rather than government, as households, particularly farm households, are primarily affected by the changes. Therefore we internalise any possible increased (decreased) savings by forcing decreases (increases) in household consumption.

Mimicking the classical Keynesian representation, in the short run the nominal levels of both investment and public consumption are exogenously fixed. In the long run, the level of investment is allowed to vary by exogenising the economy wide rate of return (*omega*). The level of public consumption is also allowed to vary, with the ratio between public and private consumption (*f5tot2*) being exogenously fixed. In conjunction with the choice of the Kaldorian closure, this has the obvious implication that adjustment in consumption due to 'forced saving' is now spread between government and private households. The combination of exogenising the ratio of public to private consumption and imposing the Kaldorian closure might result in private savings moving in the opposite direction to public savings.

A modelling difficulty in shocking the prices of raw products such as cattle, pigs and sheep is that there is a consequent increase in the input cost to the processed meat

products industry. In the absence of a corresponding increase in the output price of this industry in the model, its profitability would collapse and output would fall. In practice, the increase in farm-level prices reflects the net effect of the higher prices obtained by the meat factories and live exporters arising from the combined impact of more buoyant demand in the UK market and elsewhere, against the closure of non-EU markets. To overcome this problem, we endogenise the demand curves for exports of processed meat products and live animals, and exogenise the ratio of processed exports to live exports. Given the earlier assumption that farm level supply of livestock is fixed in the simulation, this implies that a change in the quantity of meat processed in Ireland can only occur if there is a change in the proportion of the total livestock output is exported. This is because of the assumption that a fixed proportion of exports are sent as live exports (and thus not available for processing) whereas all meat which is consumed domestically must be processed. Any switch to exports at the expense of the domestic market will thus reduce processing activity given this assumption.

4.2.4 Simulation Results

We now turn to a discussion to the results of the simulation. This discussion is divided into three sections. The first is an intuitive overview of the simulation results and as such briefly examines the results of the simulation in terms of the main macro economic variables. The subsequent two sections deal with a closer examination of the working of the model from the supply and demand sides respectively.

4.2.4.1 Overview of Simulation Results

The results for each of the simulations under the short run and long run closures are shown below in table 4.2a and 4.2b respectively.

Short-Run Breakdown of Results

In table 4.2a we divide up the aggregate results into those caused by the change in the beef price, the change in beef direct payments, change in cereals price and change in cereals direct payments plus set-aside.

As can be seen from table 4.2a, the change in the beef price is by far the most critical element of the simulations. The only component of real consumption that is allowed to vary is household consumption and, due to the employment of the Kaldorian closure, much of the economic adjustment takes place via it. The major driving force behind the simulation is the decline in the terms of trade caused by the fact that a product in which Ireland is a large net exporter has decreased in value. This introduces a tendency for the balance of payments to deteriorate, causing a national 'dissaving'. To counter this, there is a sharp decrease in household consumption of –1.22%, well below the decrease in disposable income fall of –0.49% (not reported in table). This in turn increases the domestic savings rate. The fall off in domestic demand forces firms to increase exports, with an increase in nominal exports of 0.10%. The wage rate falls in aggregate by 0. 17%, with agricultural workers bearing the brunt. The only occupations to have a higher wage rate are producers who benefit as manufactures volumes increase to fill export orders and transport/communications workers who must transport the increased export volumes.

The increase in direct payments increases household consumption, but only by half the amount of the corresponding decrease due to the fall in the price of cattle output. Again, this increase in consumption reflects both an increase in income and a decrease in savings. However the net effect of the two sets of shocks is that there remains a significant increase in savings at the expense of consumption. This savings is mostly done by urban households and to a lesser extent by rural (non-farm) households. Therefore consumption by household is actually quite smooth, as those households whose income increases (decreases) by most are the same households that greatly increases (decreases) savings.

As is clearly evident from table 4.2a, cereals are of far less significance for Ireland than beef, and the impact of the reforms on the cereal markets reflects this. The main impact of the change in the cereals price is a large reduction in the output of cereals. Other farm level agricultural industries fare quite well due both to a decrease in the input price of cereals, and the fact that a lot of land has become available because of

the decrease in cereals output. This is particularly reflected in the other arable industries which are the main competitors with cereals for land.

Table 4.2a: Results for Short Run Simulations

Macro Aggregates		Beef Price	Beef Direct	Cereals Price	Cereals Direct	Total
Population	q_h	0.00	0.00	0.00	0.00	0.00
Real Wage	realwage	0.20	0.02	0.02	0.09	0.33
Employment	employ_i	0.00	0.00	0.00	0.00	0.00
Nominal GDP	w1gdpexp	-0.55	0.11	0.01	0.21	-0.22
Balance of Trade	delB	0.00	0.00	0.00	0.00	0.00
Nominal Exchange Rate	phi	0.00	0.00	0.00	0.00	0.00
Real Devaluation	p1realdev	0.44	-0.06	-0.11	-0.12	0.15
Terms of Trade	p0toft	-0.36	0.01	0.07	0.03	-0.26
Labour Price	p0lab_io	-0.17	0.09	0.01	0.21	0.13
Capital Price	p1cap_i	-1.57	0.19	0.15	0.17	-1.07
Consumption Price	p3tot_h	-0.37	0.07	-0.01	0.12	-0.19
Investment Price	p2tot_i	-0.05	0.04	0.02	0.06	0.07
Exports Price	p4tot_d	-0.40	0.01	-0.01	0.03	-0.38
Government Price	p5tot	-0.21	0.09	-0.01	0.17	0.04
Imports Price	p0imp_c	-0.04	0.00	-0.08	0.00	-0.12
Real Primary Inputs						
Labour	x1lab_io	0.00	0.00	0.00	0.00	0.00
Capital	x1cap_i	0.00	0.00	0.00	0.00	0.00
Total	x1prim_i	-0.01	0.01	-0.02	0.04	0.03
Real Final Demands						
Consumption	x3tot_h	-0.85	0.47	-0.15	0.70	0.16
Investment	x2tot_i	0.05	-0.04	-0.02	-0.06	-0.07
Exports	x4tot_d	0.51	-0.28	0.14	-0.41	-0.05
Government	x5tot	0.21	-0.09	0.01	-0.17	-0.04
Imports	x0cif_c	-0.19	0.10	0.01	0.10	0.02
Nominal Primary Inputs						
Labour	w1lab_io	-0.17	0.09	0.01	0.21	0.13
Capital	w1cap_i	-1.57	0.19	0.15	0.17	-1.07
Nominal Final Demands						
Consumption	w3tot_h	-1.22	0.53	-0.16	0.82	-0.03
Investment	w2tot_i	0.00	0.00	0.00	0.00	0.00
Exports	w4tot_d	0.10	-0.27	0.13	-0.38	-0.42
Government	w5tot	0.00	0.00	0.00	0.00	0.00
Imports	w0cif_c	-0.23	0.10	-0.07	0.10	-0.10

Another industry that fares well is beverages and tobacco which sources some of its inputs from the cereals industry. As a result of the increased competitiveness, the

export of beverages and tobaccos increases by well over 2%. The benefits to input users such as beverages and tobacco increases labour demand in these industries, most notably producers whose wage is bid up by 0.2%. In aggregate, there is a marginal economy wide increase in the price of labour of 0.01%. In terms of the increase in subsidies together with the set-aside requirements, the combined effect, as expected, is to greatly increase the output of cereals. The model predicts that this will be larger than the reduction caused by the fall in price. This increase in the demand for cereals land, compounded by the fact that 12% additional land had to be set-aside, means that other farm level activities are crowded out to a greater extent by the subsidy and set-aside than were increased due to the fall in the cereals price. As can be seen from table 4.2a there is a fall in exports associated with the subsidies and set-aside simulation, mainly from farm level output which has been crowded out of land use. Users of cereals such as *beverages and tobacco* and *other food* remain the most important net beneficiaries.

Long-Run Breakdown of Results

The main feature of the long run simulation is that most of the impact of both the beef price decrease and increase in subsidies is to land. What happens in the beef price simulation results is that there is a very sharp fall in output of cattle, as capital and labour and all the other inputs that are used to produce cattle are put to more profitable uses. The increasingly cheap factor of production land is substituted for these other commodities. There are a number of implications for this, depending on the credibility we place on the results. Firstly, we might assume that this is in fact what will take place – farming will become increasingly land intensive, with a much lower intensity use of capital and labour. Secondly, we might believe that the elasticity of substitution of primary factors for cattle (0.24) is too high. In other words, do we really believe that land could replace capital and labour in the manner suggested by the simulation results? For a more detailed analysis of the sensitivity of model results to primary factor elasticity values, go to section 4.4.3.6.

In the long run, what is most notable is that the decline in the price of beef results in a decrease in our terms of trade by 0.07% (see table 4.2b). This induces a flight of

capital and labour, which translates into a fall in output which impacts on all the consumption aggregates. Real household and government consumption is down by –2.51%, while exports fall by –1.99%. An odd result is that real investment falls by much less than the other aggregates (-1.23%), even though aggregate capital in the economy falls. This can be explained by the fact that the big investors in the model are in manufacturing. In the long run, the investment/capital ratio is constant. Therefore a relative increase in demand for manufacturing capital in the model increases investment, even though aggregate capital falls by more. The rise in the importance of investment is at the expense of other forms of consumption as with a fixed balance of trade, savings has to rise by the same amount, so consumption actually falls somewhat further than disposable income. The increase in direct payments results in a surge in household consumption, which cancels out some of the increase in exports evident from the price simulation. The increased spending power bids up the price of non-tradeables, resulting in a significant appreciation in the currency (0.06%). The increased demand is met by an increase in capital and labour.

The cereals results show that there is an appreciation in the value of the currency by 0.04%, the explanation for which is that Ireland imports more farm level cereals than we actually export. The difference goes as an intermediate input into the production of *other food*, *farm animal feed* and *beverage and tobacco*. This results in a decrease in price for some of our more export intensive industries, which in turn results in a rise in exports. The result of the increase in direct payments to cereal producers is very similar to those for beef producers, with rising consumption displacing investment and exports. Note that as investment is so dependent on imported machinery, it is quite sensitive to changes in the real exchange rate.

Table 4.2b:

Results for Long Run Simulations

Macro Aggregates		Beef Price	Beef Direct	Cereals Price	Cereals Direct	Total
Population	q_h	0.00	0.00	0.00	0.00	0.00
Real Wage	realwage	0.00	0.00	0.00	0.00	0.00
Employment	employ_i	-2.19	3.13	1.35	-0.59	1.70
Nominal GDP	w1gdpexp	-2.52	3.08	1.25	-0.64	1.17
Balance of Trade	delB	0.00	0.00	0.00	0.00	0.00
Nominal Exchange Rate	phi	0.00	0.00	0.00	0.00	0.00
Real Devaluation	p1realdev	0.00	0.06	-0.04	-0.02	-0.01
Terms of Trade	p0toft	0.07	-0.06	0.03	0.02	0.06
Labour Price	p0lab_io	-0.10	-0.03	-0.08	0.01	-0.19
Capital Price	p1cap_i	-0.01	0.00	-0.01	0.00	-0.02
Prices						
Consumption	p3tot_h	-0.10	-0.03	-0.08	0.01	-0.19
Investment	p2tot_i	-0.03	-0.01	-0.02	0.00	-0.05
Exports	p4tot_d	0.03	-0.06	-0.07	0.02	-0.08
Government	p5tot	-0.09	-0.02	-0.06	0.02	-0.15
Imports	p0imp_c	-0.04	0.00	-0.10	0.00	-0.14
Real Primary Inputs						
Labour	x1lab_io	-2.19	3.13	1.35	-0.59	1.70
Capital	x1cap_i	-2.97	3.23	1.26	-1.02	0.49
Total	x1prim_i	-2.52	3.15	1.29	-0.64	1.28
Real Final Demands						
Consumption	x3tot_h	-2.51	3.95	1.26	-0.54	2.16
Investment	x2tot_i	-1.23	1.53	1.25	-0.46	1.09
Exports	x4tot_d	-1.99	1.81	1.40	-0.79	0.42
Government	x5tot	-2.51	3.95	1.26	-0.54	2.16
Imports	x0cif_c	-1.60	2.34	1.33	-0.58	1.48
Nominal Primary Inputs						
Labour	w1lab_io	-2.29	3.11	1.27	-0.58	1.51
Capital	w1cap_i	-2.98	3.23	1.25	-1.02	0.47
Nominal Final Demands						
Consumption	w3tot_h	-2.61	3.92	1.18	-0.53	1.97
Investment	w2tot_i	-1.26	1.53	1.23	-0.46	1.04
Exports	w4tot_d	-1.97	1.75	1.33	-0.76	0.34
Government	w5tot	-2.60	3.93	1.20	-0.53	2.00
Imports	w0cif_c	-1.64	2.34	1.23	-0.58	1.35

4.2.4.2 Examination of the Results from the Supply Side

For many elements of the model, an overview of the results as presented above proves satisfactory. However, there are two elements of the results that are not intuitively obvious, namely why does the real wage rise so sharply in the short run (by 0.13%) while aggregate employment increases by 5.87% in the long run? In an effort to answer questions such as this, we will now closely examine the sources of change in the demand for the primary factors. The purpose of this is not to 'tell a story' in terms of the what happened economically because of the CAP reforms, but rather to interrogate the model to ensure that there are no bugs in the model code, and to come to a better understanding of what drives the results.

To answer this question we have to examine the form of the aggregate production function Y = F(K, L) by comparing it initially with a simplified representation of this functional form. What will be the impact on aggregate employment within the economy of the shocks? In a simplified representation, the marginal product of labour M_l equals the real return to labour:

$$M_l = \frac{W}{P_{GNP}} \qquad (1)$$

or

$$M_l = \frac{W}{P_{CON}} \frac{P_{CON}}{P_{GNP}} \qquad (2)$$

Therefore, it depends on two terms that are shown in the second expression above. The first of these is simply the change in the real wage. The numerator of the second is the consumer price index, which is a combination of the prices of domestic and imported consumables. The denominator is the GNP deflator and as such is a combination of export and domestic prices. Therefore the movement in this ratio is reflected in changes in the terms of trade. We now discuss these simple

representations in terms of the short -run simulation results and long-run simulation results.

Short Run Simulation

In the short-run simulation, the real wage is unchanged while the second term as shown above is equal to the real devaluation of the currency of 0.15% multiplied by the share of imported goods in the production of consumption goods to give 0.06%. Therefore the change in the marginal product of labour is equal to approximately 0.06%. The marginal product of labour is an increasing function of the capital/labour ratio. Given that both aggregate capital and aggregate labour are fixed in the short run, how can this increase in the marginal product of labour be explained?

To account for this, we must go beyond this stylised model introduced above that does not account for the fact that in the simulation there are two sources of technical change, and that subsidy rates had been changed. Consider an economy with Cobb-Douglas production as follows:

$$Y = \left(\frac{LS_l}{A_l}\right)^{\alpha}\left(\frac{KS_k}{A_k}\right)^{1-\alpha} \qquad (3)$$

where α is the share of labour in the total budget, S_l and S_k are the power of subsidies and A_l and A_k are technical shift variables. The marginal product of labour can be calculated as the partial derivative of total output with respect to labour. This can be expressed in percentage change form as[3]:

	K/L Ratio	Labour	Capital
$\Delta M_l = (1-\alpha)(k-l) + \alpha(s_l - a_l) + (1-\alpha)(s_k - a_k)$			(4)
+	0	negligible	+

[3] It will be assumed for the sake of the current argument that capital incorporates land.

From this it is easy to see that changes in the K/L ratio are directly proportional to M_l, though obviously with the closure adopted, this first term is equal to zero. However, there is also a labour subsidy/technology term that is a weighted sum of changes in labour subsidies minus technology changes, and a capital subsidy/technology term which is a weighted sum of capital subsidies minus technology changes that has to be included. As shown above, the importance of each of these two expressions (which are the second and third elements of the expression above) depends in the shares of labour and capital in total output respectively, which we denote α and $1-\alpha$ respectively.

What are the changes in technology (as opposed to subsidy) that are relevant in this regard? The first comes from the fact that to ensure that milk output remains unchanged due to the existence of the quota, we endogenised an all-primary factor technology shifter *a1prim*. A figure of –1% for *a1prim("1lMilk")* in the simulation is interpreted as each unit of milk output required 1% less units of the primary factor. The interpretation for this shift is that the rent accruing to farmers as a result of the quota system is reduced. The rent accrues to the primary factors of production, so the reduction in this rent results in a reduction in the return to the primary factors for each unit of milk output.

The second technology shift in the simulation is the set-aside requirement for cereal production, which is modeled as a 12% negative technology shock for cereals land. For example, the 12% shock when applied to the £41m that accrues to cereal farmers from land implies that £5m more needs to be spent on land to achieve the same amount of output. The aggregate value to capital and land of the changes in technology is IR£1.2m, which is equivalent to –0.01% of the total economy flow to capital and land.

A similar exercise can be done to show that changes in the economy wide labour subsidy rate (as opposed to changes in technology) due to changes in the rate of subsidies is again negligible, though for capital is around 2%. Therefore it is the third term in the above expression that is large and positive – sufficient to offset the

negative first term to ensure that there is a rise in the marginal product of labour despite the fact that the capital/labour ratio is fixed.

Long-Run Simulation

In the long run simulation the wage rate is fixed with adjustment in the aggregate level of employment ensuring equilibrium. Capital is now free to move between industries to ensure that the economy wide rate of return is achieved. Can we predict what will happen to the aggregate capital stock? To start, we note the expression for the marginal product of capital:

$$\Delta M_k = r_{real} + (p_{inv} - p_{gdp}) \qquad (5)$$

$$+ \quad = 0 \quad + \quad -(-)$$

As the real rate of return is fixed in the long run, $r_{real} = 0$. The GDP price deflator decreases by –0.14% due to the fall in agricultural prices, but the price of investment goods, which rely heavily on imports (and have no direct agricultural requirements) which must now be imported at a higher price because of depreciation of the currency, only falls by -0.02%. Therefore the change in the marginal product of capital is unambiguously positive based on the equation above. This would suggest a fall in the K/L ratio. In our simulation results we see that aggregate capital rises by 0.49% in the long run, while aggregate employment increases by 1.7%, resulting in a fall in the K/L ratio of around 1.2%. The magnitude of the change will of course be affected by the same technology and subsidy effects that changes the sign of the predicted marginal product of labour.

Which elements of the model drives aggregate employment in the long run, given that it is now free to adjust to achieve the exogenously set level of real wages? This obviously depends on whether shifts in demand or supply dominate. It is only through an empirical tool such as a CGE model that the importance of such offsetting shifts can be resolved. As we can see from table 4.2 aggregate employment increases by a quite substantial 1.7%. To explain this we return to the expression for the marginal product of labour.

$$\Delta M_l = w_{real} + (p_{con} - p_{gdp}) \qquad (7)$$

We know that the value of the two expressions in brackets in this expression will be small but positive as food (which experiences a price fall) is a large element of consumption but a larger element of production. We also know that the first term is zero. Meanwhile, combining the two expression for M_l, namely (4) and (7) gives:

$$w_{real} = -(p_{con} - p_{gdp}) + (1-\alpha)(k-l) + \alpha(s_l - a_l) + (1-\alpha)(s_k - a_k) \quad (8)$$

We know that the last two terms on the right hand side are large and positive and that the first term is small and positive. Therefore we can deduce that with the real wage on the left hand side fixed, the second term must be large and negative to offset the other two. More intuitively, the fact that the aggregate level of capital per worker has fallen in this simulation obviously reduces that workers marginal product, and therefore should put downward pressure on aggregate employment. But this effect is more than made up for by the fact that the increase in subsidies makes employing workers more worthwhile, increasing labour demand.

Therefore the result of the above analysis has shown that the marginal product of labour increases in the economy due to the increase in subsidies. This increase manifests itself as an increase in wages in the short run and an increase in aggregate employment in the long run.

4.2.4.3 Examination of the Results from the Demand Side

In the short run simulation, the only variable with a scope for significant change is household consumption. The nominal value of government expenditure and investment are exogenously fixed. In the long run a rise in consumption of almost 2% is observed. To explain this long run rise, we note that the change in nominal consumption can be expressed in percentage change form as follows:

$$c = S_c^{-1}[y - S_i i - (S_x x - S_m m)] \qquad (9)$$

To determine what happened to consumption and why, we must explain changes in each of the right hand side variables. Firstly, real investment increases by 1.09% at a time when capital rose by 0.5%, with the price of investment goods falling marginally by 0.05%. In the long run simulation the balance of trade is fixed in money terms. This does not imply that the percentage change in nominal exports is equal to the percentage change in nominal imports. To see this, assume that the balance of trade is £1,000m, aggregate nominal exports is equal to £5,000m and consequently that aggregate nominal imports is £4,000m. Then an increase in nominal exports and imports of 10% will increase the balance of trade by £100m. To avoid this, in the above expression rather than having $S_x x - S_m m = 0$, we require that $S_x x - S_m m = (S_x - S_m)\, y$. Subbing this in gives a new expression for nominal consumption:

$$c = S_c^{-1}\left[(1 - S_x + S_m)y - S_i i\right] \qquad (10)$$

Therefore nominal consumption depends upon the extent to which national income changes and on the change in investment. The first share ($1 - S_x + S_m$) is 0.87, while the change in national income is 1.17% to give a combined effect of around 1%. Investment increases by 1%, which, given that investment accounts for around 10% of national income, results in the second expression being around 0.1%. Summing these two effects gives 0.9%, which when divided by the share of public and private consumption of 0.77 gives a predicted change in nominal consumption of around 1.2%. One factor not included in the representation above is the fact that increases in transfers from the EU are equivalent to an increase in exports in terms of the balance of payments. This adds approximately 0.2%/0.77 = 0.26% to national income, resulting in a predicted level of consumption of around 1.5%. The model results indicate that the increase is actually 2%.

4.2.5 Conclusion

The aim of this section was to employ the model as developed over the previous two chapters to estimate the economy wide impact of the MacSharry reforms of the

Common Agriculture Policy on the wider Irish economy. This was done in some detail in an attempt to assess model validity.

This exercise raised a number of difficult issues, particularly the need to develop model closures to simulate the relatively intricate workings of the Common Agricultural Policy. For milk, for example, it proved very difficult to target both output and price, though this was overcome satisfactorily. A very important issue that arose in relation to processing industries was acknowledging that the price change of processed food commodities will not necessarily change by the same amount as the unprocessed commodity. So, for example, a 15% fall in the price of capital is not likely to induce a 15% fall in the price of processed beef. Difficulties such as this are always likely as we move from the crude general equilibrium approximations frequently used when assessing the impact of the CAP towards a much more refined modeling of the principal intervention mechanisms.

4.3 Reconciling Partial and General Equilibrium Approaches

4.3.1 Introduction

In analysing a set of policy changes such as the MacSharry reforms, economists have had to choose between partial and general equilibrium methodologies. The partial equilibrium methodology concentrates on a particular subsection of the economy, with all other variables being treated as exogenous to the model. Given this concentration of resources, it is usually possible to model the particular industry/commodity chosen in much greater detail and with much greater care than is the case with general equilibrium models.

On the other hand, general equilibrium models attempt to describe the entire economic system, capturing not only the direct impact of (say) a policy shock on the relevant market, but also the impact on other areas of the economy and feed back effects on the original market. Technically the differentiation between a general and a partial equilibrium framework is redundant in so far as all applied general equilibrium models contain exogenously imposed variables that are in fact influenced to a greater or lesser extent by other variables within the model. For

example, in the model discussed in this thesis import prices are assumed to be exogenously fixed, regardless of the level of demand in Ireland for them. While this would seem to invalidate our boast of having a general equilibrium model, we justify our claim by restricting our simulation results to the neighbourhood of the initial equilibrium whereby changes in import prices due to changes in Irish demand are likely to be barely perceptible. Similarly, the global GTAP model (Hertel 1997), which might consider a single economy model as 'partial', itself suffers from the absence of (for example) a mechanism whereby higher incomes impact on population growth.

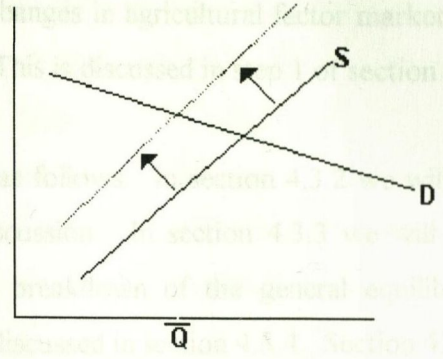
One of the obvious payoffs of having operational forms of both partial and general equilibrium strategies is in our ability to compare the results. The principal difficulty with a direct comparison between the two approaches is that it can be difficult to exactly match the features of the relatively intricate partial equilibrium model with those of its more cumbersome general equilibrium cousin. As a compromise, we can disaggregate the general equilibrium results of a simulation into its determinants, and thus answer numerous questions such as the importance of feedback effects in the overall results and the primary sources of these feedbacks. Such a strategy has a long tradition in input-output analysis, whereby model results were frequently presented as multiplier values which could be applied to partial results to measure economy wide effects.

In this analysis we will investigate the impact on the output of cattle of a 1% increase in the price of cattle that results from a negative technology shock to that sector. Obviously, there are other ways that a price shock could be introduced to the system from a change in some exogenous parameter. Most obviously, an increase in the export/import price reflecting changes in overseas demand and supply conditions could have been implemented. However there is no right or wrong approach to this.

We will first calculate the full general equilibrium elasticity via IMA*GE* and then proceed to isolate those elements of the general equilibrium simulation which could be captured in a partial equilibrium simulation.

Figure 4.2:

Imposing a 1% rise in Cattle Price via a Productivity Shock



The way the shock is imposed is illustrated in figure 4.3 above. The supply curve shifts upwards due to an (endogenous) deterioration in technology which results in a rise in the price of cattle of exactly 1%. Therefore we are shifting the supply curve and moving along the demand curve. A possible intuitive reasoning behind the deterioration in technology is due to poor weather. A justifiable alternative would have been to shift the demand curve and move along the supply curve.

It should be noted that in the core version of the model, by imposing a 1% increase in the price of any commodity via a production technology change there is a very sharp decrease in exports. The reason for this is the assumption that Ireland is a small country in relation to exports and thus faces an almost horizontal demand curve for its exports. Put another way, we assume that for tradeable goods the domestic price is determined by the overseas price. Trying to impose an increase in domestic price that deviates away from the international price causes a large change in exports. To ensure that the model results aren't dominated unrealistically by this effect, we will alter the 'small country assumption' and change the elasticity of demand from –20 to –2. Therefore, a 1% increase in price reduces export demand by 2%, not 20% as before.

At all stages, partial equilibrium models are given the benefit of the doubt in terms of model complexity, so, if anything, the analysis presented here will tend to downplay

the importance of general equilibrium modeling. There are two main instances of this. Firstly, in section 4.4.3 we include 'other food' in the definition of agriculture and assume that partial equilibrium modelers take this sector into account in their analysis. This is not typically the case. Secondly, many partial equilibrium modelers will not take account of changes in agricultural factor markets, and will instead treat land and capital as fixed. This is discussed in step 1 of section 4.4.3.

This discussion proceeds as follows: In section 4.3.2 we will define the meaning of the terms used in the discussion. In section 4.3.3 we will discuss the theoretical approach to achieve the breakdown of the general equilibrium result, while the results of the process are discussed in section 4.3.4. Section 4.3.5 concludes.

4.3.2 Definitions

As the general equilibrium model is the subject of this thesis, no further explanation of what assumptions it entails is necessary though we must take care to define our terminology. The term *general equilibrium elasticity* has the obvious interpretation as the total change in Q_i due to a 1% change in price j, including all feed back effects:

$$\varepsilon_{ij}^{GE} \equiv \frac{d \ln Q_i}{d \ln P_j} \forall i, j = 1,\ldots,N. \qquad (11)$$

It measures the percentage change in the equilibrium quantity of good i when the price of product j has changed by 1%, including all feedback effects.

The assumptions underlying the partial equilibrium model are listed below. In the actual decomposition it has not been possible to follow these rules exactly, though deviations are discussed in full in the relevant sections.

Assumption 1: Output price changes for non-agricultural industries are exogenously set.

Assumption 2: Increased/decreased non-agricultural output can have no impact on demand for agricultural commodities as an intermediate input.

Assumption 3: Factor prices changes for non-agricultural industries are exogenously set (at zero), therefore there can be no 'rebound' effect whereby the initial agricultural shock impacts on non-agricultural factor prices which in turn disturb the agricultural factor markets.

Assumption 4: Potential macro feedback effects arising from agricultural reform such as the balance of payments constraint, household budget changes etc. are not reflected in the partial equilibrium model.

The first two assumptions relate to the price and quantity interactions between agricultural and non-agricultural commodities. The first assumption states that the price of non-agricultural commodities is not influenced by any other price changes within the model. So, for example, the price of catering services is not influenced by changes in the price of agricultural products, even if agricultural products are an important input into catering services. The second assumption states that a change in output of non-agricultural products has no influence on the aggregate demand for agricultural products. So a doubling of catering output has no influence on demand for agricultural products, even if a sizeable share of existing catering inputs comes from agriculture.

The third assumption relates to factor markets, and says that agricultural factor markets are not influenced by changes in non-agricultural factor markets. Finally, the last assumption states that 'budget' constraints in commodity markets are ignored.

From this we can now define what we mean by *partial equilibrium elasticities*, which are very similar to the general equilibrium version given above. In effect, partial equilibrium models are 'general equilibrium' within the agricultural sphere, with other impulses from the economy being treated as exogenous. So for example, both models allow for an endogenous change in the price of cereals to influence the

price of cattle, but only the general equilibrium version will allow an endogenous change in the price of oil to influence the price of cattle. However, a partial equilibrium model will allow a change in the price of cereals to appropriately affect the price of feedstuffs with a subsequent impact on livestock production. The *partial equilibrium elasticity* is represented as follows:

$$\varepsilon_{ij}^{PE} \equiv \frac{d \ln Q_i}{d \ln P_j} \forall i, j = 1,....,M_{ag}. \qquad (12)$$

Therefore the first difference between the two is that *partial equilibrium elasticities* are only defined for agricultural prices. The second is that it follows different assumptions as to which feedback effects are felt as listed above. Take care not to confuse it with the *partial derivative*, which is commonly used in economics to express an elasticity. This measures the change in $\ln Q_i$ as a result of a change in $\ln P_i$, keeping all other prices - including all other agricultural prices – constant, and is expressed as follows:

$$\varepsilon_{ij} \equiv \frac{\partial \ln Q_i}{\partial \ln P_j} \forall i, j = 1,...,N. \qquad (13)$$

The difference between the two is that the *partial derivative* only allows one price to change, while the *partial equilibrium elasticity* as defined here allows all agricultural prices to change.

4.3.3 Theoretical Background

By way of example, we chose in this section to calculate both GE and PE elasticities of cattle output with respect to a 1% change in the price of cattle. The 1% change in price is assumed to arise because of a negative technology shock in the use of capital in cattle production.

The logic behind the approach chosen can be explained as follows. Following Staehr (1999), we will take the example of the elasticity of a quantity (output of a farm level

product) with respect to price. We have a 34 commodity/industry economy, 14[4] of which are agricultural, the rest of which are not, and three factors of production, which in themselves are composites of underlying factors (e.g. land is a composite of a number of different land types). The total derivative of output of the first commodity Q_1 can be expressed as a weighted sum of the derivatives of Q_1 with respect to each of the price variables $P_1, P_2, \ldots, P_n$ and the level of income Y.

$$dQ_1 = \frac{\partial Q_1}{\partial P_1} dP_1 + \frac{\partial Q_1}{\partial P_2} dP_2 + \ldots + \frac{\partial Q_1}{\partial P_n} dP_n + \frac{\partial Q_1}{\partial Y} dY \qquad (14)$$

Defining $v_i = \ln V_i$, we write:

$$\frac{dq_1}{dp_1} = \sum_{j=1}^{n} \frac{\partial q_1}{\partial p_j} \frac{dp_j}{dp_1} + \frac{\partial q_1}{\partial y} \frac{dy}{dp_1} \qquad (15)$$

While in a general equilibrium framework we cannot distinguish between demand and supply elasticities, the above expression suggests two closely related concepts – the quantity elasticity and the price elasticity. The former is the rate of change of a quantity with respect to a change in price, while the former is the rate of change of a price with respect to a change in another price.

To arrive at a partial equilibrium model, we must divide these changes into those that would be predicted by a partial equilibrium model (i.e., those that relate only to the agricultural industries) and those which are truly 'general equilibrium' in nature. This must be done for both price elasticities and quantity elasticities. The requirements to separate out the partial equilibrium result from those reported in the IMAGE model are illustrated in Table 4.4. Looking first at the output elasticities, we see that we have to calculate two n*1 vectors of partial output elasticities, one for general equilibrium and one for partial equilibrium. In practice it turns out to be very difficult to calculate these two vectors, so an approximation is required. The two n*1

[4] This comprises of all the primary agriculture industries including forestry and fishing, plus four processing industries. Note that a typical PE analysis will not include other food.

vectors of price elasticities denoted **(3)** and **(4)** are total derivatives. This means we can simply read off **(3)** directly from the IMAGE results. The calculation of **(4)** is achieved by converting the elements of **(3)** into primary factor prices, isolating 'partial equilibrium' changes in the price of primary factors and working backwards.

Table 4.3:

Elements of GE and PE Elasticities

	Output Elasticities		
Price Elast-icities		**(1)** $\frac{\partial q_1}{\partial p_i}^{GE}$	**(2)** $\frac{\partial q_1}{\partial p_i}^{PE}$
	(3) $\frac{dp_j}{dp_1}^{GE}$	**(5)** $\frac{dq_1}{dp_1}^{GE}$	-
	(4) $\frac{dp_j}{dp_1}^{PE}$	-	**(6)** $\frac{dq_1}{dp_1}^{PE}$

We do this via 2 steps, the first of which relates to the derivation of the partial equilibrium version of the quantity elasticity that is a partial derivative. The second relates to the division of the total changes in the price variables. As discussed above, of all the elements which we will attempt to identify, namely **(1)**, **(2)**, **(3)** and **(4)** in table 4.4 only **(3)** can be read directly from the IMA*GE* results file. The others must be constructed within a spreadsheet. When we have calculated these, we can then calculate **(6)** and confirm **(5)** which can just be read from the IMA*GE* results file anyway. It is the comparison between **(5)** and **(6)** that interests us.

Step 1 - Calculation of the PE Quantity Elasticities $\partial q_1 / \partial p_i^{PE}$

The elasticity $\partial q_1 / \partial p_i^{PE}$ represents the change in demand for quantity 1 due to a change in the price of commodity *i*. The approach we will take is to calculate these elasticities on the assumption of perfectly elastic factor supply, and then adjust our

results to take account of the fact that in our model, factor supply is far from being perfectly elastic. The reason this approach is attractive is that the assumption of perfectly elastic factor supply underlies the traditional Input-Output approach, and means the problem can be solved using the well-known Leontief inverse. We first of all calculate direct changes in demand for commodity *i*, and then calculate changes in intermediate output demand for cattle due to this final demand increase[5].

The calculation of the direct change in demand for good *i* due to a change in price p_i is straightforward for exports as we have an explicit demand curve. For household, investment and intermediate substitution demand there are explicit elasticities for the substitutability between the domestic and imported variant, so calculating the change in demand due to a change in price (with import prices kept constant) is a straightforward matter. Each of these changes is a function of the proportion of the domestic variant relative to the imported variant in each use, and the value of the elasticity of substitution.

The next step is to convert this vector of final demands for each product *i* into demand for cattle through inter-industry linkages. Both are easily calculated as the $(1, i)^{th}$ element of the appropriate Leontief inverse matrix which measures the total impact of a change in final demand of good *i* of 1 unit on the output of cattle. Note, the Leontief inverse calculates the amount of increased output of good 1 due to a £1 increase in final demand for good *i*. Therefore we have to convert these results into elasticities by an appropriate scaling before using it in connection with the rest of the model. In the GE case, the appropriate Leontief model is the 34 * 34 $(I-A)^{-1}$ matrix. In the PE case, the appropriate Leontief model is the 14 * 14 $(I-A)^{-1}$ matrix consisting only of the agricultural industries.

By way of example of the direct and indirect forms of change in intermediate demand, consider the effect on demand for (say) cattle due to a rise in the cattle price

[5] Intermediate demand for the domestic variant can change for two reasons. Firstly, final demand can change, which will have knock on effects for intermediate demand. We refer to this as the intermediate output effect. Secondly, for a given level of final demand, intermediate supply can

by 1%. The direct effect is that those industries that use cattle in intermediate production, mainly meat processors, will start to source more cattle from overseas that have become relatively cheaper, as well as falls in exports and household consumption. All of these result in a fall in demand for the domestic variant. The indirect demand arises from the fact that as demand for cattle as a final product falls (because of the fall in exports, household demand, direct intermediate demand etc), so will the intermediate demand for cattle, primarily as cattle are required in their own production, but also through all other input-output linkages.

As mentioned earlier, this process has left us with the values of (1) and (2) under the assumption of perfect factor mobility. Getting the dot product of (1) and (3) - which can be read from IMA*GE* – should give us the total derivative as read from IMA*GE*. The extent to which we are off is a measure of the impact of factor immobility. The IMA*GE* result is –0.54%, while the results recorded in this section was –0.74%. Therefore, the impact of factor immobility is to dampen the impact of the price change by 0.2%.

For the purposes of recreating the partial equilibrium result, we must find some way of dividing this 0.2% into the impact on the partial derivative of output with respect to price of factor immobility within agriculture and factor immobility in the rest of the economy. First of all, we must decide which factor movements are included in the partial equilibrium analysis and which are not. In the price section (Step 2) we will assume that all agricultural capital price changes and all land price changes are incorporated into the partial equilibrium analysis. So all non-agricultural capital price changes and all labour price changes are not incorporated into the partial equilibrium analysis.

This cannot be done by traditional Leontief methods, so it will have to be done via a simple approximation. This takes the form of an index for each industry that takes

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substitute between the domestic and imported variants as price changes. We refer to this as the intermediate price effect.

the value of 1 when the factors of production are perfectly mobile, and a value of 0 when they are perfectly immobile. This index is calculated as:

$$I_i = 1 - \sum_f \frac{F_{f,i}}{\sum_i F_i} \frac{F_{f,i}}{\sum_i F_f} \tag{16}$$

It is the sum of the share of each factor of production employed in each industry multiplied by the share of that industry's use of that factor of production in its entire supply. So, for land, if 30% of all factor income in cereal farming accrues to land, and land use in cereal farming accounted for half of all land use in the country, then this would contribute –0.15 to the index for cereal farming. If all factor income accrued to land, and the type of land that was suited to cereals was not suited to any other industry, then land would contribute –1 to the index that would take the value of zero. The downside of this simplification is that it takes no account of the elasticity of substitution between land and other factors of production.

The next step of the simplification is to multiply the cattle row of the IO inverse as discussed above by the index, thus recalculating the total effect with an allowance for factor immobility. In this application the approximation was a good one, with 0.18% allocated against a known total of 0.20%. The primary reason that the factor mobility effect is so high is that capital is assumed fixed in the model closure.

Step 2: Subdividing Price Elasticity

The price elasticity measures the percentage change in one equilibrium price given a one percent change in another equilibrium price. Ultimately, all changes in prices are a weighted average of changes in the price of value added and changes in the price of imports. Given that all import prices in the model are exogenous and that all direct subsidy and tax rates remain unchanged, it follows that all changes in prices are a weighted average of changes in factor prices. To determine these weights we observe that:

$$\frac{dp_i}{dp_1} = \sum_{j=1}^{n} \frac{\partial p_i}{\partial p_j} \frac{dp_j}{dp_1} + \sum_{f=1}^{m} \frac{\partial p_i}{\partial p_{prim}} \frac{dp_{prim}}{dp_1} \tag{17}$$

$$\frac{dp_i}{dp_1} = S_{ij} \frac{dp_j}{dp_1} + T_{prim} \frac{dp_{prim}}{dp_1} \tag{18}$$

where S_{ij} is the n*n matrix where the ij^{th} element represents the share of good j in the production of industry i This is known as the Ghoshian inverse after Ghosh (1958), and its use as a price model was suggested by Oosterhaven (1989). Similarly, T_{prim} represents the share of primary factors in the production of industry i. Rearranging (2) gives:

$$\frac{dp_i}{dp_1} = \left(I - S_{ij}\right)^{-1} T_{prim} \frac{dp_{prim}}{dp_1} \tag{19}$$

Therefore, applying the primary factor price changes as observed from the model gives us the commodity price changes that can also be observed from the model by way of a check. Given the link between factor prices and commodity prices, it now remains to divide up factor prices into those that would be observed in the partial equilibrium model and those that would not. This way, using the method derived in (3), we can determine what the partial equilibrium prices would be.

In summary the strategy is as follows: We have deconstructed the commodity price changes into the primary factor changes underlying them. We will now identify the primary factor price changes that could, arguably, be derived from a partial equilibrium model. Then, using the methodology derived above, work backwards to calculate the commodity price changes consistent with the primary factor price changes. Note that we do not use the same weights when working backwards. Instead of the 34*34 $(I-S_{ij})^{-1}$ matrix, we calculate the corresponding 14*14 inverse matrix of agricultural industries/commodities.

The breakdown of the factor prices actually employed is as follows. Firstly, in a partial equilibrium model, the price of all non-agricultural products will be unchanged, and thus the price of all factors employed in non-agricultural sectors will remain unchanged. In other words, the 'equilibrium' reached in partial equilibrium does not cater for endogenous changes in any prices other than for agricultural products, though they can be exogenously imposed. This still leaves the problem of determining which changes in the price of agricultural products can be assumed to have arisen out of a partial equilibrium model. We will assume that all agricultural capital price changes and all land price changes are incorporated into the partial equilibrium analysis.[6] We assume that all non-agricultural capital price changes and all labour price changes are not incorporated into the partial equilibrium analysis. Given a fixed labour supply, a change in price of one percent is likely to have an impact on the aggregate wage rate, an effect we assume is not captured in partial equilibrium analysis. A similar argument goes for non-agricultural capital.

Through this method we now have a vector of price changes representing **(4)** in table 4.4. Combing the results from Step 1 and Step 2 gives all the relevant components required of table 4.4.

4.3.4 Results

The results are shown below in table 4.5. The aggregate result, as read from IMAGE, is –0.54%. The partial equilibrium results as calculated are –0.65%, a considerable difference. A breakdown of these results is shown in table 4.6 below. As can be seen from the final column, there are two main sources for this difference. The first is the direct plus indirect effects of the changes in final demand while the second is the change in household income that actually raises demand for cattle by 0.05%. The second requires some explanation. The real value of consumption is tied to the real value of government consumption, both of which fall marginally.

[6] This intuitively appealing division contains a slight deceit – it in essence assumes that the entire change in agricultural capital prices and in land prices was due to 'within agriculture' considerations. In fact, some of the change in price of agricultural capital and land is due to feedbacks from non-agricultural industries. This is ignored.

However, on the supply side, the price of public services falls substantially due to the fact that the price of labour falls, and that public services have a very high percentage of labour in value added. Therefore, to ensure a fixed balance of trade, we must have an offsetting rise in nominal private consumption.

Table 4.4:

Elements of GE and PE Elasticities

		Output Elasticities	
		(1) $\frac{\partial q_1}{\partial p_i}^{GE}$	**(2)** $\frac{\partial q_1}{\partial p_i}^{PE}$
Price Elast-icities	**(3)** $\frac{dp_j}{dp_1}^{GE}$	**(5)** -0.54%	-
	(4) $\frac{dp_j}{dp_1}^{PE}$	-	**(6)** -0.65%

Two final remarks are relevant in relation to these results. Firstly, the most salient feature of table 4.6 is the size of two of the general equilibrium effects that are not captured in the partial equilibrium analyses. Each of demand changes and income changes are around 10% of the general equilibrium result, and therefore highly significant. The second point relates to their signs. There is no reason to expect that both should be of the same sign, so it could happen that in other examples they actually tend to cancel each other out and the partial equilibrium result could be very close to the general equilibrium result. However, this would purely happen by accident, and hardly forms an adequate defence of partial equilibrium analysis.

What are our expectations of the magnitude of results more generally? There are two sources of general equilibrium feedback that are likely to impact on agricultural production. The first is simply the impact of inter-industry connections that can be captured by an input output model (this is called changes in demand due to price in the table above). The second is the impact of changes in the economy wide price of

scarce commodities such as workers, capital or land, as well as changes in macro variables such as nominal consumption and investment.

Table 4.5:

Breakdown of Elements of GE and PE Elasticities

Source of Results	*General Equilibrium*	*Partial Equilibrium*	*Remainder*
Perfectly Mobile FOP			
Changes in Demand due to Price	-0.79	-0.84	0.05
Induced Income Changes	0.05	-	0.05
Induced Investment Changes	0.00	-	0.00
Correction for Immobility of FOP	0.20	0.19	0.00
Total	-0.54	-0.65	0.11

The magnitude of the first is likely to be shaped as an inverted-U with respect to the share of industries under examination in total output. In other words, a small industry comprising 1% of total output will have relatively small knock on effects on other industries, while a large industry with a 99% share of total output will have most of the inter-industry linkages already internalised, so the 'general equilibrium' inter-industry linkages remaining will be minor. Therefore the importance of inter-industry linkages is likely to be at a maximum for those industries that comprise around 50% of total output, all other things being equal. Note that all things are unlikely to be equal. We are likely to choose related industries to construct our partial equilibrium results. In the example in this section, we have focussed on the wider food-industry. While the impact on the own industry output is unambiguously positive, the fact that final demand changes for other commodities can be positive or negative means that the sign of the total impact is ambiguous.

The magnitude of the factor price and macro variable effects is likely to be small when shocks are applied to industries that comprise a small share of total output, and likely to be large for industries that comprise a large share of total output. Therefore

the combined effect of the two effects is indeterminate. It is likely to be larger for industries up to 50% of total output, and thereafter it might rise or fall, depending on which effect dominates.

4.3.5 Conclusion

We have shown in this section that taking into account general equilibrium effects can have a very large bearing on simulation results. Calculating the own output effect of a 1% increase in the price of cattle, we find that the general equilibrium simulation result is –0.54%, while the partial equilibrium simulation result is around 20% larger in magnitude at –0.65%. This result was achieved despite giving the benefit of the doubt to partial equilibrium analysis in two important respects. Firstly, in section 4.4.3 we include 'other food' in the definition of agriculture and assume that partial equilibrium modelers take this sector into account in their analysis that is not typically the case. Secondly, many partial equilibrium modelers will not take account of changes in agricultural factor markets, and will instead treat land and capital as fixed. The one caveat is that it was necessary to employ an approximation to correct for immobility of factors of production, though we suspect that this approximation is quite robust, and that the results would not be materially affected by removing it.

4.4 Sensitivity Analysis

4.4.1 Introduction

It is not possible to observe a large number of the parameters that are used in a CGE model, and therefore we use not-so-informed estimates of the value of these parameters. A crucial question to ask then is are the model results very sensitive to the parameters assumed? If not, the reliability of the whole exercise can be thrown into doubt.

In section 4.4.2 we introduce briefly a simulation exercise done to measure the impact of the 2001 outbreak of Foot-and-Mouth disease in the Irish economy. We then proceed in 4.4.3 to analyse four different aspects of the model to find out how sensitive the results are to different model setups. In particular, we examine the results sensitivity to various macro-closures, to various estimates of labour elasticities, to a range of values for the Armington parameters and finally to a range of values for the elasticity of substitution both between and within factors of production. We find that the simulation results are not very sensitive to the choice of macro closure, factor market elasticity or labour market closure, though are very sensitive to the choice of Armington assumption. Section 4.4.4 concludes.

4.4.2 Foot and Mouth Disease and the Irish Economy

4.4.2.1 Introduction

This simulation examines the impact of the 2001 outbreak of foot-and-mouth disease on the Irish economy. The direct impacts on the tourism sector, the agricultural sector and on government finances are identified and their overall consequences for the economy are calculated by model simulation. The overall impacts on the agricultural sector are positive because of higher prices for meat products arising from the FMD outbreak in the UK, but significant adverse impacts are found for the tourism and retailing sectors. The details of the full simulation are not included here, and can be seen in full in Matthews, O'Toole and Mulvey (2002). However in the next few sections we will give a few of the salient features of the shocks and simulation results.

4.4.2.2 Model Shocks

The three sets of model shocks are now discussed briefly.

Shock 1: Direct Impact on Agricultural Inputs and Prices

Much of the impact on the farming community of the crisis (in a monetary sense) was actually either neutral or benign. The shocks that are imposed on the model as regards the direct impact on farming are as follows.

Animals purchased for destruction in the exclusion zone in County Louth in an effort to prevent the spread of the disease were, in a purely monetary sense, just another market for the farmer for his produce. We assume that the compensation paid reflected the market price of animals. To take account of the restrictions on movement and sale of livestock during the period in question, we assume a negative technology shock of 5% in the "*farm-animal feed*" input, indicating that to produce the same quantity of cattle as in the base period, an additional 5% of farm animal feed was required. However, the most important impact was that, due to the strict mobility restrictions and widespread slaughter in the UK, a shortage of beef, pork and lamb there translated into a jump in their respective prices, an effect which significantly benefited Irish producers. The estimates for the changes in the price of cattle, sheep and pigs were that the FMD scare caused an increase in price of 4.41%, 44.58% and 4.84% respectively.

Shock 2: The impact of FMD on Tourism

To measure the vector of tourists' expenditure, we update the corresponding figures calculated by Henry and Deane (1997) for both international and domestic tourists by applying expenditure shares to the appropriate total expenditure for 2001. These estimated aggregates are then expressed as values of exports by industrial sector. The next step is to estimate the fall in tourism numbers due to the foot and mouth outbreak, for which we need an estimate of what tourism volume would have been in the absence of the outbreak. Given the worldwide slowdown in economic growth that preceded both the FMD outbreak and the 11 September terrorist attacks, it was predicted by Bord Failte, the Irish Tourist Board, that tourism numbers for 2001

would have risen above the 2000 numbers by only 5%, well below the 8% per annum actually observed since 1996. We take this as the counterfactual benchmark against which to measure the tourism impact of FMD. Finally, for the purposes of this simulation we assume that there is a zero net effect on domestic tourism flows and domestic tourism expenditure due to the FMD crisis.

Shock 3: Government Expenditure

The following major costs can be identified, along with the industry classification of where the money was spent. Note that all costs relate to direct exchequer expenditure. Changes in government receipts due to a fall off in VAT revenues as less tourists visit Ireland and purchase goods are indirect effects. The tourism expenditure figure relates to additional expenditure to counter the negative impact of the FMD publicity. The tourism advertising figure is assumed to be split between expenditure in Ireland and expenditure overseas – only the component spent in Ireland is assumed to have a knock-on affect on other industries in an input-output sense, while the overseas component is simply a services import.

Table 4.6

Estimated Breakdown of Government Expenditure in Response to the FMD Outbreak

Expense	Final Cost	Industry
Department Expenses	€16.0m	Public Services
Direct Compensation of Farmers	€10.1m	Purchase of Livestock
DAFF Staff Costs	€18.3m	Public Services
Tourism Advertising	€12.7m/2 = €6.3	Market Services
Gardai Overtime	€49.5m	Public Costs
Total	**€100.3**	

Source: INDECON (2002)

4.4.2.3 Model Results

A table of the model results are shown in table 4.7 below. What follows is a brief discussion of the results of each of the individual shocks.

Shock 1: The Impact of FMD on Agriculture

In relation to prices, the model estimates the total impact on the price of agricultural produce to be an increase of 3.88%. This dominates the results, with very little change in real output elsewhere in the economy as agricultural output is fixed in the short run. The GDP deflator increases by 0.11%, while import costs rise by 0.06%, resulting in a real appreciation of the currency of 0.05%. As can be seen from the real consumption figures, household consumption increases significantly, mainly at the expense of investment. Note also that there is a small fall in employment as the sector which benefits (agriculture) has very low labour usage, while the outputs of manufacturing and services which are relatively labour intensive by comparison decline slightly due to the real appreciation.

Shock 2: The Impact of FMD on Tourism

With the balance of payments fixed, the fall in the value of service exports (i.e. tourism) must be offset by increases in export volumes or reductions in imports. This reallocation within the economy is achieved through a real devaluation of the currency which makes imports less competitive domestically, and increases the demand for exports. In the simulation as shown, the volume of imports actually rises slightly. This is because the fall in imports due to the loss of competitiveness vis-à-vis domestic commodities is more than offset by the fact that Irish exports are very import intensive, so we require an increase in imports to achieve the required increase in exports. Given that manufacturing is highly export orientated in Ireland, the real output of that industry increases by 0.33%. Put simply, we have to export more as the amount of money we were earning per unit of export has fallen due to the taste shift away from the Irish "tourism" product. This reallocation from services to manufacturing is reflected in the occupational changes shown in Table 6 below, with service-intensive occupations generally falling.

Shock 3: The Impact of Government Spending

The increase in government expenditure (extra policing etc.) of €100m has a relatively minor impact in the sense of providing a demand injection into the

economy. Given that aggregate output is tied down to a large extent, the balance of payments fixed and the level of investment determined mostly by the exogenously fixed world interest rate, the increase in government expenditure merely crowds out domestic expenditure, with household saving increasing significantly. In particular, household spending on services reduces as the main component of government expenditure is in services (veterinarians and security).

Table 4.7:
Macro Results

	Agriculture Shocks	International Tourism Shocks	Government Spending Shocks	Total
Agricultural Prices	3.88	-0.42	-0.07	3.39
Manufactured Prices	0.08	-0.08	0	0
Service Prices	0.11	-0.3	0	-0.19
GDP deflator	0.11	-0.27	0	-0.16
Real Devaluation	-0.05	0.27	0	0.22
CPI	0.13	-0.26	0	-0.13
Nominal GNP	0.05	-0.3	0	-0.25
Employment	-0.07	-0.02	0.01	-0.08
Average Labour Tax	0.01	0.05	0	0.06
Wage Rate	0	-0.3	0.02	-0.28
Labour Income	-0.07	-0.32	0.03	-0.36
Real Output				
Agricultural	0	0	0	0
Manufactures	-0.09	0.39	-0.03	0.27
Services	-0.01	-0.15	0	-0.16
Imports	-0.01	0.07	-0.05	0.01
Real Consumption				
Investment	-0.34	0.22	-0.01	-0.13
Household	0.14	-0.24	-0.19	-0.29
Exports	-0.12	0.1	-0.04	-0.06
Government	-0.04	0.26	0.82	1.04
Real Pub. + Priv. C'ption	0.11	-0.15	-0.121	-0.161

4.4.3 Sensitivity Analysis

4.4.3.1 Introduction

This section is broken down into four sections, dealing with the macro closure, the labour market closure, the Armington parameters and the factor market elasticities of

substitution. The first two are dealt with by running a number of simulations, and comparing the results. The latter two are dealt with by Systematic Sensitivity Analysis. The section begins by discussing systematic sensitivity analysis before preceding with the four sets of sensitivity analysis.

4.4.3.2 Systematic Sensitivity Analysis.

The RunGEM[7] programme is part of the GEMPACK suite of programmes, and automates the process of systematic sensitivity analysis. The first step is to specify the distributions of the parameters which vary. In the sensitivity analysis reported, we assume that the parameters to be varied have a Systematic Triangular Distribution. The values in question lie between a fixed minimum and maximum values. Because the distribution is symmetric, the mean lies exactly half way between the minimum and the maximum values. Symmetry also means that the probability of obtaining a value a specified distance below the mean is exactly the same as the probability of obtaining a value the same distance above the mean. The word "triangular" refers to the fact that when you draw the graph of the probability distribution function, the graph consists of two straight lines, one from the minimum value to vertically above the mean and the other from vertically above the mean to the maximum value. This means that values near the extremities (min and max) are less likely than those near the mean.

The RunGEM software then develops a discrete approximation to these distributions. Then the software solves the model for each point in this discrete distribution and weights the results appropriately to produce estimates of the means and standard deviations for the different endogenous variables in the original simulation.

The results consist of estimates of the means and standard deviations for each endogenous variable of the model. From the mean and standard deviation you can infer information about the likely range of values of each endogenous variable. Note

[7] Much of this discussion is taken from the help files of the RunGEM programme, a part of the GEMPACK package which systemizes sensitivity analysis (see Pearson and Harrison)

that the results presented after a sensitivity calculation are not the exact means and standard deviations but estimates of these values.

The confidence intervals reported in the sensitivity analysis for the Armington elasticities and the primary factor elasticities are approximated via Chebyshev's inequality. Suppose that you have an endogenous variable Y with mean M and standard deviation D. Chebyshev's inequality says that, whatever the distribution of the variable in question, for each positive real number k, the probability that the value of Y does not lie within k standard deviations of the mean M is no more than $1/k^2$.

For example, the probability that its value does not lie within 2 standard deviations of the mean is no more than 0.25 [$=1/(2^2)$]. That is, you can be 75% sure that the value does lie between M-2D and M+2D.

Table 4.8

Summary Table

%confidence	No. of SDs from Mean
75	2
88.89	3
93.75	4
95	4.47

Examples of the results of this method can be seen in the sensitivity analysis for the Armington parameters and the primary factor mobility elasticities. For section 3 (Macro Closure) and section 4 (Labour market closure), the actual of the closure of the model is experimented with rather than simply a parameter value, so they are not suitable for systematic sensitivity analysis.

4.4.3.3 Macro Closure:

The problem of *macroeconomic closure* arises because of the indeterminacy of investment within the model. The nominal value of investment must be equal to total domestic savings, or the balance of payments must be allowed to ensure an adequate inflow/outflow of overseas savings to ensure the required investment totals are achieved:

$$P_I I = S_H + S_G$$

This introduces the first closure, the so-called classical closure:

- Classical Closure: Under the neo-classical closure, with fixed government investment, the value of private sector investment is determined by the value of net domestic savings plus foreign savings, regardless of the ex *ante* return on capital. Private sector savings are determined endogenously as the outcome of the income generating process and a fixed savings propensity, while government saving is determined via the flow of revenue and an exogenously determined volume of government expenditure. Within the private sector, the sectoral allocation of the given volume of aggregate private investment is return-sensitive.

There are three main class of non-classical closure identified in the literature (Dewatripont and Michel, (1987)). These are:

- Keynesian Closure: Here we allow consumption to rise or fall with national income, and assume that aggregate labour demand, which is determined by the real wage rate, can differ from aggregate labour supply, resulting in unemployment.

- Kaldorian (Forced Savings) Closure: The Kaldorian closure substitutes this mechanism by a return-sensitive investment function. Given a baseline real rate of return, aggregate private investment increases or decreases as a

function of the differential between the current period return to capital and the average return to capital established in the baseline calibration. Given government savings, the savings investment equilibrium is satisfied through endogenous changes in the household's propensity to save. In essence, investment crowds out domestic consumption. In the traditional Kaldorian setting, the marginal propensity to save of only the high income group is allowed to vary, though this is ignored here.

- Johansen Closure: Finally, the Johansen closure may allow one of the other components of consumption (e.g. Government) to intervene to bring about full employment.

The impact of each of the closures is shown in table 4.9. The nature of each of the closures is clear from the simulation results. The most obvious point is that given that the Keynesian closure allows for a departure from the employment rule, the results for it differ substantially from the others. For the other closures, it is not a case of how much is produced, only which sector of the economy bears the burden of the adjustment. Therefore, the Kaldorian closure sees consumption fall lower than it would otherwise have done to ensure an adequate amount of household savings to finance investment.

The classical closure allows investment to adjust endogenously to lower savings by adjusting the rate of return on investment. Why then from the figures as presented are nominal savings and consumption not equal? The answer is two fold – firstly, the fixity of the savings/consumption ratio is at the level of the household, not the aggregate house. Secondly, the savings/consumption decision relates to disposable income, while the figure in the table relates to gross income before tax.

The third closure, the Johansen closure, switches adjustment from consumption or investment to government to soak up any spare capacity. Note that in the default closure, nominal government expenditure is fixed. The 0.85% represents the increased expenditure due to measures to combat the FMD outbreak. Therefore, we

see that government expenditure reduces to ensure that domestic absorption hits the target level, which implies a reduction of 0.25% in government expenditure to 0.60%.

Before discussing the Keynesian closure, we switch to the Balance of Trade closure. The exogeneity of the current account balance in the other simulations embodies the notion that the balance is a macroeconomic phenomenon (Hertel and Tsigas (1997)). In a one country model this might be the most appropriate comparative static approach as it prevents borrowing overseas to finance domestic consumption, borrowing that in a comparative static model does not have to be repaid at a future date. Therefore, even if the totality of economic evidence suggests that the balance of trade can move endogenously, and that the results derived by CGE models are effectively microeconomic phenomena, perhaps the best approach to welfare analysis is to leave the balance of payments fixed. It then becomes something like a hypothetical government replacement tax – we may not actually believe that it is levied in the year under consideration, but any move for savings to leave the country must be internalized in the model somehow. In terms of the model results, there is a slight deterioration in the balance of trade, indicating a small amount of aggregate dissaving.

The final closure is the Keynesian closure, which shows the greatest difference to the other simulations. With the Keynesian simulation, aggregate output is given a greater scope to vary as demand conditions change. The other closures were in essence about moving the drop in domestic output from household consumption, investment or into government consumption, producing expenditure by agents which divert from the underlying assumptions regarding the behaviour of those agents. Therefore, given the greater scope for aggregate labour supply to vary in the Keynesian model, aggregate labour increases so that the shortfall in national output which must be matched by reduced consumption in the other closures can be recouped. This actually multiplies itself as the increase in output which is induced to 'make up' the required level of output to satisfy absorption in turn increases labour income which in turn increases household income even further. By increasing labour

supply, labour costs also fall, inducing a general deflation which in turn causes a significant increase in exports.

Table 4.9:

Macro Closure Rule: Simulation Results

		Kaldor	Classical	Johansen	Keynes	Balance of Trade
Macro Aggregates						
Population	q_h	0.00	0.00	0.00	0.00	0.00
Real Wage	realwage	-0.16	-0.17	-0.18	-0.35	-0.16
Employment	employ_i	-0.08	-0.08	-0.09	0.33	-0.08
Nominal GDP	w1gdpexp	-0.23	-0.23	-0.24	-0.08	-0.22
Balance of Trade	delB	0.00	0.00	0.00	0.00	-0.03
Nominal Exchange Rate	phi	0.00	0.00	0.00	0.00	0.00
Real Devaluation	p1realdev	0.20	0.20	0.20	0.24	0.19
Terms of Trade	p0toft	-0.06	-0.06	-0.07	-0.08	-0.06
Labour Price	p0lab_io	-0.26	-0.26	-0.29	-0.47	-0.25
Capital Price	p1cap_i	-0.62	-0.61	-0.61	-0.51	-0.61
Consumption Price	p3tot_h	-0.10	-0.10	-0.10	-0.12	-0.09
Investment Price	p2tot_i	-0.10	-0.10	-0.10	-0.13	-0.09
Exports Price	p4tot_d	0.00	0.00	0.00	-0.01	0.01
Government Price	p5tot	-0.18	-0.18	-0.20	-0.32	-0.17
Imports Price	p0imp_c	0.07	0.07	0.07	0.07	0.07
Real Primary Inputs						
Labour	x1lab_io	-0.08	-0.08	-0.09	0.33	-0.08
Capital	x1cap_i	0.00	0.00	0.00	0.00	0.00
Total	x1prim_i	-0.06	-0.06	-0.07	0.13	-0.06
Real Final Demands						
Consumption	x3tot_h	-0.26	-0.19	-0.20	-0.02	-0.18
Investment	x2tot_i	-0.15	-0.42	-0.14	-0.06	-0.15
Exports	x4tot_d	-0.07	-0.09	-0.05	0.14	-0.11
Government	x5tot	1.02	1.02	0.72	1.16	1.02
Imports	x0cif_c	0.00	-0.01	0.03	0.22	0.02
Nominal Primary Inputs						
Labour	w1lab_io	-0.34	-0.35	-0.38	-0.15	-0.33
Capital	w1cap_i	-0.62	-0.61	-0.61	-0.51	-0.61
Nominal Final Demands						
Consumption	w3tot_h	-0.36	-0.28	-0.30	-0.14	-0.28
Investment	w2tot_i	-0.24	-0.52	-0.24	-0.19	-0.25
Exports	w4tot_d	-0.07	-0.08	-0.05	0.13	-0.10
Government	w5tot	0.85	0.85	0.52	0.85	0.85
Imports	w0cif_c	0.07	0.05	0.10	0.29	0.09

Note: Exogenous Variables are underlined.

4.4.3.4 Factor Market Closure

Capital Market

A simple static general equilibrium model has two closure extremes. The short term is that capital stock is fixed. Generally, investment will be allowed to alter based on the returns received in each industry, or may be set by some other rule. This follows the logic of the flow based theory of the marginal efficiency of investment theory. The point is that this investment does not alter the capital stock. The long term is based on the marginal productivity theory and postulates that capital will adjust to ensure that returns are the same by industry.

A fundamental problem in dynamic CGE analysis is how to marry the two – if you allow investment to flow to ensure that allows intolerably large swings in investment while at no time allowing for the possibility of supernormal profits on capital. Therefore what is usually imposed is some form of marginal adjustment costs (MAC) of investment either internal or external to the firm which will allow investment to build up the capital stock gradually to the state as predicted in the marginal productivity analysis.

This raises the question that if a MAC is imposed by necessity on a dynamic CGE model to adjust the level and cost of investment flows with a resultant impact on final demand, why should such an imposition not be imposed on a static model? Therefore, for relatively high levels of investment, should the cost of investment not increase? This consideration is ignored in the model. Secondly, if we do assume a long term closure, should we make some effort to try and show what sacrifices the economy had to make when moving from one capital endowment to another? This question depends on how we perceive the capital movement to have taken place. If it is the physical movement of machinery, then obviously this imposes a very large cost in itself. More likely to allow for the fact that moving capital can impose minimal costs in the medium/long term if it is based purely on a policy of not replacing depreciated capital in 'losing' industries with heavy investment in 'winning' industries.

Another consideration is even if we allow capital to move freely between industries, should we exogenise the existing level of aggregate capital in the economy or should we exogenise the overall interest rate. Under the more plausible depreciation theory, the fact that increased investment is induced by savings rather than simply moving machinery[8], suggests that the aggregate amount of capital should be allowed to vary so as to ensure that the marginal price of capital returns the exogenous interest rate.

Labour Market

Currently the labour force is flexible to the extent that a 1% increase in the real wage induces a 0.5% increase in the aggregate supply of labour. The model currently makes no allowance for a link between aggregate employment and number of households, so this implies that a reduced labour demand results in either a decrease in participation or an increase in unemployment. However there is no unemployment assistance in the model. Four sets of simulations are run to test the model regarding the sensitivity of changes in the labour supply elasticity under various scenarios. For the purposes of this simulation analysis we merely compare different treatments of labour supply by skill level under both an assumption of fixed sectoral capital and perfectly mobile capital within sectors.

Simulations A and B

Closures: Both sets of simulations A and B involve running the model with an assumption that the effect of a 1% increase in real income increases the aggregate labour supply by 0.5, 0.25, 0, 1 and 2. Simulation A is run under the circumstances that capital is fixed by sector, while simulation B assumes that capital is perfectly mobile, and capital rents are fixed at the economy wide level.

Results: The results are shown in table 4.10. The first point is that within simulations, the results are fairly robust to changes in the aggregate labour elasticity.

[8] In the real economy. Obviously, there is no mechanism in the model for financial capital to transform into physical capital.

Taking the range of 0.25 to 1 of the aggregate elasticity, we see that output seems to increase by around 0.04%.

In the short run "A" simulations, prices are virtually unaffected by the different elasticity assumptions, despite the fact that the price of labour is 0.05% higher with an aggregate elasticity of labour of 1 compared to 0.25. In this set of simulations the return to capital actually decreases, indicating that there is a transfer from capital to labour as the mobile factor moves to more rewarding industries. They in effect cancel each other out leaving most price indices virtually unchanged. In the long run "B" simulations, rental levels are fixed, and capital is entirely free to adjust, while labour is only partially able to adjust. Therefore as we move from left to right in the long run simulations, we are moving to freer labour, and as labour is freer to move, the wage rate falls by a progressively smaller amount, reflected in prices rising in aggregate measured by either the GDP deflator or the CPI index.

The bottom number of rows is the derived labour elasticity for each occupational grouping for each simulation. As can be seen, they vary widely from the aggregate elasticity imposed. Many are also negative, indicating that an increase in the real wage would result in a decrease in the labour supply of that occupation. This is the inevitable consequence of allowing workers to swap between occupations based on marginal returns. Remember that the overall real wage is equalised across all industries and occupations. Workers therefore leave the industries that are hardest hit by the shock (Sales and commerce workers and Professional, technical and health workers) and join other industries. Another point worth noting is that the dispersion of the derived occupational elasticities about the aggregate labour elasticity is far greater in the short run than the long run (for example consider the central simulations Sim0a and Sim0b). This is because the inter-industry adjustments in output can be accommodated for by reductions in capital stock. Also, the level of dispersion within each closure rises as the aggregate labour supply elasticity increase, calculated by simply taking the sum of the squared difference about the mean aggregate labour elasticity.

Table 4.10:

Factor Market Closure - A and B Simulation Results

	Sim2a	Sim1a	Sim0a	Sim3a	Sim4a	Sim2b	Sim1b	Sim0b	Sim3b	Sim4b
K by Sector Fixed	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**No**	**No**	**No**	**No**	**No**
r by Sector Fixed	**No**	**No**	**No**	**No**	**No**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Agg L elasticity	**0**	**0.25**	**0.5**	**1**	**2**	**0**	**0.25**	**0.5**	**1**	**2**
Agricultural Prices	3.91	3.90	3.90	3.90	3.89	3.91	3.90	3.89	3.87	3.84
Manufactured Prices	0.02	0.02	0.03	0.03	0.03	-0.01	-0.01	0.00	0.01	0.03
Service Prices	-0.18	-0.18	-0.17	-0.17	-0.16	-0.12	-0.11	-0.10	-0.08	-0.05
GDP deflator	-0.14	-0.13	-0.13	-0.12	-0.12	-0.11	-0.09	-0.08	-0.06	-0.03
Real Devaluation	0.21	0.20	0.20	0.19	0.19	0.18	0.16	0.15	0.13	0.10
CPI	-0.10	-0.10	-0.10	-0.10	-0.09	0.00	0.01	0.02	0.03	0.05
Nominal GDP	-0.20	-0.22	-0.23	-0.25	-0.28	-0.32	-0.43	-0.54	-0.74	-1.07
Employment	0.00	-0.05	-0.08	-0.14	-0.21	0.00	-0.14	-0.26	-0.49	-0.87
Average Tax	0.04	0.05	0.05	0.05	0.06	0.07	0.09	0.10	0.13	0.18
Wage Rate	-0.30	-0.28	-0.26	-0.23	-0.20	-0.56	-0.53	-0.51	-0.46	-0.39
Labour Income	-0.30	-0.33	-0.34	-0.37	-0.41	-0.56	-0.67	-0.77	-0.95	-1.26
Real Output										
Agricultural	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manufactures	0.30	0.28	0.26	0.23	0.20	1.02	0.90	0.79	0.58	0.25
Services	-0.12	-0.14	-0.16	-0.20	-0.24	-0.51	-0.64	-0.77	-0.99	-1.37
Imports	0.05	0.02	0.00	-0.02	-0.06	0.38	0.25	0.14	-0.08	-0.43
Real Consumption										
Investment	-0.13	-0.14	-0.15	-0.16	-0.17	-1.07	-1.20	-1.31	-1.53	-1.88
Household	-0.21	-0.24	-0.26	-0.29	-0.34	-0.20	-0.35	-0.49	-0.74	-1.16
Exports	-0.03	-0.05	-0.07	-0.10	-0.14	0.19	0.06	-0.07	-0.29	-0.65
Government	1.05	1.04	1.02	1.01	0.98	1.21	1.19	1.17	1.14	1.09
Utility	0.01	-0.01	-0.03	-0.06	-0.10	0.05	-0.07	-0.19	-0.40	-0.76
Derived Occ Elasticity	Sim2a	Sim1a	Sim0a	Sim3a	Sim4a	Sim2b	Sim1b	Sim0b	Sim3b	Sim4b
Farm, fishing, forestry	-5.0	-5.5	-6.0	-6.9	-8.8	7.1	7.5	7.8	8.6	10.0
Manufacturing	-1.3	-1.2	-1.1	-0.9	-0.5	-0.6	-0.4	-0.1	0.3	1.3
Building and construct	-0.5	-0.4	-0.2	0.1	0.7	-0.1	0.1	0.4	0.9	1.9
Commun & transport	-2.4	-2.4	-2.4	-2.3	-2.2	-2.0	-1.7	-1.5	-1.1	-0.2
Clerical, manag & govt	-0.8	-0.6	-0.5	-0.2	0.5	-0.8	-0.6	-0.4	0.0	0.9
Sales & commerce	1.6	2.0	2.4	3.3	5.1	-0.8	-0.6	-0.4	0.1	1.0
Service workers	-2.1	-2.1	-2.1	-2.2	-2.3	-0.9	-0.8	-0.7	-0.4	0.2
Prof, tech & health	3.2	3.8	4.4	5.7	8.3	2.6	3.0	3.3	4.1	5.6
Other (incl not stated)	-1.8	-1.7	-1.7	-1.6	-1.5	-1.2	-1.0	-0.9	-0.5	0.2
Agg L elasticity	0.0	0.25	0.5	1.0	2.0	0.0	0.25	0.5	1.0	2.0

Simulations C and D

Closure

The A and B closures fixed the aggregate elasticity, while the C and D closures fix the occupation closures. Only short term simulations are run. Simulation C breaks down the occupational groupings into "skilled" and "unskilled" and applies a common elasticity of substitution to each occupation within each skill group. However note that there is no other connection to occupations in that skill group. Simulation D is the obvious alternative, and assumes that labour moves freely within skill groups, and that each skill group faces an aggregate elasticity of labour supply. The postfix "1", "2" and "3" indicates that the elasticity for the unskilled and skilled groups are (0.5, 0.5), (0.25, 0.75) and (0.0, 1.0) respectively.

Results

The results for these two sets of simulations are shown in appendix 2, and show that the macro results are not sensitive to the choice between the various elasticity choices. Notice that the aggregate labour elasticity which is derived endogenously from the results, is generally higher than either of the elasticities for the separate occupational groups. So, for example, in Sim2d, the aggregate labour supply elasticity is 0.79, while the labour supply elasticity for skilled labour is 0.75 and the labour supply elasticity for unskilled labour is 0.25.

Algebraically, we can start with:

$$E_{AGG} = \frac{x_{AGG}}{r_{AGG}} = \frac{\alpha x_s + (1-\alpha)x_u}{\alpha r_s + (1-\alpha)r_u}$$

where the aggregate elasticity is equal to the change in the aggregate labour supply divided by the change in the real wage, which in turn are weighted averages for the equivalent variables for the skilled labour group and the unskilled labour group. Alpha (α) is the percentage of the total wage bill going to skilled workers. Rearranging gives:

$$E_{AGG} = E_S\left[\frac{\alpha / r_u}{\alpha / r_u + (1-\alpha)/r_s}\right] + E_U\left[\frac{(1-\alpha)/r_s}{\alpha / r_u + (1-\alpha)/r_s}\right]$$

Therefore the aggregate economy wide elasticity is a weighted average of two expressions which sum to unity but which are not in themselves limited to a (0,1) range. If the real wage of skilled is a different sign from unskilled, then the aggregate elasticity will breach the (0,1) range.

Intuitively, presume you employ two people on the same wages, the first of which works harder when you pay him more (elasticity of labour supply of 1), while the second of which is totally unresponsive to changes in pay (elasticity of labour supply of 0). Now, increase the firsts pay by 10%, and decrease the seconds pay, also by 10%. Aggregate work effort will increase due to the fact that worker 1 is working harder while the second has not changed his effort. Your total wage bill will be unchanged, suggesting an "infinite" elasticity of labour elasticity – i.e. getting something for nothing. Therefore the aggregate elasticity is not bounded by the elasticities of the individual groups.

Note that between the C simulations and the D simulations the aggregate labour elasticity is virtually unchanged. The closer the skilled/unskilled breakdown is to a 50:50 ratio of the workforce, and the more dissimilar the two groups are in terms of their reaction to a particular shock, then the greater the aggregate labour elasticity is likely to become. Perhaps a better aggregate labour elasticity would be just a weighted average of the skill based ones, weighted on share of labour market.

Finally, in comparing A with B and C with D, it is clear that the assumption regarding capital mobility is crucial to the results. In many cases this won't be a problem – for genuine shocks we can assume that the capital stock is fixed by sector. However it does indicate the importance of this assumption, and suggests that further work in defining capital mobility is warranted. For example, we could define a fixed capital and mobile capital component.

Table 4.11

Factor Market Closure - C and D Simulation Results

	Sim1c	Sim2c	Sim3c	Sim1d	Sim2d	Sim3d
K by Sector Fixed	Yes	Yes	Yes	Yes	No	No
r by Sector Fixed	No	No	No	No	Yes	Yes
Agg L elasticity	0.5	0.81	1.14	0.5	0.79	1.07
Prices						
Agricultural	3.90	3.90	3.90	3.90	3.89	3.89
Manufactures	0.03	0.03	0.03	0.03	0.03	0.03
Services	-0.18	-0.17	-0.17	-0.19	-0.18	-0.18
GDP deflator	-0.12	-0.12	-0.12	-0.14	-0.13	-0.13
Real Devaluation	0.19	0.19	0.19	0.20	0.20	0.20
CPI	-0.11	-0.10	-0.10	-0.10	-0.10	-0.10
Nominal GDP	-0.22	-0.24	-0.25	-0.24	-0.25	-0.26
Employment	-0.07	-0.11	-0.14	-0.08	-0.12	-0.14
Average Tax	0.05	0.05	0.05	0.05	0.05	0.05
Wage Rate	-0.25	-0.24	-0.22	-0.27	-0.25	-0.23
Labour Income	-0.33	-0.34	-0.36	-0.35	-0.36	-0.38
Real Output						
Agricultural	0.00	0.00	0.00	0.00	0.00	0.00
Manufactures	0.24	0.23	0.22	0.21	0.20	0.19
Services	-0.16	-0.18	-0.19	-0.16	-0.18	-0.19
Imports	-0.01	-0.02	-0.04	-0.03	-0.04	-0.06
Real Consumption						
Investment	-0.14	-0.15	-0.15	-0.16	-0.16	-0.17
Household	-0.24	-0.26	-0.28	-0.27	-0.28	-0.30
Exports	-0.08	-0.10	-0.11	-0.10	-0.12	-0.13
Government	0.96	0.96	0.95	1.07	1.06	1.04
Utility	-0.03	-0.05	-0.06	-0.02	-0.04	-0.06
Derived Occupational Elasticity	Sim1c	Sim2c	Sim3c	Sim1d	Sim2d	Sim3d
Farm, fishing & forestry	0.5	0.25	0.0	20.4	24.0	28.9
Manufacturing workers	0.5	0.25	0.0	-0.4	-0.8	-1.2
Building & construction	0.5	0.25	0.0	-3.0	-3.9	-5.0
Communic & transport	0.5	0.25	0.0	2.6	2.7	3.0
Clerical, manage & gov't	0.5	0.75	1.0	-0.6	-0.5	-0.4
Sales and commerce	0.5	0.75	1.0	1.4	1.7	2.1
Service workers	0.5	0.75	1.0	-1.8	-1.8	-1.8
Prof, technical & health	0.5	0.75	1.0	2.3	2.8	3.3
Other (incl not stated)	0.5	0.75	1.0	-1.4	-1.4	-1.4
Agg L elasticity	0.5	0.8	1.1	0.5	0.8	1.1

Alternatively, we could group particular industries by type of capital. For example, much farm machinery is readily transferable between different farm enterprises and can be used for production in the current period. Another obvious example is property whereby many service industries have the same basic demand for capital. Note that in the model, in so far as margin commodities are used, capital can switch from (say) transporting forestry output to transporting agricultural output. So, despite the fact that aggregate capital in the user industries and the transportation industry is fixed, the capital embodied in the final product can change as output changes.

4.4.3.5 Armington Assumption

In classical trade models goods are assumed to be homogeneous, with one producers output being perfectly substitutable for those of another. However the observed two way flow of trade within the same industry grouping suggests that some allowance for product heterogeneity should be made, the most popular approach being the Armington assumption (1969). This in effect assumes that imports and domestic goods are imperfect substitutes, though each country only produces one variant, so competition within the country is perfect. The popular alternative is the monopolistic competition trade model introduced by Krugman (1980) which predicts that a large home market translates into a disproportionate share of output and a trade surplus. A reduction in trade barriers in this model causes firms to relocate to the larger market and serve the small market through exports (Head and Ries (2000)). In the Armington case, the product variety is tied to the country, leading to a reversal of the home market effect.

There is one common set of Armington elasticity in the model, which covers intermediate consumption, investment consumption and household consumption. The results of the sensitivity analysis are shown in table 4.12. They show that the results are highly sensitive to the choice of Armington parameters.

Table 4.12
Confidence Intervals for Armington Parameters

	95% Lower Bound	75% Lower Bound	Mean	75% Upper Bound	95% Upper Bound
Agricultural Prices	2.66	3.34	**3.90**	4.43	5.10
Manufactured Prices	-0.09	-0.03	**0.03**	0.08	0.14
Service Prices	-0.95	-0.52	**-0.17**	0.17	0.60
GDP deflator	-0.71	-0.39	**-0.13**	0.13	0.45
Real Devaluation	-0.06	0.08	**0.20**	0.31	0.46
CPI	-0.54	-0.30	**-0.10**	0.10	0.34
Nominal GDP	-1.27	-0.70	**-0.23**	0.23	0.81
Employment	-0.45	-0.24	**-0.08**	0.08	0.28
Average Tax	-0.17	-0.05	**0.05**	0.15	0.27
Wage Rate	-1.43	-0.79	**-0.26**	0.26	0.91
Labour Income	-1.88	-1.03	**-0.34**	0.35	1.20
Real Output					
Agricultural	0.00	0.00	**0.00**	0.00	0.00
Manufactures	-0.90	-0.26	**0.26**	0.78	1.42
Services	-0.90	-0.49	**-0.16**	0.16	0.57
Imports	-0.02	0.00	**0.00**	0.01	0.03
Real Consumption					
Investment	-0.80	-0.44	**-0.14**	0.15	0.51
Household	-1.43	-0.78	**-0.26**	0.26	0.91
Exports	-0.40	-0.22	**-0.07**	0.07	0.26
Government	-3.56	-1.03	**1.02**	3.07	5.60
Utility	-0.17	-0.09	**-0.03**	0.03	0.11

4.4.3.6 Factor Mobility Elasticities

There are three sets of factor elasticity parameters. The first is the elasticity of substitution between different land types in the production of the land composite in each industry. The second is the elasticity of substitution between different occupation types in the production of the labour composite in each industry. Finally, there are the elasticities of substitution between different factor composites (labour, capital and land) in producing the primary factor composite. The sensitivity analysis reported tests the sensitivity of the model results to allowing each of these three sets of parameter values to vary simultaneously, though independently, up to a maximum of 50% higher than the mean level and a minimum of 50% lower than the mean level. The mean level is shown in shown at the end of chapter 3. The results of this

exercise are expressed as a 75% and a 95% confidence interval based on the Chebychev inequality. What is clear from the table below is that agricultural, manufacturing and services prices taken individually are very stable. The instability in the model is in terms of real output.

Table 4.13

Confidence Intervals for Primary Factor Parameters

	95% Lower Bound	75% Lower Bound	Mean	75% Upper Bound	95% Upper Bound
	Bound	Bound		Bound	Bound
Agricultural Prices	3.88	3.89	**3.90**	3.91	3.92
Manufactured Prices	0.02	0.02	**0.03**	0.03	0.04
Service Prices	-0.22	-0.19	**-0.17**	-0.16	-0.13
GDP deflator	-0.15	-0.14	**-0.13**	-0.12	-0.11
Real Devaluation	-0.06	0.08	**0.20**	0.31	0.46
CPI	-0.12	-0.11	**-0.10**	-0.09	-0.08
Nominal GDP	-0.28	-0.25	**-0.23**	-0.21	-0.19
Employment	-0.13	-0.10	**-0.08**	-0.06	-0.03
Average Tax	0.04	0.04	**0.05**	0.06	0.06
Wage Rate	-0.37	-0.31	**-0.26**	-0.21	-0.15
Labour Income	-0.50	-0.41	**-0.34**	-0.27	-0.19
Real Output					
Agricultural	0.00	0.00	**0.00**	0.00	0.00
Manufactures	0.11	0.19	**0.26**	0.32	0.40
Services	-0.23	-0.19	**-0.16**	-0.13	-0.10
Imports	-0.09	-0.04	**0.00**	0.05	0.10
Real Consumption					
Investment	-0.25	-0.19	**-0.14**	-0.10	-0.04
Household	-0.35	-0.30	**-0.26**	-0.22	-0.18
Exports	-0.16	-0.11	**-0.07**	-0.04	0.01
Government	0.94	0.99	**1.02**	1.06	1.10
Utility	-0.09	-0.06	**-0.03**	-0.01	0.03

4.4.4 Conclusion

In summary, the results of this sensitivity analysis on a set of simulations aimed at measuring the FMD outbreak on the Irish economy have been set out in this section. They conclude that the model results for this particular simulation are not very

sensitive to the choice of macro closure, factor market elasticity or labour market closure, though are very sensitive to the choice of Armington parameter.

CHAPTER 5

METHODS FOR UPDATING INPUT-OUTPUT MODELS THEORY AND CONSEQUENCES

5.1 Introduction

There are two distinct reasons for employing the updating procedures that are the focus of this chapter. Firstly, they can be used as an updating mechanism so as to arrive at a new set of input-output coefficients but in a more timely fashion. Secondly, they can be used as a mechanism of comparing updated estimates of coefficients and actual realisations as a means of measuring a change in the technological structure of the economy. Given the tardiness of publication of input-output figures, the former is of much more practical importance than the latter and is to be found much more frequently in the literature. Therefore the motivation behind this chapter is to discuss the relative merits of the various methodologies used to update input-output models.

This chapter is organised as follows. The main discussion is divided into what de Mesnard (2001b) named as directed and non-directed methods. By directed methods, we mean methods that are based on the assumption of stable technical coefficients or stable allocation coefficients. In the second section, non-directed methods, no hypotheses are made about the direction of the economy. As de Mesnard argues, even if one of the 'supply driven[1]' or 'demand driven[2]' hypotheses was intuitively plausible, it is preferable not to pose any hypothesis when it can be avoided provided that the hypothesis could be falsified later. In section 5.4 we introduce the ESA95 methodology that will form the basis for the compulsory production of annual input-output tables in Europe, and compare it with the Monash methodology as presented in this thesis. Finally, section 5.5 concludes.

[1] Which implies stable allocation coefficients.
[2] Which implies stable technical coefficients.

5.2 Directed Methods

5.2.1 Introduction

When we discuss the stability of coefficients in relation to directed methods, we are considering the stability or otherwise of allocation coefficients, technical coefficients or some combination whereby each industry is categorised as being driven by one or the other. Allocation coefficients are the elements of a row divided by the row total, and are so called as they show for each commodity the share of the total output of that commodity that is allocated to each using industry. For example, the allocation coefficients for electricity might show that 3% of electricity output is used in the chemicals industry, 5% in the catering industry etc. The term 'technical coefficients' is more familiar from the seminal Leontief derivation, referring to the elements of a column divided by the column sum, and which therefore represent the particular industry technology. So, for example, 40% of the inputs of the electricity producing industry is oil, 35% is coal, 3% is peat etc.

Finally, we note an important feature of suppy/demand driven models. If technical coefficients are stable, then allocation coefficients are (generally) not stable. To see this, if we assume that the matrix of technical coefficients at time 1 is equal to the matrix of technical coefficients in the base period, i.e. $A_1 = A_0$, then technical coefficients have not changed over the period t=0 to t=1, and therefore the allocation coefficients B_t can be derived as follows, where $B_1 = x^{-1}{}_1 A_0 x_1$ is not equal to $x^{-1}{}_0 A_0 x_0 = B_0$ where x is the matrix of aggregate output for each industry written in a diagonal matrix whereby all off diagonal elements are zero. The alternative is a bi-proportional technology concept that has little tradition in the input-output literature. Some limited evidence of the success or otherwise of the various updating mechanisms are discussed in section 2, but they are tests of methods and are not related directly to economic intuition.

This section is broken into three parts. In section 5.2.2 we discuss the economic intuition of, and evidence for, coefficient stability in the context of a demand driven model, while in section 5.2.3 we discuss supply driven models in the same context. In section 5.2.4 we briefly mention the attempts made to cross-pollinate the two to form an intertwined model. Finally, given that coefficients are generally shown not to be stable, section 5.2.5 looks at some evidence investigating whether or not there are discernable trends in the coefficients.

5.2.2 Demand Driven Models

A demand driven model in the input-output sense is based on the hypothesis that the technical coefficients remain stable over the period in question, and that the volume of output by industry depends only on the quantity of final demand. Therefore its use to update an input-output model assumes that industry technology remains unchanged over the period of the update. In terms of a Leontief demand-driven model, stability implies that technical manufacturing processes change relatively slowly. This is represented as follows:

$$X_0 = (I - A_0)^{-1} Y_0 \qquad (1)$$

Why do we think input-output technical coefficients might be stable? Popularly, inventions are thought to revolutionise industrial practices over a relatively short space of time. However, in reality, changes in technical relationships occur slowly and orderly not only for an entire industry but also at the level of the firm itself. Capital that has been superseded by a superior technology will probably be retained until it has depreciated significantly. Labour must be trained, hired and fired, work practices must be altered, new inputs must be sourced, the firm may have to be geographically relocated, budgets must be allocated etc. All these 'bottle necks' take time to be resolved. Consider, for example, the development of production processes in the Irish electricity industry over the course of the last 50 years, a process of gradual change that will continue with, for example, the gradual introduction of so called 'renewables' over the course of the next two decades.

Unfortunately, the evidence is clear that observed input-output coefficients are anything but stable. If the arguments above are valid, why might we observe such seeming volatility? We can identify four reasons why, despite the fact that a company might use much the same technology, the observed technical coefficients might display considerable volatility.

The first and most obvious explanation for instability is a change in the product mix contained within each input-output sector. It follows that a more aggregated model may be more stable as close substitutes are combined within one sector. Sevaldson Per (1970) shows in a Norwegian study that moving from a 79 sector table to a 14 sector table results in a large reduction in variability, with a further fall as this is aggregated to 5 sectors. He concludes that, since all sets of data are derived from the same source of data, the stability of the aggregate table must be due to the substantial stability in the shares of individual detailed sectors' contribution to the aggregate sectors.

The second reason is one of scale. The fact that input-output models assume that production marginal costs are equal to average costs is one of the main criticisms of the methodology. Therefore we might expect to observe movements in 'technology' that are actually cyclical variations as, for example, the proportion of overhead costs in total costs rises and falls.

Thirdly, there is probably no such thing as a typical year in any industry, much less the economy as a whole, which is usually assumed in input-output analysis. This is exacerbated by the existence of stickiness features such as fixed contracts, hiring and firing costs, uncertainty of future demands (and supplies) etc. which could result in the building up of stocks and the hoarding of staff, all of which render calculation of a typical base year technology even more difficult, and which might erroneously suggest that technical coefficients have changed, when in fact they have not. For example, a farmer might build up an usually high amount of winter feed if he feels the weather is likely to be poor.

Fourthly, changes in relative prices can obviously result in significant substitution between commodities. This returns to the first point whereby the extent of substitution possibilities is reflected in the level of aggregation. A natural question to ask if value coefficients are more stable than volume coefficients. Stable value coefficients in essence assume a Cobb-Douglas production function as opposed to stable volume coefficients that assume a Leontief production function. Therefore, if there is a 1% rise in the price of oil, ceteris paribus, there will be a 1% fall in the volume of oil demanded, resulting in the aggregate oil bill remaining unchanged. The evidence is that value coefficients are no more stable than volume coefficients.

Finally, measurement errors, which include human errors in data collection, random errors in the collection of survey data and changes in conventions relating to the treatment of various components of the table could cause instability that may or may not mask underlying stability.

5.2.3 Supply Driven Models

Many modellers have investigated the possibility of stability of the allocation coefficients, which would imply that the share of use of commodities by industries does not vary significantly. This model is the mirror of the more familiar Leontief and was pioneered by Ghosh (1958).[3] In essence, the Ghosh model calculates changes in gross sectoral outputs for exogenously specified changes in the sectoral inputs of primary factors.

The economic intuition behind the Ghoshian model is not very strong. Oosterhaven (1988) argues that the supply driven model supposes that demand is perfectly elastic. Ignoring all forms of final demand other than consumption, this implies that consumer's expenditure reacts perfectly to any change in supply, so that if there are additional cars, they will be consumed without any requirement for a corresponding shift in petrol use. The analogy with the Leontief model is clear, whereby demand changes are met perfectly by a change in industry outputs, without any allowance for

[3] Extension of this idea to model forward linkages was made by Jones (1976), a discussion of which can be found in Matthews and O'Toole (2000a).

(say) the possibility of joint production. The Ghoshian model is defended on the grounds that:

- In monopolistic markets, output coefficients are more likely to be stable than input markets.
- Government provided goods and services tend to have relatively stable output.
- Situations of supply shortage, most notably in centrally planned economies.
- Finally, in the case of a sudden disruption in production, a firm may wish to maintain existing markets by allocating products on the basis of historical sales patterns.

Dietzenbacher (1997), on the other hand, agreed that, while the usual interpretation of the model so as to describe physical output changes as caused by changes in the physical inputs of primary factors was economically implausible, it becomes plausible once it is interpreted as a *price* model[4]. That is, sectoral output values change due to price changes, which are caused by price changes for the primary inputs. The change in the price of a particular (final demand) good will be a weighted average of price changes in primary inputs plus the price changes in the primary inputs which go into manufacturing the intermediate inputs required in its manufacture. This does not, of course, defend the use of the Ghoshian model in a predictive sense, though it does give it a meaningful role as a data description tool.

The evidence seems to conclude fairly decisively that the allocation coefficients are not very stable. Vaccara (1970), reporting on a U.S. effort to analyse long-run changes in allocation coefficients, shows that, while changes in overall uses of intermediate use of goods tend to have the same sign in different periods, the data on individual input coefficients indicates a very marked degree of variability in the extent and direction over time. So industries that had positive changes in overall

[4] An example of the use of the Ghoshian inverse in this way is illustrated in chapter 4 of this thesis.

intermediate requirements showed frequent decreases in coefficients for particular industrial consumers.

5.2.4 Combining Supply and Demand

Given that exclusively supply-driven models or exclusively demand-driven models seem to be unstable, a natural route of inquiry is whether we can identify demand driven sectors and supply driven sectors. This is particularly attractive given that the intuitive justifications of the supply driven model relate largely to market conditions in individual sectors rather than as a heuristic explanation as to how allocation is undertaken in the overall economy. It is important to note the distinction between this method and the bi-proportional matrix methods. With bi-proportional matrix methods, the inter-industry elements are formed from the dual influence of supply and demand restrictions/assumptions within each industry. With the method presented in this section, one industry's output structure is assumed to be demand driven, while another industry's is supply driven. There is no interlinking whereby we try and target/manipulate supply and demand within the same industry.

A method developed by Bon (1986)[5], which de Mesnard (2001a) mischievously dubbed the 'output coincidence for forecasts' method, tries to determine which industries are supply driven and which are demand driven. It expands on a method originally suggested by Carter (1970) of simply comparing the actual output levels realised with those predicted by the traditional Leontief model and concluding that those industries which were a close match were stable, and that those that diverged were (relatively) unstable. Bon calculates both the Leontief and Ghoshian gross output forecasts and concludes that those sectors in which the demand (supply) driven model results are closer to the realised output are demand (supply) driven.

De Mesnard's principal critique is that, in addition to the shortcomings of the Carter model, the mixing of the structure of production and the effect of exogenous demand

[5] Bon applies the same methodology to other countries than the US which can be seen in (Bon, 1993, 1996a, 1996b, 1997, 2000a); all of which are reprinted in (Bon, 2000b).

(in the case of the demand driven model) and exogenous value added (in the case of the supply driven model) renders results incomparable. A variant which overcomes this problem can be seen in Matthews and O'Toole (2000b), which, while largely based on the Leontief model, allows final demand to vary endogenously in a few selected industries so as to hit a target level of output based on externally supplied expert opinion in a number of other industries. Of course, this could not be used in the sense of the 'coincidence' methodology, as it is necessary to determine the supply driven models prior to the estimation.

Finally, for completeness we mention the method of bi-proportional filters developed by de Mesnard (1990a, 1990b, 1994, 1996, 1997 and 1998) that allows simultaneous comparison of column and rows. He finds that his contention that the stability of column coefficients cannot be taken for granted and, generally, for any sector, both row and column coefficients are found to change simultaneously is supported. Another applied example of the bi-proportional filter to measure structural changes in the Chinese economy can be seen in Andréosso-O'Callaghan et al (2000).

5.2.5 Coefficient Trends

Given that the coefficients are demonstrably unstable, can we find patterns that could help us spot trends in the data that might then be extrapolated to improve input-output forecasts? Attempts to answer this question are rare, unsurprisingly given the paucity of data on input-output structures.

The seminal study in the area was by Arrow and Hoffenberg (1959), whose model formed the basis for the study by Sawyer (1992) who, using an enviable database of 27 annual input-output matrices for Canada for the period 1961-87, raises the following issues for investigation:

- Are coefficients more stable in volume terms than in nominal terms?
- If the coefficients exhibit systematic behaviour over time, what variables best explain this systematic behaviour?

In answering the first question he concludes that there was very little difference in the amount of variation displayed by the value or volume coefficients so that there appears to be no particular advantage in doing projections with value coefficients rather than with volume coefficients. In answer to the second question, he finds that it is better to use regressions on time or variables such as relative prices or income per person to forecast the future value than just assuming that they are constant. These results reinforce the conclusion of Forssell (1970). Sevaldson (1970) who had annual input-output accounts for Norway for the period 1949-1960 for 79 production sectors, tests only for a time trend in the coefficients and finds some weak evidence in favour of the existence of time trends.

The obvious drawback of all of these analyses, of course, is that they are based on (for example) 27 observation points for the Canadian study and 12 observation points for the Norwegian study. While such data might seem lavish to an input-output modeller, for time series analysis it is paltry, so we should expect spurious time trends to appear. In conclusion, the evidence seems to be that input-output coefficients are unstable, and trends appear to be weak and of little predictive value.

5.3 Non-Directed Methods

5.3.1 Introduction

For non-directed methods, no hypotheses are made about the direction of the economy. By far the most important of these is the so-called RAS method, which is discussed in section 5.3.2. In sections 5.3.3 and 5.3.4 we introduce the Delphi method and information theory, respectively.

5.3.2 RAS Technique

Techniques used to update IO models that do not require all of the information that is usually required from a survey of the sort that underlies survey based input-output models are often referred to as partial-survey methods, or non-survey methods if all the data needed can be found in published sources. This discussion concentrates on a brief discussion of, and a recent extension of the RAS method that is by far the most widely used non-survey method employed to update input-output models.

5.3.2.1 Stone's Representation

Stone's (1962) original technique for updating IO models is by far and away the most well known and widely used, the most advantageous feature of which is the ease with which it can be used. Stone was a key member of the Cambridge Growth Project (Department of Applied Economics, University of Cambridge 1962a, 1962b, 1963), one of the central purposes of which was to estimate a detailed and comprehensive SAM for 1960. The most recently available matrix was for 1954. Stone assumed that changes in input-output factors were the result of three factors.

1. Price changes
2. The effect of absorption, measured by the extent to which commodity *i* has been replaced by/used as a substitute for other commodities in production.
3. The fabrication effect, measured by the extent to which industry j has come to absorb a changed ratio of intermediate to total inputs in its production.

We depict the coefficient matrix with time subscript A_t, and the vectors q, u and v to represent gross output, total intermediate output and total intermediate input. Firstly, we alter prices where p is a price vector where prices at t=1 are related to initial prices at t=0. Without loss of generality we define quantities such that initial prices are unitary, therefore negating the requirement of a time subscript on the price matrix. We present the price matrix in diagonal form with all off diagonal elements set at zero. Then the initial matrix converted to current values (indicated by *1 superscript) is given by:

$$A_0^{*1} = PA_0P^{-1} \qquad (2)$$

Given this, the constant coefficients estimate of the updated transactions matrix is A_0^{*1} x where x is a diagonal matrix with gross industry outputs on the diagonal, and all off diagonal elements set at zero. Stone's constrained maximum problem is to adjust this matrix so that the row and column sums equal u and v respectively. Hence

$$A_1 = RA_0^{*1}S \tag{3}$$

and combining (2) and (3) to give:

$$A_1 = RPA_0P^{-1}S \tag{4}$$

where R and S are diagonal matrices.

Ignoring the price terms, the solution is the set of **r** and **s** multipliers that satisfy:

$$a_{ij}^1 = r_{ij}a_{ij}^0 s_{ij} \tag{5}$$

This equation shows that the pre and post adjustment matrices are assumed to be bi-proportionally related. Friedlander (1961) suggested a linear approximation to this non-linear relationship, i.e. of the form:

$$a_{ij}^1 = a_{ij}^0 + r_{ij}a_{ij}^0 + s_{ij}a_{ij}^0 \tag{6}$$

A natural question to ask is what interpretation can be put on the r and s multipliers. Stone interprets r_i as a measure of the extent to which the input in question has been substituted for other inputs. It induces proportional changes in all industries coefficients of input of i, and is what Stone refers to as the 'substitution effect'. The variable s_i on the other hand is referred to as the 'fabrication effect', a measure of the extent to which the industry j has increased or decreased its input of intermediate

inputs. Leontief's (1941) interpretation differs from Stone's in that r_i is defined as a measure of the increased productivity of *i* in all uses, while s_j is regarded as a measure of the joint effect of increased productivity in industry j and of a decrease in its rate of investment. Many researchers discount this "oversimplified" view of the RAS procedure, viewing the RAS technique as a purely computational procedure, which emerges as the solution to a constrained optimisation problem subject to the row and column sums (Okuyama et al, 2000)

A more damning mathematical critique of any attempt to interpret these derived matrices is given by de Mesnard (2000). Given that we have a system of *2n* equations with *2n* unknowns, we lack sufficient degrees of freedom to specify the values of the r and s matrices. Therefore, the many modellers who apply the RAS technique and interpret the r and s matrices as fabrication and absorption do so erroneously. This can easily be seen by multiplying all of the elements of r by λ and all of the elements of s by $1/\lambda$ will provide an equally valid solution of the model. Unfortunately, of course, it will also multiply the observed fabrication effect by λ and the observed absorption effect by $1/\lambda$, which removes all significance in terms of fabrication or absorption effects. There seems to be no evidence that anybody has thus far produced a satisfactory normalisation that might overcome this problem. Therefore, the best that can be achieved is a measure of their relative values.

Finally, we can calculate the predicted intermediate output and input aggregates as follows:

$$\Sigma r_i a_{ij} s_j q_j = u_i \quad (7)$$

$$\Sigma r_i a_{ij} s_j q_j = v_j \quad (8)$$

In practice the RAS updating procedure is as follows. First, a coefficient $d_{i,0}$ is multiplied by each element of row i to ensure that the row total sums to its control total u_i. This updates the initial matrix of coefficients A to A^1. Then each element of column j of this new matrix A^1 is multiplied by c_j to ensure the column sums to v_j.

The resulting matrix A^2 becomes the starting point for the next iteration whereby a coefficient $d_{i,1}$ is multiplied by each element of row i to ensure that the row total sums to its control total u_i etc. This process is continued until a satisfactory level of accuracy has been achieved.

5.3.2.2 Snower's method of Incorporating Price and Final Demand Data

The methods discussed so far involve the process of estimating the n^2 elements of an input-output matrix given 3n pieces of information, namely aggregate (domestic) output, industry intermediate output and industry intermediate input. However in the actual process of constructing an Input-Output table we can usually access two more vectors of information, a fact taken advantage of by Snower (1990).

Incorporating Final Demand Data

Firstly, final demand can usually be estimated with relative ease from published data or generated from predictive demand equations. Remembering the familiar identity

$$X_t = (I - A_t)^{-1} Y_t \tag{9}$$

if we know or can estimate final demand, then we can calculate a new vector of gross outputs which are based on the original input-output structures as follows:

$$X_{t+1}^{E} = (I - A_t)^{-1} Y_{t+1} \tag{10}$$

According to Snower, if our predicted output vector X^*_{t+1} is equal to our observed output vector X_{t+1} then we can deduce that the input-output coefficients have remained unchanged. If, as is more likely, the predicted vector of outputs differs from the observed, the difference can be said to result from changes in the coefficient matrix. Snower then suggests that we should now proceed to change the coefficients of the inter-industry matrix by an updating method that is analogous to that of Stone.

The largest single critique of this method is that, faced with a high elasticity of

substitution between domestic and imported variants for any final demand goods, there is some question mark as to whether the results of this method are reliable as changes in final demand can be met by imports. While in his analysis Snower, in true input-output tradition, uses final demand in the sense of demand for the domestic variant, in practice household expenditure studies predict demand for commodities regardless of source, and work back to calculate demand for the domestically produced variety.

Incorporating Price Data

Secondly, Snower suggests using price and value added information (again, relatively easy to obtain) as a further refinement of the results. The price system in a Leontief model can be expressed as follows:

$$P_t = A_t' P_t + VA_t \qquad (11)$$

By pre-multiplying each element of the above expression by the amount of output, we see that the left hand side is aggregate cost of the good, while the right hand side is equal to the cost of intermediate input plus value added. As with the final demand argument presented above, we assume that value added data and price data are collected annually. Therefore it follows that if inter-industry coefficients remained unchanged from t to t+1 we can calculate prices as a weighted sum of value added by industry, where the weights are as shown:

$$P_{t+1}^E = (1 - A_t')^{-1} VA_{t+1} \qquad (12)$$

By the same reasoning as above, the extent to which prices as calculated above differs from prices observed in t+1. Again, Snower suggests an iterative balancing procedure along the lines of RAS to balance the inter-industry matrix.

5.3.2.3 Empirical Evidence

So how well does the RAS technique do in updating input-output models? The

findings of Okuyama et al (1998) is that the RAS technique is a reasonable estimation procedure for a short time period, or for a period with few structural changes, as compared to some regression models. They add the caution that for a longer time period or for a time of significant structural change, the errors produced by the RAS procedure tend to be quite large. Lecomber (1975)[6] and Allen and Lecomber (1975) suggest that the exogenisation of key elements as identified by a 'fields of influence' study is a mechanism for improving accuracy without requiring a large amount of additional data.

5.3.3 The Delphi method

For completeness we briefly mention the Delphi method. This is loosely a Bayesian concept that uses prior information regarding the probabilities of future events, and then allows the revision of these estimated future probabilities in terms of estimated interactions among those events. For discussion of the method together with a presentation of applications of the Delphi method, see Linstone and Turoff (1975).

Given the large costs involved in constructing input-output models, others, as reported by Fisher and Chilton (1972), have also used 'expert opinion' to estimate initial technological structures of industry. In essence, instead of the laborious process of matching purchase and sale data to create the inter-industry flows, they propose using expert opinion to estimate the technological coefficient shares within each industry. While not of specific interest in terms of the discussion in so far as this relates to creating a table from scratch rather than updating an existing table, it is interesting in that it could be seen as a move towards creating 'marginal' tables that, it might be hoped, would be more accurate in updating than other methods.

5.3.4 Information theory

The "Maximum Entropy" approach to estimating unknown and unobservable data, based on Information Theory, has been reintroduced to the input-output problem recently by Golan, Judge and Miller (1996) and Golan, Judge and Robinson (1994). Proponents argue that the approach is very flexible and sparse in its assumptions, and

[6] As cited by Okuyama et al (1998)

can be used when there is insufficient information to recover estimates to use the traditional procedures of mathematical inversion.

The term information means, informally, the amount of 'news' rather than the amount of 'facts'. So, taking Bacharach's (1970) example, if it is in the middle of July then a forecast of warm, dry weather is less informative than a similar forecast in the middle of February. Therefore with input-output analysis, given a particular initial matrix of coefficients, the estimate will have the property that while satisfying the constraints, the resulting matrix is the one that is least likely to 'surprise' us.

5.3.4.1 Introduction to Maximum Entropy

The work of Shannon (1948), who initiated the theory of information theory, was focussed on communication engineering. Given a set of symbols, each with a constant probability x_i, he suggested that the amount of information contained in the message is:

$$H(x) = \sum_{i=1}^{n} x_i \log \frac{1}{x_i} \tag{13}$$

Consider[7] an event E with a prior probability of x, while let y be the probability of E after a message concerning E has been received. Now, where

$$h(z) = -\log z \tag{14}$$

the expression

$$h(x) - h(y) = \log \frac{y}{x} \tag{15}$$

[7] This example, along with much of the discussion in this subsection, relies heavily on Garrouste (1998).

represents the gain of information inherent in y. More generally, given prior probabilities $x_1, x_2, \ldots, x_n$, for n events and posterior probabilities $y_1, y_2, \ldots, y_n$, then the aggregate gain in information is:

$$I(y/x) = \sum_{i=1}^{n} y_i \log \frac{y_i}{x_i} \qquad (16)$$

Therefore the gain in information is a weighted average of the gain in information for each individual event due to the message, where the weights are the updated probabilities of each event occurring. Theil offers two interpretations for $I(y/x)$. Firstly, it can represent the content of information of the message. Secondly, if the x_i's are interpreted as predictions and y_i's are interpreted as actual realised outcomes, then $I(y/x)$ represents the inaccuracy of the prediction.

5.3.4.2 Maximum Entropy and RAS

Theil originally used maximum entropy to model the problem of firm concentration in an industry. Where y_i is the market share of firm i, the concentration within an industry is given by

$$H(y) = \sum_{i=1}^{n} y_i \log y_i \qquad (17)$$

So, the more important is the entropy (entropy means uncertainty and is the reciprocal of H), the less is the concentration.

The problem was then extended to matrix updating, with a lot of attention being paid to a method developed by Golan, Judge and Miller (1994). Given the fact that the RAS technique has not performed well when predicted tables are compared to actual realisations, the hunger for another more satisfactory method is understandable. However it has long been known as far back as 1970 as shown by Michael Bacharach that RAS itself was an entropy-theoretic model (Bacharach, 1970). The next natural question to ask is how do RAS and the methods proposed by Golan,

Judge and Miller compare. They derive a cross entropy procedure to derive a very general formulation. They minimise an objective function:

$$CE = \sum_{j=1}^{n}\sum_{i=1}^{n} b_{ij} \log \frac{b_{ij}}{a_{ij}} \qquad (18)$$

Subject to:

$$\sum_{j=1}^{n} a_{ij} v_{\bullet j} = v_{i\bullet} \qquad (19)$$

$$\sum_{j=1}^{n} a_{ij} = 1 \qquad (20)$$

In essence, each column is treated as a separate probability distribution. The key point of this, as pointed out by McDougall, R.A. (1999), is that the cross entropy measure above is just an unweighted sum of entropies, and is not an entropy in itself. There is no particular reason why CE = $\Sigma_j CE_j$ is the most desirable in terms of economic properties. Consider now the RAS function. McDougall shows that it takes the form:

$$CE = \sum_{j=1}^{n}\sum_{i=1}^{n} \frac{v_{\bullet j}}{v_{\bullet\bullet}} b_{ij} \log \frac{b_{ij}}{a_{ij}} \qquad (21)$$

McDougall shows that the cross entropy methods break some desirable ordering conditions. For example, with so-called MSCE (Minimum Sum of Cross Entropies), he shows that if (say) the ratio of usage of input i_2 to usage of input i_1 is smaller in industry j_2 than in industry j_1, then we can find a numerical example whereby this is reversed in the final estimates. Given that we have provided no new information as regards the industry technology structure, such shifts are undesirable. RAS suffers from no such problems. So in the final estimates in our example the ratio of usage of input i_2 to usage of input i_1 will remain smaller in industry j_2 than in industry j_1.

In conclusion, the use of maximum entropy in this manner turns out to be theoretically weaker than RAS, and it is not surprising therefore that there is no evidence yet that the quality of predictions using maximum entropy is an improvement on the results derived from the RAS technique.

5.4 ESA 1995 and updating Input-Output Models

Prior to the European System of National Accounts (ESA95), the process of member states supplying input-output tables has been moved from a 'gentleman's agreement' to a legal requirement. Beginning in 2002, each member of the European Union will be required to supply five yearly input-output tables and annual supply and use tables to both supplement these and to bridge the gap between the last set of tables and the most recent sets of national accounts. Given the numerous and diverse methods in circulation for calculating input-output tables, Eurostat has developed a new updating methodology, a full discussion of which can be seen in Beutel (2000 and 2001).

The new updating procedure is based on three central assumptions. Firstly, that there are substitution processes which are changing input usage patterns, secondly that there are production effects which are influencing outputs and finally that there are price effects which affect both inputs and outputs. As the language of these three assumptions suggest, the method has its roots very firmly in the RAS tradition, though there are important differences. In essence, the ESA method tries to derive the input and output levels for the various branches of the economy that are compatible with the exogenous information on value added by branch and final demand components. Column and row vectors for intermediate consumption and final demand, which would be exogenously imposed in the RAS methodology, are derived as endogenous variables.

The methodology developed in the Monash model, which is applied in chapter 6 of this thesis, is centered on the formation of an appropriate model closure, called the historical closure[8]. Historical closures include in their exogenous set two types of variables, observables and assignables. Observables are those variables that can be

[8] For a full discussion see Dixon and Rimmer (2000)

readily observed for the period of interest, e.g. consumer price inflation. Obviously, the more time passes, the more variables are observed. Assignable variables are naturally exogenous variables in all types of simulations. We can then chose in our list of endogenous variables those that would usually be exogenous, but whose endogeneity is required to ensure our observables can be exogenised. For example, we can exogenise the observed spending by consumers on cars by endogenising the taste variable for car consumption. Using this historical closure, we can shock the base year data by the exogenous observables, thus arriving at an updated model of the economy. All changes in flows can be interpreted within a framework of explicitly modeled technologies that assume profit/utility maximising agents. In summary, given an initial consistent database, the Monash model calculates what shifts in taste and technology are required to replicate the observed data in the 'target' year.

So how does the Monash method, a version of which is applied in the succeeding chapters, compare with the Eurostat approach? Many of the advantages of the Eurostat approach are inherent in the Monash approach. In particular:

- Both are low cost, with low data requirements (relative to a full input output construction project) and which can be completed quickly
- Both produce integrated estimates of all elements of the table, ensuring that the table is internally consistent
- No arbitrary changes of input coefficients
- Row and column sums for intermediate consumption are derived endogenously rather than fixed as a share of aggregate output as is typical of other methodologies
- Composition of final demand is allowed freedom to adjust to match the observed data
- Consistency of supply and demand is ensured with both.

The other obvious advantage of the Monash approach is that all changes are interpreted in terms of specific technology functions, while the Eurostat approach

uses untraceable averaging and rebalancing techniques. With Monash, any industries change in output can be decomposed into the effect of changes in its own output, changes in the price of inputs, change in its own price etc. Of course explicitly quoting numerous changes such is this is dangerous given that much of the data is inferred, and an industry-by-industry critique could uncover substantial discrepancies with reality. Admittedly this argument presupposes that the technologies and markets as modeled in the Monash model are good simplifications of real world processes, an assumption that at times is difficult to sustain. For example, the Monash model assumes a uniform price change for a commodity regardless of the market into which the good is being sold (excluding export markets, for which price can diverge), while we would expect in reality each flow to have its own price deflator. For example, we would expect that changes in the price of machinery used in (say) the construction industry would differ from changes in the price of machinery used in the insurance industry.

The corollary of this argument is that specifying industry technologies is only useful in so far as the underlying technology of the industry is accurately represented. This is a fair criticism, especially given that in the Monash application presented in this thesis, many of the technologies are overridden by imposing restrictions on product flows.

The main disadvantage of the Monash methodology is that negative flows are possible when the Johanson solution method is used for solving the model. Resolving such rogue observations are easy however through the exogenisation of the relevant flow. More traditional matrix updating methods do not allow the manipulation of individual entries with ease. In fact, another advantage of the Monash method over any matrix methods is the ease with which diverse data control totals can be imposed.

5.5 Conclusion

The main discussion in this chapter was divided up into a brief discussion of directed and non-directed methods while in section 5.4 we introduced the ESA95

methodology that will form the basis for the compulsory production of annual input-output tables in Europe and compared it with the method employed in this thesis.

The evidence seems to be that traditional demand driven or supply driven models (i.e. directed methods) prove to be poor estimators of future input-output tables. Methodologies that do not assume the stability of one or other of the coefficient sets (i.e. non-directed methods) have also proved to be of little benefit. While no empirical tests have been completed on the Monash approach (to our knowledge), its ability to incorporate with ease any data available at the time of construction is of huge benefit. As more data for a particular year becomes available, it can be incorporated into the updated model. In effect, the 'full' input-output data sets as calculated by the statistical agencies can be thought of as the limit of a series of Monash-style updates, assuming that the Monash model is a reasonable model of the economy. The final advantage of this methodology is that we can interpret changes in the input-output coefficients in terms of price effects, income effects, taste and technology effects etc. The method goes beyond the 'dumb' matrix manipulation method of RAS and its descendants.

CHAPTER 6

UPDATING THE MODEL FROM 1993 TO 1998

6.1 Introduction

In chapters 2 and 3 we described the construction of a model for 1993, with an illustrative application in chapter 4. We now move to updating the model from 1993 to 1998. Ideally, of course, we would build the 1998 model in isolation, but we lack much of the relevant data, most noticeably the input-output data of inter-industry flows.

Therefore the obvious motivation of this exercise is to obtain updated flows relating to 1998. Input output tables are not produced for every time period and those that are produced are subject to very significant time delays. The relevance of results in 2001 of simulations based on 1993 data is highly suspect, and is open to the charge of irrelevancy. This is particularly true in the case of Ireland, which witnessed very high growth from 1994 onwards which has substantially changed the structure of the economy.

There are a number of possible ways this updating could be achieved. The most popular updating techniques such as RAS[1] are merely a set of mathematical procedures that, cumulatively, result in a mathematically appropriate set of results. They provide very little intuition as to why a particular result occurred. Given the very significant growth in the Irish economy in the mid 1990s, an ability not only to update the input output table, but also to explain the causes of the recorded changes would be highly useful. It is this second reason that provides the motivation for choosing the Monash procedure (Dixon and Rimmer, 2000) to update the model that allows us to retrieve much information explaining the source of changes. The approach will be basically to run a series of comparative static simulations which takes the starting point (1993), and asks what 1993 would have been like given the

[1] See chapter 5 for a full discussion of updating techniques.

1998 endowment of labour, capital, export flows, household consumption etc. Therefore we are adding what we know about 1998, but assuming that the underlying model for 1993 can fill in any gaps for which we do not have data.

This is done through a series of so-called historical and decomposition simulations. The aim of the historical simulation is to update the 1993 economy to fit the observed data of the 1998 economy. To do this, we exogenise many variables which ordinarily would be endogenised within the model and set them at the observed 1998 values. In general we target variables relating to the SAM – other variables such as the growth in the number of households of each type, or the number of workers per occupation are either set exogenously (as in the case of the former) or derived from the model without reference to external data sources (as in the case of the latter). Also, we generally target quite specific nominal flows, while allowing technology shift variables to ensure more general price targets such as the Consumer Price Index are met. The choice of closure in the historical simulation does not really reflect any economic intuition, but instead reflects the need to impose particular pieces of data. Put another way, we do not expect to or wish to learn anything about the economy from the historical simulations, but interpret them purely to ensure that the data is being imposed in a reasonably sensible way.

While a valid criticism could be made that the choice of what is exogenous and what is endogenous is largely a matter of judgement, in defence of the method it should be noted that this merely reflects the quantity and quality of data we are able to bring to bear on the model – other approaches ignore much of this data completely. The other criticism valid both here but also for most input-output models whether updated or otherwise is that they (typically) have no monetary element o do not allow for cyclical swings in business activity. This concern is perhaps greater in terms of comparing two comparative static results for 1993 to 1998, as in first differences such cyclical swings will be much more important than in levels. Any effect arising from business cycles or monetary phenomenon in the model will be interpreted in changes in technology which, perhaps, in a limited sense they are. In a

wider sense however we are trying to identify long-run changes in technology rather than short run transitory 'blips'.

Consider a simple partial equilibrium model of household consumption, which we wished to update to match observed consumption patterns. Assuming a CES function for household preferences, the derived demand for good x can be expressed in percentage change form as follows:

$$x_i - a_i = x_{tot} + \sigma_i (p_i + a_i - p_{tot}) \qquad (1)$$

Therefore, ignoring the a_i terms momentarily, demand is directly proportional to total household demand x_{tot}, and the ratio of the price of good i, p_i, to the CPI, p_{tot}. In a standard simulation we would (say) increase the price of the good relative to other consumables and therefore predict a new level of x_i. In such a standard comparative static simulation, we would know nothing about the taste variable a_i, so we would exogenise it and leave it unshocked, in other words we would set it at zero.

In an ex post historical simulation, however, we know the observed levels of x_i and x_{tot}, as well as the observed changes in the price of good i and the change in the CPI. The model is now over determined, so, other than by fluke, the predicted total of consumption is unlikely to exactly match the observed total. Therefore, we will allow some naturally exogenous variable to vary endogenously to ensure a model solution. We have a choice of which normally exogenous variable to endogenise. We could pick a taste variable, which are almost always exogenous in normal simulations as taste is very difficult to measure and about which economists have very little to say. Alternatively, we could pick the elasticity of substitution σ_i, though this is rarely done in practice.

So, for example, if demand for consumables has risen by 10%, the elasticity of subsitution is -2, and the price of good i has risen 5% faster than the CPI, we would expect, ceteris paribus, that demand for good i would remain unchanged, with the increased demand for consumables being entirely offset by the increase in price of

good *i*.

$$x_i - a_i = 10\% - 2*(a_i + 5\%) \qquad (2)$$

If we observe that x_i has actually fallen by 10%, then there must have been a shift in tastes. More specifically, the taste 'shifter' a_i must be equal to 10%, which results in both sides of the equation equaling –20%.

$$-10\% - a_i = 10\% - 2*(a_i + 5\%) \qquad (3)$$

As far as updating our simple partial equilibrium consumption model, this is where the process would end. However, in a general equilibrium model, we must hit a lot more 'targets' and therefore endogenise a lot more naturally exogenous variables. For example, we will observe the change in the amount of labour and land used in farming along with the amount of output from each branch of farming. Again, other than by fluke, it is unlikely that a production function will exactly predict changes in output given these changes in inputs. Therefore we allow the technology vector to change to ensure that it does.

At the end of the process we will have derived a large number of changes in taste, technology and other variables. Given its general equilibrium nature, each of these variables is likely to have an impact on the entire economy. To analyse this, we calculate a series of so-called decomposition simulations. These are very traditional CGE comparative static simulations. We start with the 1993 data, and then impose each of the changes in tastes and technologies in turn. When we have shocked all of the exogenous variables, we end up with the changes from 1993-1998. But we also have a series of intermediate results through which we can 'decompose' various changes in the intervening period. For example, if the observed amount of labour used in farming decreased by 20%, we might see that 5% of this can be attributed to changes in tastes which encouraged consumers to purchase less food, 10% might be attributed to changes in technology on the farm due to increased mechanisation, and 5% due to factors (such as export demand) which resulted in an increased scarcity of

labour.

The actual results calculated of the decomposition simulation for the 1993 to 1998 time period turn out to be somewhat unenlightening. In essence, what drove the economy in Ireland over the period was a large increase in production from multinational firms that are concentrated in a couple of sectors. In relation to the magnitude of these changes, changes in the structure of various final demand components other than exports are not particularly significant, as they are drowned out by the FDI effect. Therefore this section of the updating procedure did not yield very informative results.

This chapter is arranged as follows. Section 6.2 discusses the changes in the economy that it is the aim of this chapter to explain, along with a brief discussion of the factors that have been posited for this growth. Section 6.3 introduces the so-called 'historical simulation', which imposes the observed changes in the economy over the period 1993-1998. Section 6.4 contains the 'decomposition simulation' that takes the changes in the naturally exogenous variables from the previous section to decompose the aggregate economy changes into a series of what-if comparative static results while section 6.5 concludes. The updated input-output data set for 1998 is shown in Appendix 3.

6.2 Performance of The Irish Economy 1993-1998

6.2.1 Introduction

Given that this is an exercise designed both to update the input-output model and to decompose the observed changes in the economy over the period 1993–1998, it makes sense to begin by sketching what actually happened in that period. We begin in 6.2.2 by sketching the changes in the macro economic aggregates that are of concern in this investigation. In section 6.2.3 we discuss some of the explanations frequently put forward to explain the extraordinary performance of the economy.

6.2.2 Ireland's Macro Performance 1993-1998

Over the period 1993-1998 output growth has averaged almost 10% per annum,

bringing GDP per capita in purchasing power parity terms to a higher level than the European Union average. This growth is reflected in a large rise in employment due to a reversal in the Irish trend of substantial emigration, a large fall in unemployment and an increase in the female participation ratio, which was relatively low in 1993 compared to those of our European partners.

Table 6.1

Highlights of Irish Economic Performance, 1993 -1998

	Total
Macro Aggregates	
Population	3%
Exployment	26%
Nominal GDP	89%
Prices	
Consumption	13%
Investment	39%
Exports	16%
Government	16%
Imports	38%
Nominal Demands	
Consumption	77%
Investment	167%
Exports	139%
Government	53%
Imports	146%

Source: CSO, Statistical Bulletins, various years

6.2.3 Domestic Policy Explanations for the Performance of the Economy

While external factors, particularly the continued boom in the American economy, can help to explain some of the success of the economy in the 1990s, the fact that Ireland's performance outperformed its peers by such a margin requires an explanation that goes beyond international factors. ESRI (1999) identifies two elements of domestic policy as being particularly relevant – firstly industrial policy, specifically the success in attracting FDI, and secondly the monetary and fiscal

policies adopted in this period. Each is now dealt with briefly in turn.

Industrial Policy and Foreign Direct Investment

One of the primary explanations put forward for Ireland's recent performance is the massive inflow of direct investment. In 1997, Ireland ranked fifth in the world as a destination for US direct investment outflows. FDI inflows into Ireland have not gone into sectors in which there was a traditional comparative advantage. The most notable sectors in relation to this are Chemicals, and Metals and Engineering, both of which have seen a large inflow of FDI, but in which Ireland had a revealed comparative disadvantage in the 1960s. Another salient feature of the Irish FDI experience is that a considerable proportion of employment in the foreign sector of Irish manufacturing is located in relatively high-technology sectors. Those sectors that account for over 70% of employment in foreign industry in Ireland show a relatively higher skills level compared with aggregate manufacturing. Also, Barrios, Barry, and Strobl (1998) report that average wages in foreign firms in 1993 were 25% higher than in indigenous industry.

Finally, the relatively low level of backward linkages of foreign industry in Ireland is worth noting, with imported inputs representing 65.5% of gross output for foreign firms, compared to only 21.7% for indigenous firms. Barry et al cite Rodriguez-Clare (1996) who argues that the appropriate linkage measure is the number of jobs created upstream *per job* rather than per unit of output. O'Malley (1995) shows that, in the Irish experience, the backward linkages per job are actually higher than those for domestic industry.

The OECD identify the chief explanations for the increase in FDI as the quality, price and availability of an English speaking labour force, the exploitation of "first-mover advantages", robust and prolonged expansion of the US economy, an open trade regime, a transparent regulatory framework and a favourable tax regime with substantial industrial supports. They finish off by stressing the importance of the success of national wage agreements in preventing social discord while allowing substantial changes in work practices.

Fiscal and Monetary Policy

In respect of fiscal policy, the ESRI follow many other commentators in identifying the fiscal consolidation of 1987 as the turning point in the public finances. Prior to the turnaround, Ireland had been close to the point of bankruptcy with a debt/GDP ratio of 120%. In that year a minority Fianna Fail government with the backing of the main opposition party in what was to become known as "The Tallaght strategy" pursued with vigour a policy of fiscal restraint that they had vehemently opposed while in opposition. By 1989, much of the adjustment had already been made, with the public finances resuming a more typical cyclical pattern in line with real economic growth and with little borrowing. However, the ESRI is critical of the subsequent loosening of fiscal policy that was effectively masked by an explosion in taxation revenues. Throughout the period there was a sharp fall in personal taxation rates, an expansion of the tax bands. Foreign direct investment was encouraged through the cutting of corporation taxation rates and the setting up of the IFSC[2] to encourage the development of financial services.

The ESRI point out that monetary policy in Ireland 1990s constituted an important part of the economy's preparation for the advent of the Euro. There was generally benevolent domestic environment and a systematic global trend towards lower inflation. The only large disruption to this general picture was during the Gulf war when an effort to maintain the Irish punt's position in the ERM pushed up domestic interest significantly, and was at least partially the cause of the economic slowdown in the early 1990s. Otherwise, monetary policy was quite passive, with the fiscal contraction of 1987/1989 taking central stage. With the exception of the period of the Gulf war, interest rates remained very low throughout the 1990s.

6.3 Historical Simulation

6.3.1 Introduction

We now introduce the historical simulation, which is the process of making the model target particular variables that can be easily observed in 1998. The process

[2] Irish Financial Services Centre

could be a single step one – we could take all the variables observed in 1998, calculate the percentage change for each over the corresponding 1993 value, and impose them all in one go. However, this would result in errors being very difficult to spot, so instead we use a cumulative step-by-step approach to updating the model. Each of these updating steps is broken down into the data assumptions employed in calculating the percentage change in the variables that are to be imposed and the changes required in the model to accommodate this data. The reason the data collection is not treated separately in Chapter 3 is two fold. Firstly, the interpretation of many of the results will be very sensitive to the form of, and confidence in, the data, and the proper interpretation of the former requires a careful understanding of the issues relating to the collation of the latter. Secondly, much of the discussion in Chapter 3 relates to working around an existing Input-Output table, in particular how to accommodate inconsistencies. The problems faced in terms of updating the data are often quite different.

Most notably, the guiding principle in Chapter 3 was, in case of doubt, to assume that the IO table was accurate. In this chapter, we have no such guidance. The principle that was adopted was, where possible, to introduce data in a form closest to the source data as possible. This was done so that, if changes had to be made in the future, the origin of the imposed changes in this version of the model could be traced back with a minimum of hassle. For example, if we have a figure for personal consumption on food in 1998 of £3,400m, but we need this broken down into meat, dairy and other foods, we will explicitly create a new sector in the Tablo code called 'food' which will be an amalgam of the three sectors. We will then explicitly impose any assumptions regarding how much of the increase since 1998 can be attributed to each of the three sectors by an explicit rule for movement of the sectoral shifters. However, attention also must be paid to the costs in terms of development time of such a strategy. To accommodate the food example above, a new set must be defined, equations linking the new set and the old set may be necessary, new shift variables will have to be inserted, etc. Therefore the policy used in practice was to implement the data in a form that was as transparent as possible, but mindful of the

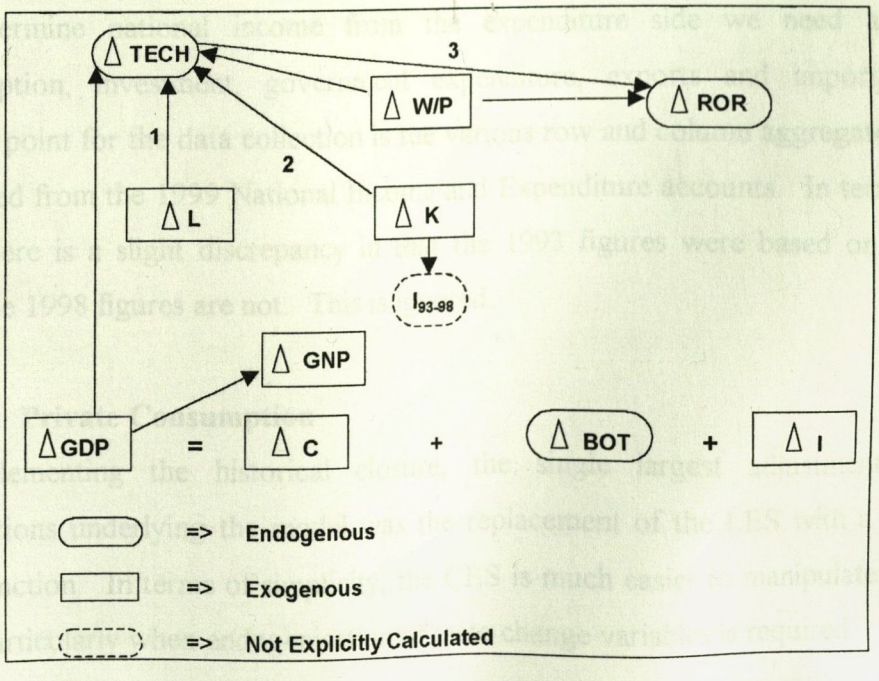
[2] Irish Financial Services Centre

resources required to implement changes internally in the model.

6.3.2 Historical Closure

An important step in understanding the historical simulation results is to understand the historical closure – the choice of endogenous and exogenous variables required to close the model. The macro connections in the historical closure are illustrated in figure 6.1. All exogenous variables are shown in rectangles while endogenous variables are shown in ellipses. The arrows from one set of variable to the others illustrate the 'direction of causation' within the model. So, for example, the exogenously set change in aggregate labour, along with the exogenously set changes in aggregate capital, will dictate how the underlying technological structure of the economy will change. The arrows 1 and 2 indicate the influence of labour and capital respectively. Further, the changes in technology dictate the changes in the rate of return achieved on capital (as indicated by the arrow denoted 3), both of which are influenced by the real wage rate that is exogenously set. The bottom line in the graph represents the familiar national accounting identity. It is clear from the diagram that the centers of focus are the changes in technology variables. We then exogenously fix capital growth, population growth and the real wage rate.

Figure 6. 1: Illustration of The Historical Closure



6.3.3 Step-by-Step Approach to Updating Model

As already mentioned, our approach in updating the model follows that of Dixon and Rimmer (2000). Rather than impose all of the shocks in one go, we introduce shocks sequentially as a mechanism for spotting errors. However, it must be stressed that the results of each step as presented do not have the usual comparative static interpretation. So, for example, if we exogenise household consumption in step 1, then all subsequent changes are in terms of an economy with this level of consumption. The taste variable that will result at the end of each subsequent step is likely to be very different as it adjusts to reconcile each additional piece of data. Only after all the external information is supplied can we put a strong interpretation on these taste shifts.

It should be clear, therefore, that there is no particular order to understanding the updating or to discuss the relevant results. The only results of relevance are the final set, which incorporate all the shocks. However, a step-by-step approach is easier to understand, and makes errors less likely. While the effect of introducing new information is discussed in economic terms after each step, this is merely to garner a better understanding of the model and to ensure that various aspects of the model are doing what we would expect.

To determine national income from the expenditure side we need aggregate consumption, investment, government expenditure, exports and imports. The starting point for the data collection is the various row and column aggregates, which are culled from the 1999 National Income and Expenditure accounts. In terms of the data, there is a slight discrepancy in that the 1993 figures were based on ESA 79 while the 1998 figures are not. This is ignored.

Step A: Private Consumption

In implementing the historical closure, the single largest adjustment in the assumptions underlying the model was the replacement of the LES with a standard CES function. In terms of simplicity, the CES is much easier to manipulate than the LES, particularly when endogenisation of taste change variables is required.

The change in private consumption is achieved in two steps. Firstly, we target the aggregate level of output, and then we impose changes in the relative consumption of ten NIE consumption categories.

Recall from chapter 3, aggregate consumption in the CGE model includes an allowance for dwellings. Hence the figure of IR£31,219m from NIE99(5) which is domestic and imported consumption at purchasers prices must be augmented by IR£4,378.3 to arrive at a total of IR£35,597.37. This gives an increase from 1993 to 1998 of 77.125%. To accommodate this observed increase, the usually exogenous variable *delB* (change in the balance of trade) is endogenised and the aggregate nominal value of household consumption is exogenised.

Macro Swap[3] swap delB = w3tot_h

The second step was to determine the relative shifts in demand for each commodity. Unfortunately, we do not have detailed data on the amount of consumption of each of the 34 IMAGE commodity categories. However, we do have data on consumption at current market prices from NIE99(13) which is broken down into a number of categories which are then (external to the model) mapped to the IMAGE categories (see below). The form of our household expenditure data in summed over product source. Therefore, the model has a significant degree of autonomy in allocating flows of domestic goods to each individual sector. The relative consumption within each consumption category is then exogenised while retaining w3tot_h from above as our aggregate target.

Micro Swap swap a3_s(COM,HOU) = f3_s(COM,HOU);
swap f3_cs(HOU) = a3tot(HOU);

Equation E_w3_s_obs # *Demand for composite commodities* #
(**all**,c,com)(**all**,h,HOU) w3_s(c,h) = w3_s_obs(c,h) + f3_s(c,h) + f3_cs(h);

[3] A "macroswap" refers to a situation when we swap two macro variables. A "microswap" is when we swap industry or commodity level variables.

Equation E_x3_s # *Total household demand for composite commodities* #
(all,c,COM)(all,h,HOU)
x3_s(c,h)-a3_s(c,h) - a3tot(h) =
x3tot(h) + HH_ELAST(c)*(p3_s(c,h)+a3_s(c,h)+a3tot(h)-p3tot(h));

This required two swaps. The first more obvious swap exogenises *f3_s* which in effect turns on the equation *E_w3_s_obs* by forcing *w3_s* (which is total consumption for each good regardless of source) to equal *w3_s_obs*, the observed value of *w3_s*. This is achieved by endogensing the variable *a3_s* which results in a shift away from (or towards) consumption of each good as demanded by each household.

The second, less obvious, swap exogenises *a3tot* in place of *f3_cs*. This in effect drives a wedge between *w3_s* and *w3_s_obs*, which are the nominal level of consumption per household and the observed level of consumption per household respectively. The second swap has two functions. Firstly, it allows the level of consumption to vary to match changing aggregate consumption. It also allows changes in the aggregate level of household consumption to vary by household type. So, for example, farm household's expenditure might not rise so quickly given a lower level of increase in income.

In terms of data, the first task is to devise a mapping between the NIE13 categories and the corresponding IO sectors. This is largely guided by a similar mapping in chapter 3. One problem arises in that the NIE13 figures include expenditure by non-residents, which in themselves are a component of invisible exports. Therefore we make the simplifying assumption that non-resident expenditure increases at the same rate as resident expenditure within each of the NIE13 categories. To the extent that the non-resident expenditure increase was greater than the resident expenditure increase over the relevant time period, this will have the impact of overestimating the change in consumption in sectors with a relatively high non-resident level of expenditure such as catering.

Interpreting the results from the expenditure side, first we see that in step A1 we increase aggregate consumption, C which increases both C and G as real public consumption is tied to real private consumption by assumption. Changes in absorption are accommodated by changes in the balance of trade. The rise in consumption in nominal terms of 77% would require an increase in Y by 47% (61 * 77%) for private consumption and by a further 15% for public consumption. This rise in nominal public consumption consists of the rise in real public consumption and the relatively high increase in the cost of providing these services. These increases are accommodated for by a decrease in nominal exports of 97% and of investment of 65%.

This realignment of output towards domestic consumption and away from imports requires a substantial increase in the price that can be got in the domestic market relative to the export market. This requires that the prices of non-tradeable goods increase sharply, which is achieved through a substantial revaluation of the currency by 11%. Most importantly, the economy undergoes a huge shift away from the production of tradeables to non-tradeables with the requirement of the former now being met by importers.

Of the above figures, the fall in imports at a time of a real appreciation of the currency by 27%, requires comment. There are two principal explanations. The highest intensity import shares are for manufactured goods (as opposed to farm level production and services), and these sectors show the largest fall in output as supply is more elastic for these goods. Secondly, the fall in demand for capital in turn reduces investment expenditure, which is very highly import intensive due to Ireland's heavy reliance on overseas machinery.

Now looking at the simulation results reported in the first column of table 6.2 from the income side we see that real output falls by 5% due to the fall in capital, though this is offset by the increased indirect tax take from consumption, which is relatively highly taxed. Household expenditure (and even more so government expenditure) is relatively labour intensive. Given the assumption that the rate of return on capital is

fixed in the historical closure, the fall in demand for capital results in a fall in the capital stock to ensure that the exogenously determined rate of return is maintained.

Step B: Investment

The change in the value of gross fixed capital formation at purchaser's prices increased by 167.479%. To understand the investment swap, it is helpful to re-examine the relevant equations.

Macro Swap swap ffinv_i = w2tot_i;

Equation E_x2totA # *Investment rule* #
(**all**,i,ENDOGINV)
x2tot(i) - x1cap(i) = finv(i) + 0.33*[r1cap(i) - omega];

Equation E_x2totB # *Investment in exogenous industries* #
(**all**,i,EXOGINV) x2tot(i) = x2tot_i + finv(i);

Equation E_finv # *Investment shifter* #
(**all**,i,ind) finv(i) = ffinv(i) + ffinv_i ;

There are two possible candidates that can be endogenised in place of aggregate nominal investment *w2tot_i*, both of which operate in much the same way. The first is *ffinv_i*, which is a 'dumb' shifter that results in uniform increases in the investment of each industry. The second is omega, which is the economy wide rate of return. We choose the former, which in effect allows a large increase in the investment/capital ratio.

In Step B we exogenise nominal investment and increase it by around 230% (from –65% to +167 %). The main impact of the increased investment is increases in imports of machinery - it has no direct impact on the capital stock in a cumulative sense, however it is important in so far as investment inputs are quite capital intensive. The increase in imports brings about a further appreciation of the currency that negatively impacts on exports.

Step C: Government

The level of government consumption of goods and services increased by 52.873% from IR£5,218.70 in 1993 to IR£7,978.00 in 1998, some 25% lower than the increase in private consumption. To implement this increase, we must break the current indexing of government consumption with private consumption by endogenising *f5tot2* which effectively 'turns off' equation *E_f5tot*. In its place, we exogenise the total nominal consumption of goods and services by government *w5tot*.

Macro Swap swap f5tot2 = w5tot

Equation E_f5tot # Overall government demands shift #
f5tot = x3tot_h + f5tot2;

As we are breaking the link which equates changes in real private and public expenditure, and private consumption rose at a higher rate and public consumption over the period in question, simulation C effectively imposes a reduction in (nominal) government expenditure of 32% (53% - 85%). Given that public consumption is a non-tradeable, it is no surprise to find that this reduction directly offsets some of the results presented in Step A. Step A results in a large shift in the economy away from capital, which in turn results in a fall in investment. Given that we are in effect holding C, L, A, ROR and APC constant, adjustment comes through the balance of trade, which improves slightly as absorption decreases.

Step D: Exports

Export and import data were calculated from data provided by the CSO of exports and imports (weight and where applicable quantity) at a 5 digit level, for each country. These country-by-country figures were then summed to give totals for trade in each category with the whole world

Aggregate exports increased over the 5-year period by 139.155%. The comparable figure for the export of goods[4] shows an increase of 127.662%, implying an increase

[4] Trade Statistics, 1999, Table 5

of 237.721[5] in the export of services, which is similar to the corresponding increase in imports. In the model we assume that these exports are by service industries, which of course is not necessarily the case in practice.

How can this be accommodated in a change in the macro closure? Dixon and Rimmer suggest two possible alternatives. Firstly, we might allow vertical or horizontal shifts in export demand curves. Implementing shifts in the export demand curves results in a massive real appreciation of the currency that attracts imports to replace the domestically consumed local produce that has now gone overseas due to the demand curve shift. These results can be 'watered down' by introducing the second alternative – namely an all factor productivity increase that will allow increased productivity so that the increased export demand can be met partially by increased local production. It is implemented by exogenising the price deflator for manufacturing industries and endogenising the all factor technology shift.

The intuition behind this swap is that a large appreciation is necessary to produce a ratio of traded to non-traded prices compatible with the allocation of resources between production of traded and non-traded goods required by the exogenisation of C, G, I, X and M. By restricting this price increase by exogenising changes in the price of manufactured commodities, we now require a substantial increase in factor productivity to increase domestic output. Further to this shock of the price of manufactures, it was decided to exogenise and shock the price of services (derived from Statistical Bulletin). This is simply because the model has very few control totals for service industries.

Finally, we introduce the micro shocks, and impose export targets on each good separately. Technically the constraint that total exports should increase by 123% should now be redundant (as taken from the national accounts) is redundant. However given that the export data by industry is likely to be inconsistent with national account data, the *f4_dc* is retained endogenous and becomes a measure of how inconsistent the figures are. In this simulation we have a figure of f4_dc of -1%

[5] Calculated as (52,585 - 45,145) / (22,033 – 19,830) = 262%

which indicates that the combined exports as calculated (and assumed in the case of imports) are only 1% higher than the national income accounts calculation. We also impose a uniform increase in the export of services of 237%, which is calculated as the growth in the difference between total exports in the national accounts and total exports from the trade statistics which only counts goods.

```
Macro Swap:    swap    f4_dc = w4tot_d;

Micro Swap:    swap    f4p_d  = w4_d_obs
               swap    f1tot_manu = p0com_manu;
               swap    f1prim_is = p3tot_hs;
```

```
Equation E_f4pshiftA
(all,c,TRADEXP)(all,d,DES) f4pshift(c,d) = f4p_d(c)+ f4p(c,d) + f4pgen;

Equation E_x4A  # Trad'l export demand functions # (all,c,TRADEXP)(all,d,DES)
 x4(c,d) - f4q(c,d) = EXP_ELAST(c,d)*[p4(c,d) - phi - f4pshift(c,d)];

Equation E_w4_d_obs
(all,c,COM)  w4_d(c) = w4_d_obs(c) + w4_adj(c) + f4_dc;
```

Imposing the aggregate increase in exports requires the shocking of aggregate nominal exports by a massive 243% (139% - (- 104%)). As discussed above, such an increase in output either requires a very large terms of trade shift in Ireland's favour, or a very large increase in productivity. As aggregate employment is fixed, production increases are mainly brought about by changes in technology. The results show that a massive improvement in technology is required to accommodate the increase in exports. In essence, around 40% less is needed of the primary factor composite in services and 20% less of all inputs in manufacturing to produce the same level of output. The results also confirm a massive increase in output from manufacturing output as a result of the increase in exports.

Step E: Labour Usage

Implementing an increase in employment is fairly straightforward – if we simply

shocked the (already exogenous) variable employ_i by 26.307%. Remember, the closure is such that labour is free to move between industries and between occupations in the long run. Thus the breakdown into occupations is nothing more than for reporting purposes other than in its allocation of labour income to the different household types. Population growth 2.908% is also implemented at this stage.

The second major set of shocks in this sector is to industry-by-industry wage bills in manufacturing. The data for this were derived from the Census of Industrial Production. There were no reliable figures for farm level agriculture or services. To accommodate these, we endogenise the costless technology twist towards (away from) labour at the expense of (in favour of) capital.

```
Micro Swap      swap    f_twist_lk(I2MANU) = w1lab_o(I2MANU);

Equation E_twist_lk  # lab/cap costless twist variable #
(all,i,IND)  twist_lk(i) = f_twist_lk(i) + f_twist_lk_i ;

Equation E_x1lab_o  # Industry demands for effective labour #
(all,i,IND)  x1lab_o(i) - a1lab_o(i) =
 x1prim(i)- SIGMA1PRIM(i)*[p1lab_o(i)+ a1lab_o(i) - p1prim(i)]
  + SOURCE_SHR("cap_LK",i) * twist_lk(i);

Equation E_x1cap  # Industry demands for capital #
(all,i,IND)  x1cap(i) - a1cap(i) =
  x1prim(i) - SIGMA1PRIM(i)*[p1cap(i)+ a1cap(i) - p1prim(i)]
  - SOURCE_SHR("lab_LK",i) * twist_lk(i);
```

The twist variable is constructed as a costless shift in technology from labour to capital. Consider when the price of the capital and the labour composite do not change, and all technology variables other than the twist variable. Then the equations *E_x1lab_o* and *E_x1cap* change to:

```
Equation E_x1lab_o  # Industry demands for effective labour #
(all,i,IND)  x1lab_o(i) = x1prim(i) + SOURCE_SHR("cap_LK",i) * twist_lk(i);
```

Equation E_x1cap # *Industry demands for capital* #
(all,i,IND) x1cap(i) = x1prim(i) - SOURCE_SHR(*"lab_LK"*,i) * twist_lk(i);

SOURCE_SHR("cap_LK",i) is the share of aggregate payments to labour and capital accruing to capital, with a similar definition for *SOURCE_SHR("lab_LK",i)*. Therefore *SOURCE_SHR("lab_LK",i)* = 1 - *SOURCE_SHR("cap_LK",i)*.

Rearranging these equations gives:

Equation E_x1lab_o # *Industry demands for effective labour* #
(all,i,IND) x1lab_o(i) - x1prim(i) = SOURCE_SHR(*"cap_LK"*,i) * twist_lk(i);

Equation E_x1cap # *Industry demands for capital* #
(all,i,IND) x1cap(i) - x1prim(i) + twist_lk(i) = SOURCE_SHR(*"cap_LK"*,i) * twist_lk(i);

Noting that the right hand side of both equations are the same, and equating these gives *twist_lk(i) = x1lab_o(i) - x1cap(i)*, in other words (for a positive result) a move away from capital and towards labour.

In terms of results, from *Step E* we see that the increase in employment quickly starts to unravel the primary factor productivity increase from step D, as the increase in exports is now reconciled with an increase in the availability of the fixed factor of production, labour, required to produce them. This increased availability of labour also attracts the capital necessary to expand production. Finally, the reported twist values in the labour capital ratio are fairly consistently large and negative, suggesting a shift towards capital at the expense of labour that is not associated with a change in the relative price of the two.

Step F: Capital, Land and Subsidies

The amount of capital and land flows in 1998 is calculated as a residual of Net Domestic Product at Factor Cost and labour income. As with 1993, the aggregate land price is taken from Barrett and Trace (1998) who have the data up to 1997. The

percentage increase in the average traded land price from 1997 to 1998 is applied to the average land price for 1997 to arrive at a figure for 1998. The reason this figure may be inaccurate is that traded land does not mirror the aggregate land stock. The original land flow was a fixed % of land price (3.5%). This figure is retained, therefore assuming that the expected rate of return is unchanged, and is therefore not directly linked to the price of other assets (notably capital). We do not believe this to be a serious omission.

```
Macro Swap      swap    f_twist_lk_i = w1cap_i;
                swap    a1lnd_il = w1lnd_il;
                swap    w1sub_cs_adj = w1sub_csi;
                swap    w1_exagsub=wtotalsub;

Farm Direct Subsidy By Industry
swap    ff_subsidy(I1AGRI)      =       w1sub_cs_obs(I1AGRI);

Non-Farm Direct Subsidy By Industry
swap    ff_subsidy(I2MANU) = w1sub_cs_obs(I2MANU);
swap    ff_subsidy(I3SERV) = w1sub_cs_obs(I3SERV);

Export Subsidies
swap    f_t4exp("C2Cattle","D3World")           =       wvalexp("C2Cattle");
swap    f_t4exp("C16MeatProds","D3World")       =       wvalexp("C16MeatProds");
swap    f_t4exp("C17MilkProds","D3World")       =       wvalexp("C17MilkProds");

Equation E_w1sub_cs_obsA # Agricultural Subsidy Payments Observed #
(all,i,I1AGRI)  w1sub_cs(i) = w1sub_cs_obs(i) + w1sub_cs_adj;
```

We start by hitting the macro targets. The first of the four macro swaps shown allows a uniform labour-capital twist variable as seen in Step E to target the amount of nominal payments which accrue to capital, *w1cap_i*. The second allows a uniform land technology shift across all industries which employ land to match the aggregate nominal flow to land *w1lnd_il*. The third swap allows for the targeting of changes in total nominal direct subsidies in agriculture through a uniform shift in observed subsidy flows. Finally, the aggregate economy wide nominal increase in subsidies is

exogenised by the endogenisation of a shifter of non-agricultural subsidies.

In terms of data for this shift, the land price is calculated on deals of land the average size (in terms of hectares) of which increased substantially in the 1993 – 1998 period. On average, the larger the hectare size, the lower the price per hectare. Therefore we do suspect that the change in the land price is probably somewhat underestimated. The total subsidy figure is taken as the sum of public authorities subsidies and EU subsidies. This is all classed as intermediate with the exception of a small amount for public consumption (which is accounted for by the CIE subvention). The figure quoted in the base IO table for 1993 of a CIE subvention does not match the corresponding figure in NIE99(23). Therefore the percentage increase of –1.863% is applied instead.

An important feature as to how subsidy changes are imposed is that, as can be seen from equation *E_w1sub_cs_obs* reproduced above, a uniform rate of change of subsidy payments is applied across all industries to hit our target for aggregate industry subsidies. The reasoning behind this is simple. Let us say we have two industries of equal size in 1993 that benefit equally from subsidy payments. Over the course of the period 1993-1998 industry A doubles in size while industry B remains the same size. While an adjustment rule for, say, labour might allow aggregate employment within each industry to adjust so that more labour flows into the larger industry, such a rule is not appropriate in the case of subsidies. We may (or may not) expect the stagnant industry to receive a greater share of subsidies than the successful industry.

The next three groups of shocks impose changes in agricultural subsidies by farm industry and by non-farm industry through the endogenisation of subsidy rate shifters, and changes in export subsidies for exports of livestock, processed meat and processed milk outside the EU.

The results of *Step F* can be seen in table 6.2. The two major changes are the imposition of the aggregate nominal flow of capital and land. The first is in effect a

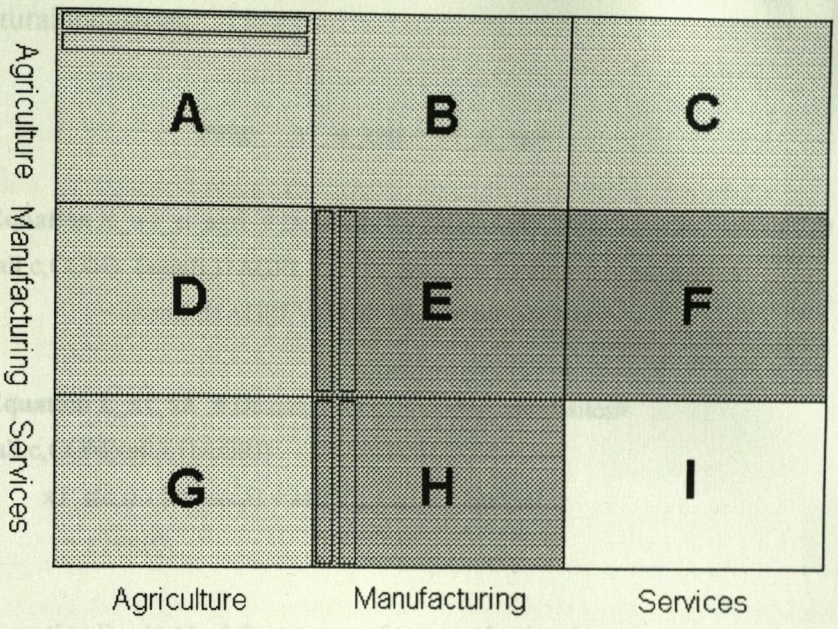
decrease in (nominal) flows to capital by 19% (115% – 134%) while the second is a substantial increase in flows to land of 45% (47% - 2%). The results imply a fairly substantial (uniform) shift towards labour and away from capital. However, remember that we already allowed an industry-by-industry twist in labour/capital technologies for the manufacturing industries, which showed generally a strong move towards capital. While the uniform twist in this sector tends to reduce this somewhat, the twist towards capital remains very strong in the manufacturing industries.

Step G: Other Demands: Inventories and Intermediate Adjustment

The implementation of various control totals on intermediate inputs is illustrated in figure 6.2. The first step was implementation of output and inputs relating to farm level agricultural production, which are represented in Figure 6.2 as the lightly shaded cells. Farm inputs are represented by the cells A, D and G. Similarly, the use of farm outputs as a non-farm intermediate input is imposed in B and C.

The dark shaded cells H, E and F represent the demand of manufacturing industries for both manufacturing and service inputs, and the supply of manufactures to the service industry. Finally, the use of services as an intermediate input for the service industry is represented by the unshaded cell I.

Figure 6.2: Implementation of Intermediate Inputs



Step G.1: *Agricultural Inputs/Outputs*

The primary source for much of the intermediate agriculture data is the statistical bulletin (1999), which in Table 2, page 610, gives details of total agricultural inputs. While we do not have enough information to reconstruct the full agricultural input matrix, we do have row totals summed over the eight agricultural industries. So, for example, we know that agricultural use of electricity and gas rose (in nominal terms) by 41%, but we do not know which agricultural industries accounted for this increase. We now impose these subtotals for the various intermediate inputs and for labour.

We introduce the variable *w1_si_agri*, which is the total (nominal) use of each commodity by agricultural industries, and a corresponding shift variable, *a1_si_agri*. Of course the input categories given in the statistical bulletin must be converted into their IO sector equivalents. This is done using the bridge coefficient matrix designed to convert CSO input definitions to IO sectoral definitions (O'Connor and Matthews, 2000). The variable *w1_si_agri* is defined in *E_w1_si_agri* while the shift variable is added to both the derived demand function *E_x1_sA* and the zero pure profit condition *E_p1totA*. Note that the latter two equations are defined over only the

agricultural industries.

```
swap     a1_si_agri = w1_si_agri
```

```
Equation E_w1_si_agri  # Demands for commodity composites in agriculture#
(all,c,COM)  {sum[i,I1AGRI,V1PUR_S(c,i)] + TINY}* w1_si_agri(c)
        = {sum(i,I1AGRI,V1PUR_S(c,i) * w1_s(c,i))};

Equation E_x1_sA  # Demands for commodity composites#
(all,c,COM)(all,i,I1AGRI)
    x1_s(c,i) - [a1_s(c,i) + a1tot(i) + a1_si_agri(c)]
      = x1tot(i);

Equation E_p1totA  # Zero pure profits in production #
(all,i,I1AGRI)
V1TOT(i)*[p1tot(i)-a1tot(i)] =
sum{c,COM,  V1PUR_S(c,i)  *[p1_s(c,i) + a1_s(c,i) + a1_si_agri(c)] }
     +  V1PRIM(i)     *[p1prim(i) + a1prim(i) + f1prim_i]
     +  V1OCT(i)      *[p1oct(i) + a1oct(i)];
```

By way of example, these equations are represented in cell A of figure 6.2 as the row sum as indicated by the horizontal box.

We must be careful to ensure that the total cost of inputs for each agriculture industry is correct. There are two main reasons why it might not be. Firstly, the initial matrix of input use by farm industries might not be correct, or the structure of intermediate use may have changed substantially. Secondly, the bridge matrix, which allocates the change in value of DAFF input categories to IO input categories, may not be accurate. Applying the changes in prices to the initial matrix of intermediate demands suggests an average increase of 23% in input values, ranging from a 15% increase for cereals to a 32% increase for other crops, which compares well with the 21% increase in aggregate farm inputs independent of farm type as taken from the Statistical Bulletin from 1993-1998.

The important intermediate outputs for agriculture are those that are passed on to the

manufacturing sector. These are now dealt with in turn.

C1 Milk

The milk output and disposal figures given in DAFF21 is only given in volume terms, so we shock the appropriate x1(c,s,i) variable rather than the equivalent w1(c,s,i). It is not clear how the breakdown between intermediate input to the milk products industry and the other food industry was achieved in the 1993 table, so we create a new variable milkuse98 that is the increase in milk output passed on for further processing.

```
Equation E_milkuse # Dividing up milk production - hist simulation. #
[V1PUR("c1milk","dom","I17Milkprods")+V1PUR("c1milk","dom","I19Otherfood")]
      *milkuse98
   = V1PUR("c1milk","dom","I17Milkprods") * x1("c1milk","dom","I17Milkprods")
   + V1PUR("c1milk","dom","I19Otherfood") * x1("c1milk","dom","I19Otherfood");
```

We then equate the shift paramenters a1(c,s,i) for the two flows. Effectively this means that intermediate input use of milk is tied to the observed 1998 level, with milk being allocated endogenously to each of the two using industries based on changes in output.

C2 Cattle

The figures for aggregate output of cattle is divided up by market in DAFF Review and Outlook, 1999/2000, Page 16. This gives both value and quantity changes (assuming head of cattle can be treated as a constant quantity). At first, the closure approach was to endogenise the appropriate a1 technology shift variable accommodating the change in the nominal value of cattle inputs to the meat processing industry.

C3 Sheep & Wool

The figure for aggregate output of sheep is divided up by market in DAFF Review and Outlook, 1999/2000. The wool proportion sent to the textiles industry for further processing is calculated by first changing the quantity of wool in line with the

changes in sheep numbers, and then applying the CPI increase.

C4 Pigs, Poultry, Horses

Again, the figures for upstream usage of these farm outputs were culled from DAFF. However exports of horses were unknown, though this was calculated residually after allowing a small amount for other foods, and applying changes in stocks as derived from the Statistical Bulletin.

Step G.2: Manufacturing Inputs/Ouputs

Much of the manufacturing data for the industrial sectors (I13 – I23) is derived from the Census of Industrial Production, 1998. These figures are based on two sets of figures, the Census of Industrial Local Units (henceforth 'local census') and the Census of Industrial Enterprises (henceforth 'Enterprise census'). A local unit is defined as an enterprise situated in a geographically identified place, while an enterprise is defined as the smallest combination of legal units that is an organisational unit producing goods and services, which benefits from a certain degree of autonomy in decision making. In practice, the enterprise is equivalent to a company. Therefore there will be no difference in the figures for a company located geographically in one area. Differences arise when a company has a number of branches in different geographical areas. The enterprise census results were used, as they were the more comprehensive.

Two sets of adjustments were made before examination of the data for inclusion in the model. Firstly, the *Gross Output* figure for CIP 1993 was compared with *Total Input* from the 1993 Input Output model to ensure that the industry mapping adopted was appropriate. This was generally the case, though a number of sectors displayed a wide divergence. In particular, *Wood & Paper* derived from the CIP was 76% higher than the corresponding IO figure, *Rubber & Plastic* 21% lower, *Petrol & Coal* 98% higher and *Non-Metallic Minerals* 43% lower. The 1998 figures were adjusted to take account of this differential.

There remained a much smaller differential between the local census and enterprise

census figures. However exact equality was not to be expected. The local census refers to 'gross output' which is most directly comparable with the derived 'production value' variable. The primary reason given for the difference (other than the slightly different sample of companies) was the difference in treatment between excise duties and operating subsidies in the two censuses. This problem was ignored, with a pro-rata adjustment being implemented for enterprise census results to ensure equality between 'gross output' and 'production value'. The increase in Gross output from the Census of Industrial Local Units census from 1993 to 1998 was then applied to each of the industries 11 – 23.

Therefore the form of the data for intermediate manufacturing inputs differs substantially from that of the agricultural industries whereby we fixed the aggregate nominal use of each commodity over all industries. With the manufacturing data, we know the aggregate increase in use of 'types' of intermediate commodities for each industry. So, for example, we know that industry 13 increased its use of non-industrial services by 113%, so while we will allow purchases of individual services depending on price, we will impose the restriction that the total services bill increases by 113%.

We introduce the variable *w1_ci_manu*, which is the total (nominal) use of each commodity group by agricultural industries, and a corresponding shift variable, *a1_si_agri*. We note that the existing subsets *R2MANU* and *R3SERV* partition the commodities set into non-industrial services and all other intermediate purchases. We have more detailed information from the Census of industrial production, namely a breakdown for each industry of all other intermediate purchases into total industrial services, and materials and fuel. However we cannot use this as these services are provided by manufacturing industries and are therefore contained in the single commodity bundle produced by that industry.

Note that we have already allocated domestic agricultural intermediate flows, i.e. the *R1AGRI-I2SERV* cell, cell B, from table 6.2. Given that we know the domestic flow from farms to industries, we could theoretically subtract total domestic inputs from

farms to industries from the total of all inputs from either *I1AGRI* or *I2SERV* to arrive at total inputs of *R2MANU* plus imported farm inputs. We could then determine some mechanism for distributing between these two competing claims to the change in flows. However given that domestic farm inputs to the relevant industries form such a large portion of total intermediate input, this would be very unwise to do. Instead, we apply the percentage increase in total inputs to the inputs *of R2MANU* industries.

For example, in 1993 over 70% of meat processing intermediate inputs came from domestic farms, with the remaining 30% comprising all other types of inputs (e.g. electricity) plus inputs from overseas farms. If we knew from the CIP that total intermediate use rose by 5% while we knew from agricultural sources that total purchases of animals from domestic farms fell by 5%, then we could imply that the amount spent on other inputs rose by 28%. However if we subsequently discover that total intermediate inputs only rose by 1%, not 5%, then this would imply that the amount spent on all other inputs would rise by only 15%. Therefore the solution would be very sensitive to relatively small errors.

Equations for fixing nominal flows:

Equation E_w1_manu_serv # *Demands for services in manufacturing#*
(**all**,i,I2MANU) {**sum**[c,R3SERV,V1PUR_S(c,i)] + TINY}* w1_manu_serv(i)
= {**sum**(c,R3SERV,V1PUR_S(c,i) * w1_s(c,i))};

Equation E_w1_manu_manu # *Demands for manufacturing in manufacturing#*
(**all**,i,I2MANU) {**sum**[c,R2MANU,V1PUR_S(c,i)] + TINY}* w1_manu_manu(i)
= {**sum**(c,R2MANU,V1PUR_S(c,i) * w1_s(c,i))};

Derived demand equations:

Equation E_x1_sB # Demands for commodity composites#
(all,c,R1AGRI)(all,i,I2MANU)
x1_s(c,i) - [a1_s(c,i) + a1tot(i)]
= x1tot(i);

Equation E_x1_sD # Demands for commodity composites#
(all,c,R2MANU)(all,i,I2MANU)
x1_s(c,i) - [a1_s(c,i) + a1tot(i) + a1_manu_manu(i)]

```
    = x1tot(i);
Equation E_x1_sE  # Demands for commodity composites#
(all,c,R3SERV)(all,i,I2MANU)
      x1_s(c,i) - [a1_s(c,i) + a1tot(i) + a1_manu_serv(i)]
        = x1tot(i);
```

Equation imposing zero pure profit Condition:

```
Equation E_p1totB  # Zero pure profits in production #
(all,i,I2MANU)
V1TOT(i)*[p1tot(i)-a1tot(i)] =
 sum{c,R1AGRI,  V1PUR_S(c,i)  *[p1_s(c,i) + a1_s(c,i)] }
+ sum{c,R2MANU,  V1PUR_S(c,i)  *[p1_s(c,i) + a1_s(c,i) + a1_manu_manu(i)] }
+ sum{c,R3SERV,  V1PUR_S(c,i)  *[p1_s(c,i) + a1_s(c,i) + a1_manu_serv(i)] }
      +  V1PRIM(i)    *[p1prim(i) + a1prim(i) + f1prim_i]
        +  V1OCT(i)     *[p1oct(i) + a1oct(i)];
```

Note that for service industries, until such time as the Annual Services Inquiry is available, they are left to adjust of their own accord. Each of these sectors is substantially 'tied down' to a varying extent. The two non-market service industries, which are dominated by governmental provision, are restricted, as we know the change in expenditure on government services. Further, our imposed changes in household expenditure also greatly restrict movement. Beyond this, however, the model is left to fend for itself. For example, the large increase in two-way trade in services is imposed as control totals on aggregate services is allocated between industries based largely on historical export and import flows, and thus allocates to sectors such as international transport. It is hoped that future versions of the model will correct for this.

Step G.3 *Adjusting Inventories*

The final area of demand that needs to be adjusted is inventories. When viewing the command file, the most important thing to remember about inventories is that the variables for changes in inventories (*delx6*) is a change variable, meaning that a shock of 1.00 is a shock of £1 million, not a shock of 1%. In terms of implementing

an appropriate model closure to accommodate the changes in inventory, the price of inventories is assumed to increase at the rate p0. Changes in inventories can be implemented with ease, as delx6 is already exogenous. However, note that to achieve the amount of subsidies, the change in subsidies imposed must be the updated amount minus the 1993 amount.

In dealing with changes in stock using the CIP information, the problem arises that technically we should include all increases in stock – not only of finished goods but also of intermediate inputs. So a table manufacturer's changes in stock include both unsold tables and unused timber. This would raise the prospect of having to allocate the various inputs into the appropriate commodity categories. Therefore we exclude unused materials and fuel, and only count the industry's goods plus goods that are passed on without further processing.

The cumulative results of all these changes are shown in column G. These changes are particularly interesting from an industry-by-industry perspective.

In terms of the intermediate inputs into the farm industries, the imposed increase in the use of services as an input to farming was somewhat larger than predicted from the last step, though the use of other farm inputs and manufactures was in line with predictions, though significant industry-by-industry variations were evident.

In relation to the manufacturing inputs, for most industries the shocks implied a much larger increase in intermediate inputs of other manufactures than predicted from step F. Interestingly, this is not true for two of the fastest growing industries, namely chemicals and machinery. However, these industries show a very large increase in the use of imported intermediates, possibly reflecting in part licenses and royalty fees of foreign owned multinationals operating in Ireland that dominate these two industries.

Step H: Imports

The imports of goods in Ireland over the period 1993 to 1998 increased by 110%

with particularly sharp increases for producers goods (191%) and materials for further production (114%) with consumption of goods ready for use increasing at a slower rate than the other two categories, but still ahead of the increase in aggregate private consumption (86%). However, what is particularly important is the fact that the change in aggregate imports (including services) as contained in the national accounts is 146%[6], which implies an increase of services imports of 262%[7].

Macro Swap	swap	w0cif_adj_c = w0cif_c;	
	swap	ftw_src_serv = w0cif_serv;	
Micro Swap	swap	ftwist_src(R2MANU)	= w0cif_adj(R2MANU);
	swap	w0cif_adj("C9Forestry")	=ftwist_src("C9Forestry") ;

Therefore, we first change the model closure by exogenising the aggregate nominal level of inputs w0cif_c, allowing a uniform shift in imports to hit the target. Secondly, we apply a similar shock so that we can target imports of services.

Secondly, we allow the variable *ftwist_src* to vary to ensure we match the observed nominal imports by industry, *w0cif_adj*. This variable follows the intuition of the variable *twist_lk* introduced earlier. It is based on the idea that changes in the share of the use of the domestic variant as opposed to the imported variant in forming any composite commodity can be broken down into that part of the change that can be attributable to a change in price, and that part which is cost-neutral. So, for example, we might suspect that Irish consumers have developed a taste for European cheeses over the period 1993-1998 and thus increased their consumption, even though the ratio of the price of European and Irish cheeses might be unchanged.

In this section we also shock phi, the nominal exchange rate which is of course the numeraire. Note that by shocking the numeraire, we are in essence making the nominal "£-in-your-hand" the numeraire, which is obviously ideal in terms of interpreting results. The reason that we cannot do that in the counterfactual

[6] Calculated from NIE98(5) for the 1993 aggregate and NIE99(5) for the 1998 aggregate.
[7] Calculated as (45,678 – 31,278) / (18860 – 14885) = 262.264%

simulation is that we have no monetary equation to determine this price. Technically, this is also not valid until all the shocks have been implemented to 'recreate' 1998. This technicality is ignored and the closure chosen in relation to the price level will be assumed to be valid. From 1993 to 1998 the effective exchange rate of the punt actually fell by 3.168%, while the consumer price index rose by 10.843%.

Step I: Final Adjustments

Some final adjustments were felt necessary to tidy up some results. Firstly, some negative entries were observed after *Step H*. These were of a very small magnitude and related mostly to imports of intermediate inputs of sums of the order of IR£0.1m or less. However it was felt better to remove them altogether. Secondly, some prices predicted endogenously in the model differed substantially from those observed from published figures for the period under consideration.

Two primary sets of adjustments were therefore imposed. For agricultural and manufacturing industries, prices were adjusted, by way of an industry all factor productivity shift. For service industries we allow an all factor productivity shift to ensure output price for consumable services matches the change in the price of services component of the CPI.

Secondly, once the aggregate value of inputs has now been determined, the availability of data relating to the various output usages raises the prospect of a mismatch between aggregate input and aggregate output. For example, in determining changes in the use of manufacturing output, we have derived estimates for intermediate usage of manufactures by agricultural industries, manufacturing industries and service industries, the level of government usage (if any), the level of exports, the level of private consumption, any changes in stock and the use of the good for gross physical capital formation. The decision as to which data we accept and which data we reject is likely to have a considerable material impact on the results of the simulation. The decision was taken only to impose these shifts on sectors which returned negative entries in the updated input-output table.

Micro Shocks

```
swap    f1tot(I1AGRI)   =       p0dom(R1AGRI);
swap    f1tot(I2MANU)   =       p0dom(R2MANU);
swap    f1prim_is = p3tot_hs;
swap    w4_adj(MANU)    =       w1tot_maobs(MANU);[8]
```

Equation E_w1tot # Historical: Nominal Output #
(all,i,I1AGRI) w1tot(i) = p1tot(i) + x1tot(i);
Equation E_w1tot_obs # Historical: Observed nominal output#
(all,i,I1AGRI) w1tot(i) = w1tot_obs(i) + f1tot_obs(i);

The results of this step are not in themselves of particular interest, but are included as column I of table 6.1 for completeness. Note that the penultimate column indicates the difference between the sum of each of the individual steps, which are calculated via the Johanson method, and the total simulation, which is calculated via the more exact Gragg method. As such, this error column indicates the inaccuracies caused by the linearisation error in one or more of the reported steps, and does not affect the total economy result.

[8] In the actual implementation this swap is over a subset of Manufacturing. Details are omitted here.

Table 6.2 *Historical Simulation: Selected Macro Results - Cumulative*

Macro Aggregates		*Step A*	*Step B*	*Step C*	*Step D*	*Step E*	*Step F*	*Step G*	*Step H*	*Step I*	*Error*	*Total*
Population	q_h	0	0	0	0	3	3	3	3	3	0	3
Real Wage	realwage	10	12	11	108	48	61	50	-1	26	-11	15
Employment	employ_i	0	0	0	0	26	26	26	26	26	0	26
Nominal GDP	w0gdpexp	7	10	11	122	111	113	116	88	89	0	89
Balance of Trade	delB	0	-1	-1	0	0	0	0	0	0	0	0
Nominal Exchange Rate	phi	0	0	0	0	0	0	0	-3	-3	0	-3
Real Devaluation	p0realdev	-11	-13	-12	-80	-36	-44	-71	-19	32	-2	30
Terms of Trade	p0toft	3	4	3	49	23	27	57	39	-18	2	-16
Labour Pice	p0lab_io	21	26	23	169	75	94	97	39	40	-9	31
Capital Price	p1cap_i	3	4	3	17	7	6	9	18	11	0	11
Consumption Price	p3tot_h	11	14	12	61	26	33	46	39	13	0	13
Investment Price	p2tot_i	7	10	9	42	18	23	30	55	38	1	39
Export Price	p4tot_d	5	6	6	62	28	34	65	84	24	-8	16
Government Price	p5tot	17	22	19	127	55	70	78	38	17	-1	16
Import Price	p0imp_c	2	2	2	13	6	7	8	46	42	-4	38
Real Sectoral Output												
Farm	x0com_agri	-57	-80	-68	-48	-12	-9	-11	-12	5	1	6
Manufacturing	x0com_manu	-74	-89	-75	46	82	76	45	17	82	-2	80
Services	x0com_serv	23	28	27	18	63	55	64	71	93	-11	82
GDP	x0gdpexp	-5	-6	-3	29	70	62	37	23	79	-1	78
Real Primary Inputs												
Labour	x1lab_io	0	0	0	0	26	26	26	26	26	0	26
Capital	x1cap_i	-27	-36	-28	64	127	109	106	97	104	-10	94
Total	x1prim_i	-12	-15	-12	27	69	61	60	56	89	-7	82
Real Consumption	x3tot_h	66	63	65	16	51	44	31	38	64	-8	56
Real Investment	x2tot_i	-72	157	158	125	149	144	138	112	129	-36	93
Real Exports	x4tot_d	-102	-127	-110	77	111	105	74	55	115	-8	107
Real Government	x5tot	66	63	34	-74	-3	-17	-25	15	36	-4	32
Real Imports	x0cif_c	-29	-13	-5	61	91	86	80	100	104	-25	79
Nominal Primary Inputs												
Labour	w1lab_io	21	26	23	169	101	120	123	65	66	-1	65
Capital	w1cap_i	-24	-32	-24	80	134	115	115	115	115	0	115
Nominal Final Demands												
Consumption	w3tot_h	77	77	77	77	77	77	77	77	77	0	77
Investment	w2tot_i	-65	167	167	167	167	167	167	167	167	0	167
Exports	w4tot_d	-97	-121	-104	139	139	139	139	139	139	0	139
Government	w5tot	83	85	53	53	53	53	53	53	53	0	53
Imports	w0cif_c	-27	-11	-3	74	96	93	89	146	146	0	146

Table 6.3 ***Historical Simulation: Micro Results – Cumulative Real Output***

	Step A	*Step B*	*Step C*	*Step D*	*Step E*	*Step F*	*Step G*	*Step H*	*Step I*	*Error*	*Total*
I1Milk	-54	-77	-65	-43	-9	-16	-2	-2	1	-2	-1
I2Cattle	-53	-74	-63	-58	-22	-8	-12	-14	5	2	7
I3SheepWool	-72	-99	-85	-56	-16	-5	-6	-24	-5	1	-4
I4OtherLive	-69	-94	-81	-40	-3	1	-14	-10	27	3	30
I5Cereals	-87	-119	-102	-61	-17	-24	-63	-66	-15	10	-5
I6FruitVeg	-56	-76	-67	8	40	31	24	25	43	-2	41
I7RootGreen	-35	-54	-44	-47	-6	-14	-67	-62	-19	5	-14
I8OtherCrops	-32	-49	-40	-27	9	8	-12	-11	32	2	34
I9Forestry	440	620	527	343	101	64	86	137	64	-15	49
I10Fishing	-73	-99	-85	-19	6	1	-2	-41	-34	2	-32
I11PetCoal	-23	-30	-23	7	42	36	44	259	233	-29	204
I12ElecGas	-4	-10	-5	3	45	37	20	16	56	-9	47
I13NonMet	-23	4	12	4	50	41	30	42	78	-11	67
I14Chemicals	-110	-146	-127	184	221	214	190	182	214	-12	202
I15Metal	-108	-114	-98	112	144	138	116	19	86	2	88
I16MeatProds	-56	-79	-67	-50	-12	-4	-21	-15	11	1	12
I17MilkProds	-54	-77	-65	-42	-9	-15	-74	-89	-5	2	-3
I18AnimFeed	-64	-89	-76	-55	-14	-10	-54	-59	14	1	15
I19OtherFood	-74	-102	-88	-62	-25	-32	-115	-121	16	-3	13
I20BevTob	8	-6	1	-6	33	25	21	20	58	-2	56
I21Textiles	-114	-149	-128	-53	-12	-20	-27	34	51	-6	45
I22WoodPaper	-8	-12	-7	2	46	37	-42	-33	146	-15	131
I23RubPlas	-77	-90	-76	20	63	55	53	50	83	-5	78
I24Construct	22	87	88	57	93	85	89	99	122	-20	102
I25TradeMarg	4	13	19	39	70	65	71	70	100	-12	88
I26LodgCater	29	19	25	32	84	73	71	96	113	-10	103
I27InlndTran	9	8	14	27	66	59	80	92	113	-11	102
I28OtherTran	-93	-119	-101	85	131	122	132	127	145	-13	132
I29Commun	21	15	18	34	79	70	86	93	113	-11	102
I30Credit	-14	-20	-13	36	76	69	122	137	159	-11	148
I31OtherSers	20	16	19	26	66	58	74	47	68	-9	59
I32PublServ	56	53	29	-56	11	-2	-7	27	48	-5	43
I33ONonMkt	62	58	38	-63	8	-6	-13	25	46	-5	41
I34Dwellings	114	111	112	44	90	80	71	85	107	-11	96

6.4 Decomposition Simulation

6.4.1 Introduction

In the first section of this chapter we imposed numerous restrictions on the data relating to flows in 1998. To accommodate these flows, it was necessary to allow some naturally exogenous variables to shift endogenously. In the second section of the chapter we take these endogenous shifts, exogenise them and shock them by a value equal to the endogenous movement as calculated in section one. The overall results for the economy calculated for the decomposition analysis are identical to those that are now calculated for the decomposition analysis, only the model closure and therefore set of shocks is different. Returning to the example in the introduction of the chapter in section 6.1:

$$x_i - a_i = x_{tot} + \sigma_i(p_i + a_i - p_{tot}) \tag{3}$$

We know from the historical simulation that for the time period under consideration, a_i must be set at 10% to reconcile the observed data with the model structure. Therefore we take this value into the decomposition simulation:

$$x_i - 10\% = x_{tot} + \sigma_i(p_i + 10\% - p_{tot}) \tag{4}$$

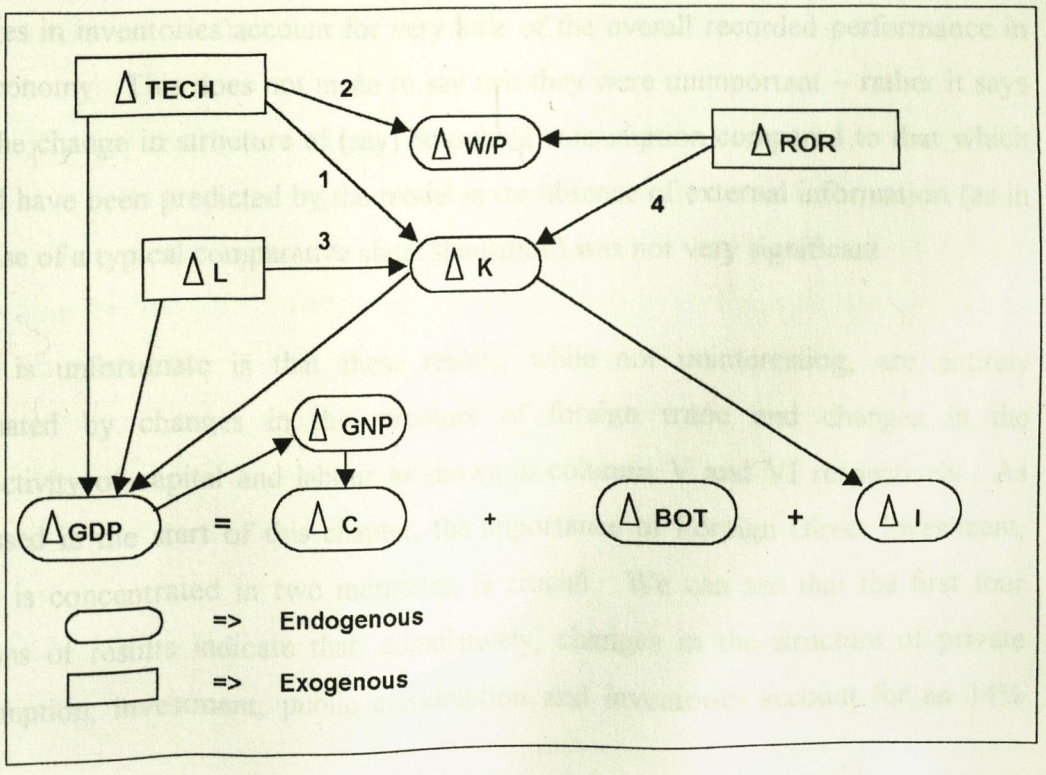
When we impose the known change in total consumption of 10% together with the increase in the price of good i relative to all consumables by 5%, we endogenously calculate the value of x_i as –10%, which is the 'target' level set initially.

Extending this logic from a partial equilibrium setting to a general equilibrium one, we can impose groups of shifts one by one which, in effect, will 'decompose' the impact each has had on both macro variables and the structure of various industries. When we sum all these individual impacts we will return to the total economy wide change over the entire period.

6.4.2 Decomposition Closure

The macro connections in the decomposition closure are illustrated in figure 6.3. As with the corresponding diagram for the historical closure, all exogenous variables are shown in rectangles while endogenous variables are shown in ellipses. The arrows from one set of variable to the others illustrate the 'direction of causation' within the model. So, for example, the change in the underlying technology in each industry, which was calculated in the historical simulation, is now imposed exogenously in the decomposition closure. Through arrows 1 and 2 we can see these technological changes change the aggregate capital stock and the real wage respectively. For example, a positive labour productivity shift increases the real wage. Given this change in technology, the other factors which determine the aggregate supply of capital is the supply of labour and the real rate of return, as shown in arrows 3 and 4 respectively. Other arrows indicate that GDP is now determined by the exogenous change in labour and technology and the endogenous change in capital. The change in GDP further determines GNP which in turn determines consumption possibilities. Note that the direction of causation is opposite to that of the historical simulation.

Figure 6.3: Illustration of The Decomposition Closure



6.4.3 Results of Decomposition Analysis

The next step is to actually explain the results of the decomposition. In all, 362 variables are shocked, so listing the impact of each is prohibitively voluminous. Therefore we divide each set of simulation results into one of six groups, which are now discussed in turn. The simulation results as presented in Table 6.4 are calculated using the quick and convenient 1-step Johansen method[9], while the total economy results are calculated using the Gragg method that divides up the entire shocks into a number of intervals, and calculates the return in each interval using an extrapolation procedure. Therefore, the sum of all the shocks does not match the total results. Therefore a separate column is retained for the linearisation error.

Overview of Results

Before discussing the individual columns of results, we can briefly discuss the entire set of results in terms of their overall contribution to the changes for the entire economy over the period. What is obvious from table 6.4 is that the effect of changing household consumption patterns, changes in the composition and quantity of investment (investment here is by way of a final demand, not in the sense of adding to the economy's capital stock), changes in government spending and changes in inventories account for very little of the overall recorded performance in the economy. This does not mean to say that they were unimportant – rather it says that the change in structure of (say) household consumption compared to that which would have been predicted by the model in the absence of external information (as in the case of a typical comparative static simulation) was not very significant.

What is unfortunate is that these results, while not uninteresting, are entirely dominated by changes in the structure of foreign trade and changes in the productivity of capital and labour as shown in columns V and VI respectively. As discussed in the start of this chapter, the importance of Foreign Direct Investment, which is concentrated in two industries, is crucial. We can see that the first four columns of results indicate that, cumulatively, changes in the structure of private consumption, investment, public consumption and inventories account for an 14%

(1% + 6% + 5% + 2%) increase in real manufacturing output. For most countries over most rolling five-year periods, the reasons behind such a result would be of great interest. For Ireland from 1993 to 1998, these figures are drowned out by the huge increase in manufacturing output that arose from foreign multinationals based in Ireland. Put another way, FDI is equivalent to a massive exogenous shock to both our international trade and the form of our productive processes.

For these same reasons it is somewhat difficult to discuss these two columns V and VI individually. The changes in foreign trade conditions would clearly not have happened had the changes in productive processes introduced by foreign firms not happened. In fact, what happens in column V (i.e. foreign trade) is that the improvement in trading conditions without increases in the size of the labour force or changes in labour productivity results in a large deterioration in our terms of trade, resulting in a shift in production towards exporting sectors, with imports filling the gap for domestic consumption. This is really of little economic interest or significance. By summing the two columns we almost have the full economy wide results, so this again provides little insight.

We now proceed to discuss the columns individually.

Group I: Household Consumption

The first group of shocks imposes the apparent change in household consumption, along with the observed change in the balance of trade over the period 1993-1998. Given that the balance of trade is fixed, then for any given level of imports we can derive domestic absorption. Government consumption is tied to domestic consumption, while investment is tied to the level of the capital stock to ensure that the investment/capital ratio remains unchanged. Therefore, household consumption can be derived from national income.

From table 6.4 we can see that the effect of these shocks is to greatly decrease domestic consumption as the change in the balance of trade equivalent to 3% of GDP

[9] For a full discussion see Chapter 2.

requires an increase in exports relative to imports which results in a decrease in domestic absorption of an equivalent amount. The change in tastes within the basket of consumables results in farm output falling much more sharply that manufactures or services, both of which actually record a slight growth. Finally, consumption is also crowded out by increased investment due to the increase in the capital stock of manufacturing industries.

Note that, as before with the historical simulation, the penultimate column indicates the difference between the sum of each of the individual steps, which are calculated via the Johanson method, and the total simulation, which is calculated via the more exact Gragg method. This error column indicates the inaccuracies caused by the linearisation error in one or more of the reported steps, and does not affect the total economy result.

Group II: Investment

Given that the returns to capital are assumed fixed in a simulation, the increase in nominal investment was achieved in the historical simulation by endogenising the investment/capital ratio, which almost doubles. As can be seen from column 2, this increase in gross fixed capital formation requires a sharp increase in imports, primarily of machinery. Given the fixed balance of trade condition, this induces a real devaluation of 1%, sufficient to result in a rise in exports of 8%.

The principal beneficiaries are on the one hand those industries involved directly with the formation of capital (M15 Machinery and M24 Construction), and those that export a significant portion of their output. It is important to remember that while the model incorporates both investment decisions and the level of capital, it abstracts entirely from time and thus the two are not linked in any causative sense.

Table 6.4 ***Decomposition Simulation: Macro Results – Real Output***

		House	*Invest*	*Govt*	*Invent's*	*Trade*	*Prod.*	*Error*	*Total*
Macro Aggregates	Variable	I	II	III	IV	V	VI		
Population	q_h	0	0	0	0	0	3	0	3
Real Wage	realwage	-1	-1	0	0	-10	38	-11	15
Employment	employ_i	0	0	0	0	0	26	0	26
Nominal GDP	w0gdpexp	-3	-1	2	0	18	71	0	89
Balance of Trade	delB	0	0	0	0	0	0	0	0
Nom Exchange Rate	phi	0	0	0	0	-3	0	0	-3
Real Devaluation	p0realdev	1	1	0	0	30	1	-3	30
Terms of Trade	p0toft	0	0	0	0	-14	-3	2	-16
Labour Price	p0lab_io	-2	-2	-1	0	8	36	-9	31
Capital Price	p1cap_i	0	0	0	0	13	-2	0	11
Consumption Price	p3tot_h	-1	-1	0	0	18	-2	0	13
Investment Price	p2tot_i	-1	0	0	0	37	2	0	39
Export Price	p4tot_d	0	0	0	0	28	-3	-8	16
Government Price	p5tot	-2	-1	-1	0	9	11	-1	16
Import Price	p0imp_c	0	0	0	0	42	0	-4	38
Real Farm Output	x0com_agri	-14	-1	5	-2	-147	164	2	6
Real Manu Output	x0com_manu	1	6	5	2	3	64	-2	80
Real Services Output	x0com_serv	1	-1	1	0	0	93	-10	82
GDP	x0gdpexp	-1	0	3	0	6	72	-1	78
Labour	x1lab_io	0	0	0	0	0	26	0	26
Capital	x1cap_i	-1	1	5	1	11	87	-10	94
Total	x1prim_i	-1	0	2	1	5	82	-7	82
Real Consumption	x3tot_h	-6	-12	8	-1	-4	80	-8	56
Real Investment	x2tot_i	2	93	5	3	29	-2	-36	93
Real Exports	x4tot_d	7	8	5	1	42	52	-8	107
Real Government	x5tot	-6	-12	-20	-1	-4	80	-4	32
Real Imports	x0cif_c	3	10	5	1	41	44	-25	79
Nominal Labour	w1lab_io	-2	-2	-1	0	8	62	-1	65
Nominal Capital	w1cap_i	-2	1	5	1	25	85	0	115
Consumption (Nom)	w3tot_h	-7	-13	8	-1	14	77	0	77
Investment (Nom)	w2tot_i	1	93	5	3	66	0	0	167
Exports (Nom)	w4tot_d	7	8	4	1	70	50	0	139
Government (Nom)	w5tot	-8	-14	-21	-1	5	91	0	53
Imports (Nom)	w0cif_c	3	10	5	1	84	44	0	146

Group III: Government Expenditure

The results for the change in government expenditure are shown in the third column of results in table 6.4. It should be noted that what is shocked in this simulation is not the change in the level of government expenditure, but the change in the ratio of public to private consumption. Since public consumption did not quite keep pace with private consumption over the time period, we see the real value of government expenditure fall by 20%.

Since government expenditure is highly labour intensive, this results in a fall in nominal wages, which increases the marginal product of capital. The increased supply of labour pushes up exports, while the consumption by households increases by 8%.

Group IV: Changes in Inventories

The imposition of the recorded change in inventories has little economy wide impact as can be seen in column four of table 6.4. The model has no mechanism for explaining inventories, so they are set exogenously. Imposing the observed levels, therefore, requires no adjustment in the model closure.

Group V: Foreign Trade

The results for the grouping 'Foreign Trade' can be seen in column five of table 6.4. The shocks imposed at this stage come under three subheadings that are now dealt with in turn.

Changes in Import Prices

As mentioned previously, Ireland is assumed to be a small country and thus a price taker in relation to imports. Therefore import prices are taken as exogenous in both the decomposition and historical simulations.

In the base year data for 1993, 67% of total imports were for intermediate use, 8% was used in gross fixed capital formation while households consumed the remainder,

24%. From table 6.3 we can see that the implied rise in aggregate import prices over this period was 42%. While imported intermediate and domestic products saw a price rise of this magnitude, the price of imports for investment (which consists almost entirely of machinery) rose by 70%. Remember that all of these figures should be interpreted in light of the fact that the numeraire is the exchange rate.

Shifts in Foreign Export Demands

The most salient feature in the shifts in export demand curves in agriculture are the large fall in the demand curve for beef (which can be explained by the BSE crises), and the rise in the demand curve for exported fruit and vegetables, with a fall of similar magnitude for cereals. In terms of manufactures, there is a significant fall in the demand curve for exported textiles. The largest rises are for chemicals and metals, which is not surprising given the increasing dominance of FDI in these two industries, with multi-national companies producing almost entirely for the export market. Finally, the observed increase in the international trade in services is reflected in an upward shift in the demand curves for all service industries.

Twists in Domestic/Imported Variants

The final group of variables that were shocked in this group was the twist in preferences between the domestic and imported variants of each good. There was a large twist in favour of imported services at the expense of the domestic variant, which is possibly explained by the advent of the Single Market at the beginning of the decade. No such discernable rule could be observed for manufactures, though there did seem to be a move towards imported goods of goods that are dominated by personal consumption, while goods largely used as intermediaries were more stable.

Group VI: Primary Factor Adjustments

This group incorporates numerous adjustments relating to primary factor inputs. In terms of labour, it imposes the increase in both the workforce and the population, while twists in technology between labour and capital in the manufacturing industries needed to explain the change in the wage share are also imposed. There is also an economy wide labour-capital twist, which was introduced to explain the change in

flows to capital. Finally, changes in the calculated technological coefficient for land are also imposed. Also included in this grouping are changes in subsidy levels, which of course have a very important role in determining farm output.

This grouping also imposes changes in the all factor productivity shifts. These are almost all negative, indicating that in most industries, less was needed of all factors to produce the good in question. Its role is to accommodate observed price changes in the model while simultaneously maintaining the assumption of perfect competition. The results of this set of shocks are shown in column six of table 6.4.

6.5 Conclusion

This chapter had two primary aims, the first of which was to update the 1993 database from 1993 to 1998, while the second was to interpret the technology and taste variables to try and provide a breakdown explaining the nature of Ireland's economic experience over the five-year period under examination.

The former was done via a so-called historical simulation. In many respects the principal difficulty in relation to the historical simulation was in choosing which data to impose, and at what level of disaggregation the data is used. Frequently two pieces of data proved to be inconsistent, either causing the model not to solve at all or for it to diverge rapidly. The second major difficulty was in choosing appropriate closures to ensure that the model converged at a reasonable rate. The explanation for the frequent incidence of the second problem can probably be put down to the fact that the closures used were not familiar in the same way as the usual comparative static simulation closures were. This may be due to the fact that the manipulation of a Cobb-Douglas or CES function with fixed technology is a familiar task for any student of economics, a task which forms the basis of the 'standard' closure. It is not surprising given the complexity of the model that most of the methods finally chosen were arrived at only after a long procedure of trial and error. It was certainly not obvious *a priori* which changes in the model closure would 'calm' the model ensuring it will converge faster, and which would result in the model either

converging slower or diverging. The updated input output tables are shown in the appendix.

The interpretation of the technology and taste variables was done via the decomposition simulation. While this method has proved popular in Australia where it was originally developed, the feasibility of the methodology to explain the type of growth experienced by Ireland over the period from 1993 to 1998 is thrown into doubt by the results presented here. In particular, the performance of the Irish economy over the period in question was dominated by the impact of an increase in FDI that impacted primarily on two industries, namely machinery and chemicals. Had this resulted in a large increase in demand for intermediate products, the CGE/IO framework might have proved more enlightening. However these two industries are highly vertically integrated, and source the main bulk of their inputs from overseas, usually from other branches of the same multi-national. Therefore very little of the story of the success of the Irish economy can be illustrated through the methodology employed in this chapter – of far greater importance are issues such as technology transfer, learning by doing, etc.

CHAPTER 7

THE AGENDA 2000 REFORMS OF THE COMMON AGRICULTURAL POLICY

7.1 Introduction

At the European summit in Berlin, 26 March 1999, agreement among the EU members was reached on the Agenda 2000 package, a set of reforms intended to continue and deepen the earlier MacSharry reforms of the European Common Agricultural Policy. Note that in this chapter we are only modelling the agricultural elements of the package, not the structural fund changes.

The thrust of these reforms was to bring EU internal agricultural prices closer to world levels, with support switching to direct payments to farmers, and was supposed to deal with the issue of the imminent enlargement of the EU to include some of the former communist eastern countries. Without reform, it was feared that the extension of the CAP to new member states in the CEECs would result in unsustainable additional budgetary costs and also encourage production in those countries, leading to additional surpluses. The actual reforms when they appeared were somewhat more modest than perhaps was previously hoped, with much needed reform of the dairy sector being postponed until 2005. However significant reform of the beef market was achieved, which started to take effect almost immediately with a reduction in price and an increase in direct support.

In this chapter, we model the impact of the Agenda 2000 reform package in each year from 2000 to 2005. In essence, we do this by creating a baseline of the Irish economy and how it might look in each year from 1998 to 2005. The initial baseline set of figures is the updated 1998 model, the derivation of which is described in some detail in chapter 6. The baseline for each year can be taken as a counterfactual of the Irish economy in the absence of the Agenda 2000 reforms. The process of

developing a forecast simulation is very similar to the historical/decomposition simulations. As with the historical simulations, we construct the baseline scenario by exogenising many typically endogenous macro variables. Also, many typically exogenous variables that are readily observable are also shocked, for example, aggregate labour supply. The process is much more straightforward than the historical simulation for the simple reason that we know a lot less about the future than we do about the past. In particular, we know little about industry-by-industry returns from 1998 – 2005, though we have estimates of most of the macro variables such as GNP, balance of payments etc. In the Monash approach, this procedure was called the 'forecast model' while any simulations measuring deviations from the baseline scenario was called the 'policy model' (see Dixon and Rimmer, 2000). Note that while we forecast for each year from 1999 to 2005, these forecasts are not chain-linked in that the capital accumulated in one is not linked to the capital in use in the following year.

The chapter is organised as follows. The assumptions underlying the baseline forecast and the methods used to impose the data are discussed in section 7.2. The method used for employing the Agenda 2000 reforms of the Common Agricultural Policy are discussed in section 7.3, while the results relative to those calculated by the FAPRI-Ireland partial equilibrium model are discussed in section 7.4. Finally, section 7.5 concludes.

7.2 Baseline Forecast 1998 – 2005

7.2.1 Introduction

The base case is calculated annually from 1999 to 2005. This gives a set of input-output accounts for each year, or seven in total. We do this by imposing changes in private consumption (by endogenising taste shift variables), public consumption (by endogenising the ratio of public to private consumption), investment (by endogenising the investment/capital ratio) and exports (by endogenising horizontal shifts in export demand curves).

An important point to note is that the model is not cumulative in terms of having a direct investment/capital linkage or in terms of a direct savings/investment income linkage and therefore results for the individual years are not chain linked. For example, a correctly specified investment/capital linkage would mean that if car industry investment increased by 50% in 2002, then the amount of capital available to produce cars in 2003 would be around 30% higher than in 2002, allowing for some depreciation of the existing stock. Similarly, a correctly specified savings/investment income would allow for the fact that if (say) the government increased borrowing in 2002 to finance a deficit, then debt repayments would be higher in the following year assuming interest rates are unchanged. While these are potentially important mechanisms, they are not directly incorporated in the model, but should be kept in mind. Note that we say that there is no *direct* linkage between investment and capital. However the determination of the capital stock based on economy wide rates of return in 2003 stems from the same impulses that form investment in the base year. So high return on capital in the chemicals industry is likely to increase both investment in 2002 and capital in 2003, so there is an indirect linkage that stems from the fact that they are both driven by the same mechanism.

7.2.2 The ESRI Medium Term Forecasts

The assumptions underlying the updating procedure were largely taken from the ESRI medium term review of the Irish economy (ESRI, 1999). This provides a detailed picture as to the development of both the macro economy and a broad sectoral breakdown and covered the period 1999 – 2005. Their analysis suggests that the Irish economy, which was growing very quickly up to 1998, would unwind gradually and eventually return to the EU average rate of growth after 2010. In this section we will discuss the main features of the forecasts, the external environment which moulds them and the principal risks that might throw the economy away from the central forecast.

7.2.2.1 Output

Given a background of an economy in 1998 that was fully 'wound up' and growing very rapidly, the ESRI predicts that the most likely scenario for the next decade is

that the economy will gradually unwind, with a revision to a more normal European growth rate after 2010. This would see Irish income per head pass the European average in 2005. While they predict that manufacturing will retain its momentum up to 2005, there will be a shift from high tech manufacturing to internationally traded services as the engine of growth thereafter. The ESRI's forecasted changes in output by industry are shown below in table 7.1.

Figure 7.1

Forecasted Changes in Output by Industry

Real Output	*1999* %	*2000* %	*2001* %	*2002* %	*2003* %	*2004* %	*2005* %	*99-05* %	*99-05* %
Agriculture	0	-0.5	-0.2	-0.4	-0.3	1.3	1.3	1.2	0.2
Manufacturing	10.4	9	6.3	6.4	5.8	5.8	5.8	61.2	10.0
Utilities	5.5	3.8	3.8	3.8	3.8	3.8	3.8	32.0	5.7
Building	15	2.2	1.8	1.8	0.6	0	-0.4	22.0	4.1
Distribution	5.3	7.6	6.7	6.6	6	6.2	6.1	53.9	9.0
Transport & Communications	5.3	6	6	6	6	6	6	49.4	8.4
Other Market Services	6.5	4.1	5.9	5.7	5.5	5.3	5.2	45.0	7.7
Non Market Services	1.3	2.7	2.7	2.6	2.6	2.6	2.6	18.4	3.4

Following the very sharp rise in employment from 1993 to 1998, there has been a halving in the unemployment rate, a reversal in the outward migration which was previously endemic in the economy and an increase in the participation rate which had been among the lowest in Europe. While the ESRI predict that aggregate employment will slow down somewhat, there will be continued large increases in employment in services, building and the high tech sector. This is at the expense of traditional manufacturing and, of course, agriculture. The ESRI do warn that this benign scenario could be upset by excessive wage expectations. The predicted increases in employment as culled from the medium term review are shown in table 7.2.

In terms of price movements, the arrival of the Euro means that we will have a fixed exchange rate with some of our main trading partners, lessening any inflationary

threat. It is assumed that high growth in the Euro area economies will result in an appreciation in the Euro vis-à-vis the dollar, thus easing inflationary pressures.

Figure 7.2

Forecasted Changes in Employment by Industry

	1999 %	*2000 %*	*2001 %*	*2002 %*	*2003 %*	*2004 %*	*2005 %*	*99-05 %*
Agriculture	-1.6	-3	-2.9	-2.9	-2.8	-2.8	-2.8	-17.4
Traditional Manufacturing	0.9	-0.1	-1.2	-1.3	-1.4	-1.5	-1.7	-6.2
Non-Trad. Manufacturing	9.2	5.7	2.9	2.9	1.9	2.4	2.4	30.6
Food Processing	5	-0.5	-1	-1	-1	-1	-1	-0.6
Utilities	0	0	0	0	0	0	0	0.0
Building	12.5	3.8	2.2	2.2	0	0.3	0.6	23.1
Distribution	7.1	4.9	3.6	3.7	3.3	2.9	2.8	31.9
Transport & Communications	6.4	5	3.2	3.1	3	2.8	2.7	29.3
Other Market Services	5.3	6.7	5	4.5	3.8	4.2	3.5	38.0
Non-Market Services	1.4	2.4	2.4	2.4	2.4	2.4	2.4	16.9
Total Employment	4.8	3.5	2.4	2.3	1.9	2	1.9	20.3

Source: ESRI (1999)

In terms of wage pressures, it is anticipated that the restraint shown by workers in their wage demands due to the social partnership agreements that typified the 1990s will disappear as we approach full employment. This will be particularly noticeable in the public sector. The forecast assumes a growth in earnings of 6% in nominal terms for total non-agricultural income, with 7% growth for non-market services (i.e. public servants). With an assumption for the consumer price index to increase by an average of 2.9%, this translates into a real wage growth rate of around 4% for public sector workers and 3% for private sector workers.

7.2.2.2 Expenditure

From the expenditure side of the national income identity, ignoring inventories, we must get estimates of the following:

$$Y = C + I + G + (X\text{-}M)$$

The twin impact of increased disposable income due to falling tax rates and increased pre-tax earnings resulted in dramatically increased private consumption in the 1990s. Against the background of continued high consumer confidence, the ESRI predict that the volume of consumption will continue to grow at a rate of 4.5% between 2000 and 2010. Under the assumption of increased expectations, the prediction is for public consumption to rise at a historically high rate of 3.6%. Note that as public consumption consists largely of non-traded goods and services, the cost of increased public expenditure is likely to increase substantially faster than private expenditure.

The predictions for investment in the future can be divided into the requirement for private sector investment to build and expand on current capacity, but more urgently the need for public sector investment to develop the economy's infrastructure which is a more pressing constraint on continued growth. In particular, the ESRI identify investment in building and construction because of the need to improve infrastructure. Overall, they forecast that this investment will increase at a real annual rate of 3.1% to 2005 on what was anyway a very high base.

As previously mentioned, while the second half of the 1990s saw a historically high growth rate of over 16% per annum in industrial exports, a second feature of the recent Irish experience has been a boom in service exports which mirrors developments in other more advanced European economies. As sectors of the economy mature and capacity constraints start to curtail further expansion over the course of the next decade, the ESRI predict a slowing down of export growth rates which is exacerbated by increased competition from the Pacific Rim and former communist eastern European countries. Interestingly, the ESRI have factored in a very slow real growth rate for tourism based on increased costs with an average increase of around 1% per annum for the period from 2000 to 2010.

The main assumptions underlying these aggregates as taken from the ESRI are shown below in table 7.3.

Table 7.3

Principal Macro Assumptions Underlying Base Case Scenario

	1999	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*99 – 05*
	%	*%*	*%*	*%*	*%*	*%*	*%*	*%*
GNP	6.3	5.8	5.5	5.0	4.9	5.0	5.0	44.1
CPI	1.8	2.2	2.9	2.9	2.9	3.0	3.0	20.3
Personal Consumption	8.1	7.0	4.4	4.4	4.5	4.6	4.7	
Public Consumption	3.0	3.9	3.5	3.6	3.6	3.6	3.6	
Investment	11.4	5.6	4.9	4.8	3.4	3.3	3.5	
Exports	15.7	9.2	6.5	6.6	5.9	6.1	6.1	
Imports	17.7	10.8	5.9	6.4	5.8	6.0	6.0	

Source: ESRI (1999)

7.2.2.3 Deviation from the Central Forecast

The ESRI's central forecast represents their best estimate of how the economy will progress until 2005, though it stresses that the potential downside is a lot 'deeper' than the potential of the economy to exceed expectations. The principal mechanism through which this downside could manifest itself starts with a negative shock to the external economy which is magnified domestically by a the potential bursting of the housing price bubble, excessive wage inflation and the failure to implement the necessary investment in physical infrastructure.

Between the time this review was published by the ESRI in 1999 and the time of writing this synopsis of their results, a lot of new information has become available. Most obviously, the ESRI predictions are based on a forecast of economic performance for 1999 and 2000 that we now can readily observe. We can say that, on the positive side, the predicted ESRI results have significantly underestimated the performance of the Irish economy in 1999 and 2000. For example, while the ESRI predicted that the unemployment rate would continually decrease until 2005 and hover above 5% by then, in actual fact the 5% barrier was broken as early as 2000.

Less benignly, a number of external shocks have emerged which could potentially begin the chain of events anticipated in the review of a negative external shock

followed by a property collapse resulting in a very sharp deterioration in Ireland's economic performance.

- Firstly, and most seriously for the Irish economy, there has been a collapse of the high technology sector in America to which Ireland has a very large exposure. In 2001 this led to a number of high profile setbacks for the domestic economy, most notably the closure of the Gateway and Motorola plants.
- The advent of foot-and-mouth disease in Britain and subsequently in Ireland in 2001 impacted not only on agriculture, but also on trade with Britain which is dominated by indigenous firms and tends to be relatively labour intensive, and finally on the tourism industry. The latter caused particular worry given its importance to the Irish economy - in 2000 tourism revenue was estimated at a record IR£3 billion, providing jobs for 153,000 people in the Irish economy from almost 6.3 million visitors.
- Finally, while the slowdown in the US economy had been predicted to be relatively short lived, and had been countered by the continued strength of consumer spending there, the impact of the terrorist attacks on the World Trade Centre and the Pentagon on the 11th September has thrown that in doubt. There are other possible repercussions of this tragedy that, while being a minor footnote in the face of the overwhelming human suffering inflicted by the terrorists, are not insignificant in their own right. In particular, the impact on the stock market, oil price and US investment in the medium term is, at the time of writing, still very unclear, and very dependent on the actions of the Federal Reserve in America and of OPEC in the Middle East. It is also unclear what actions America might take militarily, and what impact they could have on the Middle East.

For the purpose of forecasting the model, the out performance of the Irish economy in the early years relative to the forecast and the series of negative shocks outlined above were not included. This was decided on purely pragmatic grounds. Firstly, the forecasts as presented provide an entire economy wide picture of the

development of the economy from an independent, highly regarded source which gives comparative simulations based on them more credibility. The results are well known and widely cited and thus form a fair basis of comparison between the CGE methodology employed and any other methods. Secondly, it is far from clear what impact each of the shocks will have on the economy, particularly the events in September 2001 in New York. The incorporation of this new information given this uncertainty would require the simulation of numerous scenarios. While the form of the base year economy clearly 'matters' in terms of the results, of far greater relevance is the method used to implement the Agenda 2000 shocks and their relationship with the partial equilibrium results as measured in models such as the FAPRI–Ireland model (Donnellan et al, 1999). Therefore effort is concentrated on this element of the model.

7.2.3 Methods Used To Impose Data

This section briefly outlines the swaps and shocks used to impose the data on the 1998 model to create each of the baseline data sets from 1999-2005. This was done in two broad steps – firstly, aggregate nominal flows were targeted, and secondly, technology shifts were allowed to ensure various predictions for price indices were met.

In terms of macro aggregates, the main task was to target the nominal totals for the main absorption aggregates. The variable *w3tot_h* (aggregate nominal household consumption consisting of both subsistence and luxury expenditure) was exogenised while the balance of trade, *delB*, was endogenised. As in chapter 6, there are two possible candidates that can be endogenised in place of aggregate nominal investment *w2tot_i*, both of which operate in much the same way. The first is *ffinv_i*, which is a 'dumb' shifter that results in uniform increases in the investment of each industry. The second is omega, which is the economy wide rate of return. We choose the former, which in effect allows a change in the investment/capital ratio to ensure that the target for aggregate nominal consumption is met. Finally, in the underlying closure government expenditure is fixed in real terms, so we only need a

slight alteration by exogenising nominal government expenditure *w5tot* and endogenising real government expenditure *x5tot*.

Nominal export flows were treated at a much more detailed level given their importance to agriculture. The nominal value of exports for each of the eight farm industries, the corresponding food processing industries, the aggregate exports of services and the aggregate exports of non-food processing manufactures were targeted. They were exogenised by endogenising the corresponding horizontal shift variable for demand for Irish products on international markets irrespective of export destination, namely the variable *f4p_d*. So, for example, the nominal target of (say) manufacturing exports was achieved by an equal shift in the demand curve for Irish manufactures in each of the UK, continental Europe and the rest of the world. Finally, aggregate employment was also shocked, though this creates no difficulties in terms of model closure, as this variable is exogenous anyway.

The next major step was to endogenise various technology shifters and exogenise targets of price aggregates. The predicted change in *p3tot_h* which is the price index in the model for consumer expenditure and correspond to the consumer price index was exogenised and shocked, while *ff1tot_i* was endogenised. The role of *ff1tot_i* can be seen in equations *E_a1totA*, *E_a1totB* and *E_a1totB* below which determine the value of the all-factor productivity shift variable *a1tot* for agriculture, manufacturing and services respectively. Intuitively, a change of 1% in this variable implies that 1% more of each input is required to produce the same amount of output. Conversely, a change of –1% implies that the same amount of output can be achieved with 1% less of inputs. Given that the underlying structure of the model is based on perfect competition, the less inputs that are required, the lower the price of the good.

```
Equation E_a1totA  # Production Shifter #
(all,i,I1AGRI)  a1tot(i) = ff1tot_i + ff1tot_ia + f1tot(i) ;
Equation E_a1totB  # Production Shifter #
(all,i,I2MANU)  a1tot(i) = ff1tot_i + ff1tot_im + f1tot(i) ;
Equation E_a1totC  # Production Shifter #
(all,i,I3SERV)  a1tot(i) = ff1tot_i + ff1tot_is + f1tot(i) ;
```

As can be seen from these equations, the *ff1tot_i* variable causes a uniform shift in technology in all industries of an equal magnitude.

The other two major price targets are the index for the output price of manufactures, *p0com_manu*, and the index for the output price of agricultural produce, *p0com_agri*. These are exogenised (and then shocked) by endogenising the corresponding technology shift variables *ff1tot_im* and *ff1tot_ia*. Their role can easily be seen from the equations above, and have a similar interpretation to *ff1tot_i*, though of course are specific to manufacturing and agriculture respectively. Note that we could not now endogenise the services price index *p0com_serv* as this would lead to singularity problems. The final set of shocks is to the already exogenous import prices.

7.3 The Agenda 2000 Simulation

7.3.1 Introduction

The Agenda 2000 reforms affect three sectors of European agriculture: cereals, beef and dairy, with the latter two in particular being of critical importance to Irish farming. This chapter concentrates on modelling the reform of beef and dairy, and ignores reforms in cereals. One of the primary objectives of the European Council was to achieve a stabilization of agricultural expenditure in real terms during the 2000-2006 periods at about 40.5 billion euros, which was the level of expenditure in 1999 (Hardy 1999). This objective should be seen in the context of budgetary rigour at the level of the EU as a whole and also against the background of the coming enlargement of the EU to include new member states from East and Central Europe.

The baseline assumptions for agriculture are taken from the FAPRI-Ireland model as documented in Donnellan et al (1999). The FAPRI –Ireland partnership was founded in 1997 and is linked with FAPRI, the Food and Agricultural Policy Research Institute at the University of Missouri.

7.3.2 Model Closure

As in chapter 4, in choosing an appropriate economic environment we must close both the supply and demand sides of the model. It is very debatable exactly which form of the model we should take. On the one hand, the actual measures introduced by the EU aren't set in stone, and as such will be under review in 2002. This might suggest a 'surprise' element to the model, thereby indicating that a short term simulation is warranted. On the other hand, to the extent that the broad thrust of policies can be correctly anticipated, a long run closure whereby capital and labour is free to adjust to the new circumstances is more appropriate. Therefore, we choose a middle path. Given that the timescale in question is not very long, we will retain the assumption that capital is sectorally fixed for the simulation in question. However we will assume that the real wage is flexible enough to ensure that full employment is retained. Therefore, this version of the model very much assumes that increases or decreases in employment are related more to decreased/increased unemployment rather than any migration effects which might tend to equalise real wages to an exogenous target in the long run.

Therefore, in terms of the labour market, the assumption is made that aggregate employment is fixed, with the real wage adjusting to ensure that the labour market clears. Labour is free to move between industries. We assume capital to be fixed in each industry with capital rents by industry adjusting to ensure equilibrium. Finally, the quantity of land of each quality class is exogenously fixed in both the short and long term. Finally we note that as in chapter 4 we assume that direct subsidies are land subsidies as most payments to cattle are now linked to minimum stocking rates per hectare.

In terms of the demand side, we employ a Kaldorian closure which allows the marginal propensity to consume to vary to ensure that the investment/savings balance is achieved. Therefore adjustment is forced onto consumption. In the simulation the balance of trade is exogenously set. The reasoning for this is that, as before, that in the sense that the model measures utility, an ability of borrow overseas results in a gain in welfare (in terms of consumption) without a balancing requirement to repay

the debt occurred. Therefore in terms of measuring utility, the most appropriate choice is to fix the balance of trade. Household consumption Investment is allowed to vary, with the economy wide rate of return (*omega*). The real value of public consumption is fixed.

7.3.3 Beef Reforms

The decade leading up to the Agenda 2000 reforms was a tumultuous one for beef farmers, with the twin crises of BSE and, subsequently, foot-and-mouth disease both impacting negatively on consumer confidence. The spectre of falling prices and the potential build up of large intervention stocks provided the impetus for the beef reforms, which were by far the deepest and most significant of the round. In essence, the policy of reducing support prices while increasing direct payments initiated with the MacSharry reforms was extended. The intervention price will be cut by 20% in three steps as from the 2000/2001 year with a special "safety net" intervention system if the average market price falls below a certain level.

The main changes in premia rates as a result of the reforms, as discussed in DAFF (2000), are as follows:

- higher rates of payment under the Suckler Cow Premium and Special Beef Premium Schemes
- a new all-year round Slaughter Premium for all bovine animals over 8 months subject to a National Quota ceiling
- higher rates of payment and new rules for determining "forage area" and stocking density for Extensification Premium
- a higher Special Beef Premium National Quota ceiling
- earlier eligibility of animals (steers and bulls) for the Special Beef Premium
- a higher limit of 180 animals per age bracket for the Special Beef Premium
- changes to the way in which milk quota is treated in calculating stocking density for the 2 LU limit per hectare limit for the Suckler Cow Premium and Special Beef Premium
- a new "National Envelope" of money to be spent annually by Member States in the beef sector

- reductions in the Special Beef Premium arising from any overshoot in the National Quota will not apply to farmers with less than 50 animals

According to the FAPRI-Ireland, the main impact on cow numbers will come as a result of the changes in the suckler cow quota and premia rather than through lower prices. In their baseline scenario, the suckler cow herd contracts by 1.5%. In the FAPRI-Ireland analysis the Agenda 2000 reduction of the suckler cow quota and the facility that allows suckler premia to be claimed on heifers results in a further reduction of 3.1%.

Table 7.4:

Summary of Berlin Agenda 2000 Agreement for Irish Beef Sector (IR£)

	1999	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
Price Change (FAPRI) %	0.00	-6.30	-11.77	-15.68	-16.44	-12.55	-12.85
Special Beef Premium (steers)	90.17	96.08	107.11	118.13	118.13	118.13	118.13
Special Beef Premium (bulls)	111.98	126.01	145.70	165.39	165.39	165.39	165.39
Suckler Cow Premium	140.23	147.39	162.36	176.53	176.53	176.53	176.53
Direct Comp. (% Land Income)	10%	20%	30%	30%	30%	30%	30%

The imposition of tougher stocking density calculations is modelled as a negative shift in land technology. By way of example, the changes for 2000 are implemented in the model as follows:

Changing Export/Import Prices

```
shock  f_t4exp 70          =        -6.301083725;
shock  f_t4exp 84          =        -4.084782543;
shock  f4p_d       2       =        -6.301083725;
shock  f4p_d       16      =        -4.084782543;
shock  pf0cif 2            =        -6.301083725;
shock  pf0cif 16           =        -4.084782543;
```

Increased Extensification Requirement

```
shock  a1lnd_1 2       =        1;
```

Increased Land Subsidies

```
shock  f_tllnd_l  2  =  10;
```

Fixing Domestic Prices

```
swap   pltot  2 16  =  alprim 2 16;
shock  pltot 2      =  -6.301083725;
shock  pltot 16     =  -4.084782543;
```

7.3.4 Dairy Reforms

The background for the dairy sector was weakness in both the Russian and South East Asian markets, and this proved crucial in shaping the reforms. In the end, changes in dairy policy, particularly the issue of quota elimination was postponed, and the cut in intervention prices over three years of 15% was delayed until the 2005/2006 year.

While the assumptions for development of the European dairy market underpinning all the scenarios assumes that there is a switch in production away from SMP to cheese to match the observed secular trend in increased cheese assumption, it is assumed that there is very little change in the composition of the Irish product mix under either the baseline or Agenda 2000 projections. Ireland is expected to remain very dependent on intervention products, and will therefore suffer more directly from the fall in the intervention price. This constancy in the makeup of Irish dairy output is fortunate in terms of the IMA*GE* model given that all dairy products are amalgamated into one sector and therefore cannot easily be differentiated. The EU milk production quota will be increased by 2.4% in three equal steps from the 2003/2004 quota year, but some countries (Greece, Spain, Ireland, Italy and Northern Ireland) will benefit as from 2000 onwards. Intervention price reductions and the implementation of direct payments are deferred until 2005.

Table 7.5: Summary of Berlin Agenda 2000 Agreement for Irish Dairy Sector

	2000/2001	*20001/2002*	*2005/2006*	*2006/2007*	*2006/2007*
Quota Increase on 99/00	1.83%	2.86%	2.86%	2.86%	2.86%
Intervn Price Fall on 99/00	-	-	5%	10%	15%
Dir Comp, Pence per gallon	-	-	3.07	6.14	9.21

Source: Reproduced from Donnellan et al, (1999)

As in chapter 5, the approach taken to model the milk quota is to assume that it is binding at all times and to allow endogenous shifts in the supply curve to ensure that a target exogenous level of quota is achieved. As before, this implies endogenising *a1prim(i)* which is the technology shift variable for the use of primary factors in industry *i*. A value of –1% implies that 1% less is needed of the primary factors of production to produce each unit of output, and is therefore interpreted as a positive technology shift. The reduction in intervention prices is assumed to impact on Ireland by way of a change in the import and export prices of dairy products. Finally, while there are direct payments made to land, the amount of subsidy is linked to production that is itself fixed. Therefore the *rate* of land subsidy is endogenised to ensure that the *value* of the subsidy paid to land is fixed. The rate of direct compensation of 3.07 pence per gallon based on a total allocation of 1,120 million gallons for the state is equivalent to an increase in land subsidies of 54.6%.

These changes are implemented in the model (for 2000) as follows:

Milk Quota

```
swap    a1prim 1            =       x1tot 1;        !Milk
```

Increasing Milk Quota

```
shock   x1tot 1             =       1.83;           !Milk 2000
```

Price Changes in Agenda 2000

```
shock   p4("R1Dairy",D3World) =     0.00;
shock   p0cif("R1Dairy")    =       0.00;           !Milk 2000
```

Direct Compensation (2005 only)

```
shock f4p       17 51 85        = uniform       -3;
shock pf0cif    1               =               -5;
shock pf0cif    17              =               -3;

!Direct Compensation (2005 only)
swap    f1tot 1         =       x1tot 1;
shock   x1tot 1         =       2.70;
```

```
!Direct Compensation (2005 only)
swap    f_tllnd_l("I1Milk")      =      wlsub_lnd("I1Milk");
shock   wlsub_lnd("I1Milk")      =      54.6;
```

One problem with the 2005 simulation is with achieving a model closure. Ordinarily, output and price are determined endogenously within the model. By endogenising technology within the industry we can exogenise either the output level or the price level. We cannot simultaneously target both. Not exogenising milk, but just letting the international price of milk fall by 5% and the international price of milk products fall by 3% sidestepped this problem. This 3% is derived in a similar manner as with beef – it is 60% of the raw milk decrease, where 60% is the portion of total costs of the milk industry spent on raw milk.

7.4 Simulation Results

As with the MacSharry reform, it is difficult *ex-ante* to anticipate the model results given that output was not decoupled from support, so much of the effect of the reform is on essentially general equilibrium phenomenon (e.g. the effect of where consumers spend income 'freed up' due to lower prices).

The results of the simulations presented above are now discussed. They are divided into a discussion of the macro impacts of Agenda 2000, and then a discussion of industry results. The form the discussion takes is based on the principle that good CGE analysis should, where possible, use the strengths of partial equilibrium analysis to achieve an appropriate initial shock, and then use the results as a means of increasing the relevance of partial equilibrium analyses rather than supplanting it.

Note also that we have not replicated the partial equilibrium analysis undertaken in the FAPRI simulation with the general equilibrium analysis, as this is not possible given the differing level of complexity and form of the two models. Therefore it is not correct to interpret the difference between (say) nominal milk output based on the FAPRI results and the IMAGE results as being due solely to general equilibrium factors. However, we will try when discussing the results to discuss the general

equilibrium effects which are likely to have most impact and to estimate the quantitative effect they have.

7.4.1 Macro Results

To interpret the macro results reported in table 7.7 we begin by observing the changes in absorption. The first point to note is the fall in nominal consumption of approximately 0.2% over the course of the simulations. There are two possible explanations for this fall. Firstly, there has been a change in disposable income. In fact in the simulation we find that disposable income actually rises slightly, which masks a fall in income for farm households being outweighed by a rise in income for non-farm households. Therefore, if income has risen in aggregate, why has consumption fallen? The answer lies in the fact that export prices have declined due to the reforms, putting pressure on the balance of payments. However, our model closure indicated that the balance of payments should be fixed, so to ensure this we must hold down nominal imports. This is achieved through two mechanisms. Firstly, the exchange rate devalues by around 0.05%, allowing import substitution away from imports. Secondly, this is achieved by dampening down domestic consumption demand. This change in the marginal propensity to consume as observed in the model results imply that there is an increase in the marginal propensity to save, with aggregate consumer saving rising around 2%.

There are also relatively minor falls in nominal government expenditure. Given that real government expenditure is exogenously set, this fall in nominal terms reflects falling prices due to the fall in food prices. Nominal export demand in aggregate also falls by a marginal –0.01% to –0.03%. This is as a result of a small rise in export volumes being outweighed by a fall in prices. Note also that import prices also fall slightly – this is due to the price of beef imports falling due to the reforms. All import price changes for other commodities are exogenously set at zero.

Investment demand plays an important role in the mechanism discussed above. The devaluation causes an increase in demand for the produce of non-agricultural exporters such as the metals/machinery industry. These industries in turn are the

large investors in capital, and as such an increase in the rental price of capital induced by increased export demands results in an increase in investment. Investment in turn is very import intensive (comprising almost 50% of total investment inputs), resulting in an increase in import demand. This is 'against the grain' of the decrease in consumption which is required to reduce imports, and explains why the reduction in consumption relative to income, and the associated increase in savings, is so dramatic. The final row in table 7.6 is the welfare measure that is comprised of a weighted average of household consumption, household savings and government income.

Finally, there is an apparent anomaly in real primary inputs that requires explanation. Notice in the table that while aggregate employment in the economy as a whole is fixed, and that the aggregate capital stock is fixed by industry and thus in aggregate, and finally that the aggregate land base is also (naturally) fixed, why does the total endowment of primary factors, x1prim_i, increase by around 0.2%? The answer lies in the fact that the modelling of the milk quota assumes that there is a variable 'rent' accruing to dairy farmers which is interpreted in the model as a change in the productiveness of the primary factors in dairy farming. For example, if the value of the milk quota in terms of higher incomes for farmers than would otherwise pertain rises, in the model this is interpreted as an increase in the productivity of primary factors employed in dairy farming. Therefore the stock of primary factors has increased due to this productivity increase.

Table 7.6

Deviation from Baseline

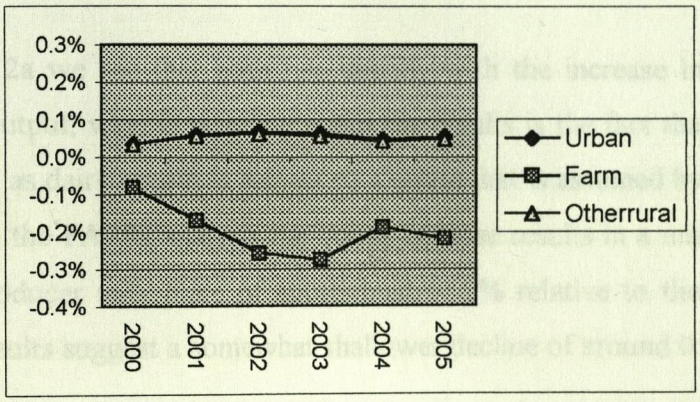
Macro Aggregates		*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
Real Wage	realwage	0.09	0.16	0.20	0.20	0.15	0.20
Employment	employ_i	0.00	0.00	0.00	0.00	0.00	0.00
Nominal GDP	w1gdpexp	-0.04	-0.07	-0.10	-0.10	-0.07	-0.11
Balance of Trade	delB	0.00	0.00	0.00	0.00	0.00	0.00
Nominal Exchange Rate	phi	0.00	0.00	0.00	0.00	0.00	0.00
Real Devaluation	p0realdev	0.06	0.11	0.13	0.13	0.08	0.09

Terms of Trade	p0toft	-0.03	-0.05	-0.06	-0.06	-0.04	-0.07
Labour Price	p0lab_io	0.03	0.05	0.05	0.05	0.04	0.04
Capital Price	p1cap_i	-0.11	-0.19	-0.23	-0.21	-0.16	-0.21
Prices							
Consumption	p3tot_h	-0.06	-0.11	-0.15	-0.15	-0.11	-0.16
Investment	p2tot_i	0.01	0.01	0.01	0.01	0.01	0.01
Exports	p4tot_d	-0.04	-0.07	-0.08	-0.08	-0.06	-0.10
Government	p5tot	0.01	0.01	0.01	0.00	0.00	0.00
Imports	p0imp_c	-0.01	-0.02	-0.03	-0.03	-0.02	-0.03
Real Primary Inputs							
Labour	x1lab_io	0.00	0.00	0.00	0.00	0.00	0.00
Capital	x1cap_i	0.00	0.00	0.00	0.00	0.00	0.00
Total	x1prim_i	0.02	0.04	0.04	0.04	0.03	0.03
Real Final Demands							
Consumption	x3tot_h	0.00	0.01	0.01	0.02	0.01	-0.02
Investment	x2tot_i	0.00	0.01	0.01	0.01	0.00	0.01
Exports	x4tot_d	0.02	0.03	0.04	0.04	0.03	0.06
Government	x5tot	0.00	0.00	0.00	0.00	0.00	0.00
Imports	x0cif_c	0.00	0.00	0.00	0.01	0.00	0.01
Nominal Primary Inputs							
Labour	w1lab_io	0.03	0.05	0.05	0.05	0.04	0.04
Capital	w1cap_i	-0.11	-0.19	-0.23	-0.21	-0.16	-0.21
Nominal Final Demands							
Consumption	w3tot_h	-0.06	-0.10	-0.14	-0.14	-0.10	-0.18
Investment	w2tot_i	0.01	0.02	0.02	0.02	0.01	0.02
Exports	w4tot_d	-0.02	-0.03	-0.04	-0.04	-0.03	-0.04
Government	w5tot	0.01	0.01	0.01	0.00	0.00	0.00
Imports	w0cif_c	-0.01	-0.02	-0.02	-0.02	-0.01	-0.02
National Welfare	welfare	-0.06	-0.12	-0.14	-0.15	-0.07	-0.06

As discussed above, aggregate land of each type is fixed, capital is assumed fixed while labour is free to move between industries to ensure that the change in the wage rate is constant among industries. As Agenda 2000 involves the increased subsidisation of land, there is a substitution away from labour (the only other mobile factor of production) as cattle production becomes more land intensive. This release reduces the quantity of agricultural workers by around 1% - 2%, with small increases in all other occupation types.

Figure 7.1

Change in Labour Income by Household



As shown in figure 7.1 above, this results in a fall in aggregate labour income accruing to farm households, while increasing aggregate labour income to urban and rural non-farm households marginally.

7.4.2 Industry Results

In discussing the industry level results, rather than list the results of all 34 industries, we will divide the discussion into those industries directly impacted by the reforms, and then discuss the results for manufacturing, services and agriculture, with the results for the three sectors excluding cattle, dairy, beef and milk industries.

7.4.2.1 Dairy/Milk and Cattle/Beef Industries

We now turn to an examination of the simulated changes in the two industries that were directly affected by the reforms, namely beef and dairy. In terms of the milk

market, the results are not particularly interesting given that the forecasted model only extends to 2005, while the bulk of the decrease in the price of milk with the associated direct compensation was scheduled to take place in 2006 and 2007. However, in 2005 the process had begun, with a 5% reduction in the milk price. The percentage change in nominal and real output from the base year scenario based on both the FAPRI-Ireland and IMA*GE* simulations are shown in figures 7.2a and 7.2b below. Note that two different IMA*GE* simulations are shown. The first set maintains the quota at its 1998 level, and does not decrease the price of milk in the base year. This is done to separate out the simulated impact of the Agenda 2000 beef reforms on the dairy market from the impact of the reforms of the dairy market itself.

From figure 7.2a we see that both rise initially with the increase in the quota. In terms of real output, what is puzzling about the results is the fact that the results are divergent at all as dairy output is subject to a quota that is assumed by both models to be binding. In the FAPRI analysis the quota increase results in a marginal reduction in the Irish producer milk price of approximately 2% relative to the baseline, while the IMA*GE* results suggest a somewhat shallower decline of around 0.5%.

Figure 7.2a

Deviation of Nominal Milk Output from Baseline

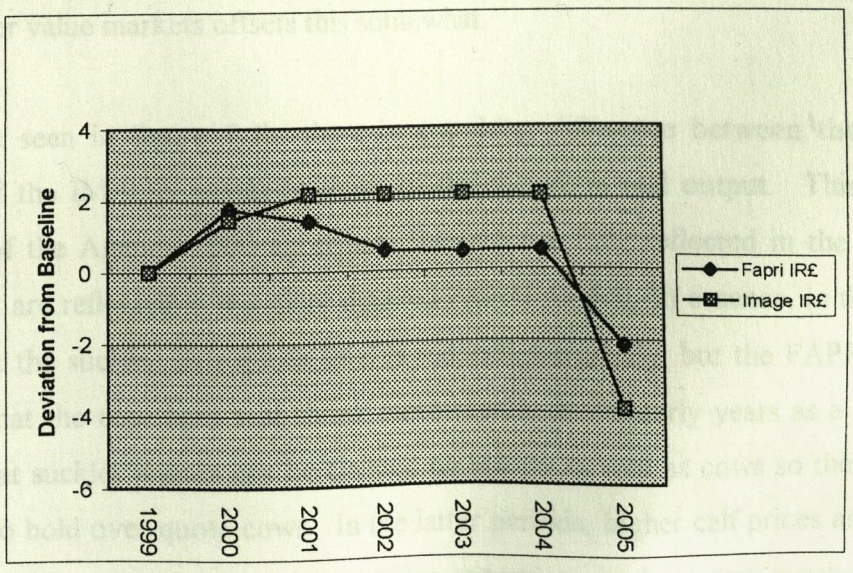
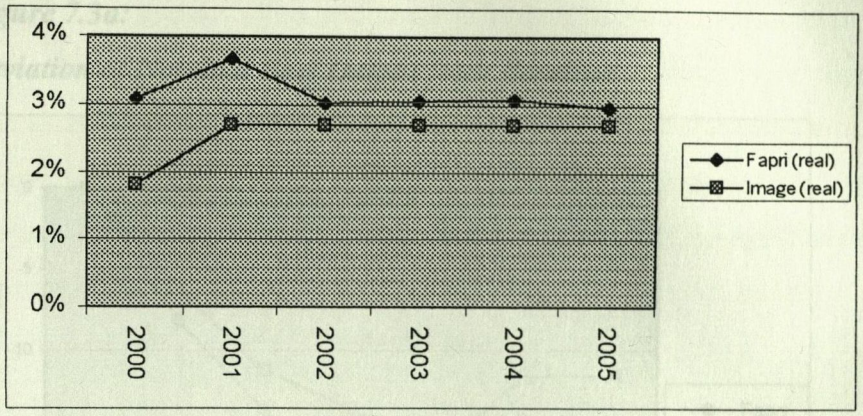


Figure 7.2b

Deviation of Real Milk Output from Baseline



We now turn to the impact on cattle and beef production of the Agenda 2000 reforms. The assumed changes in price as calculated by the FAPRI model also underlie the IMA*GE* model. The baseline model, while assuming that the EU price falls over the period in question because of continued weakness in international markets, predicts that the Irish price remains unchanged. This is due firstly to the reversing of some of the negative perceptions of Irish beef, coupled with an increased portion of Irish output going to the higher value European markets.
Under the Berlin Agreement, the FAPRI analysis predicts that falling EU prices feed into the Irish market, although increased sales to the European market at the expense of the lower value markets offsets this somewhat.

As can be seen in figure 7.3b, there is a striking difference between the FAPRI results and the IMA*GE* results in terms of the change in real output. This reflects elements of the Agenda 2000 agreement that are not fully reflected in the IMA*GE* model, but are reflected in the more detailed FAPRI model. In essence, in the Berlin Agreement the suckler cow quota level is reduced marginally, but the FAPRI model suggests that the cow herd will shrink more rapidly in the early years as a result of the fact that suckler premia can be claimed on heifers as well as cows so there is less incentive to hold over quota cows. In the latter periods, higher calf prices as a result of increased direct payments and continuing reductions in dairy cow numbers result

in a leveling off of numbers. For a full discussion of this, see Teagasc (2000). Such intricacies are not captured in the IMA*GE* model.

Figure 7.3a:

Deviation of Nominal Beef Output from Baseline

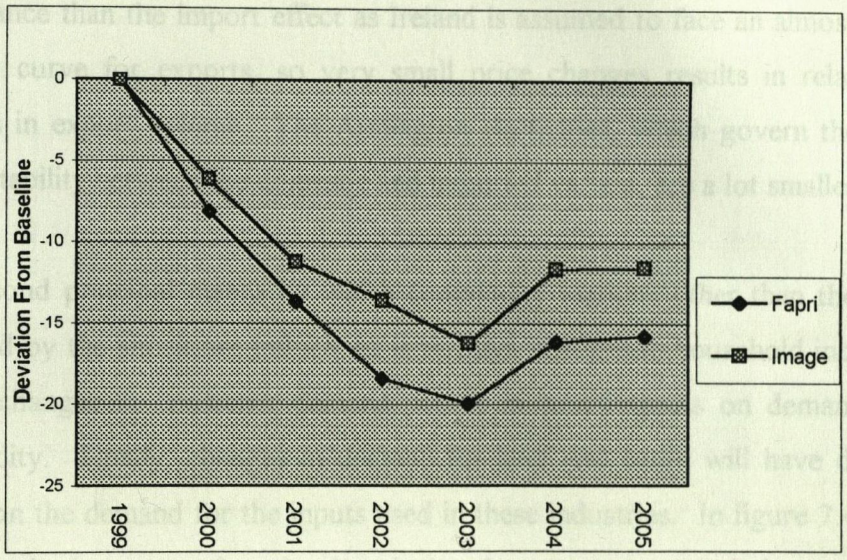
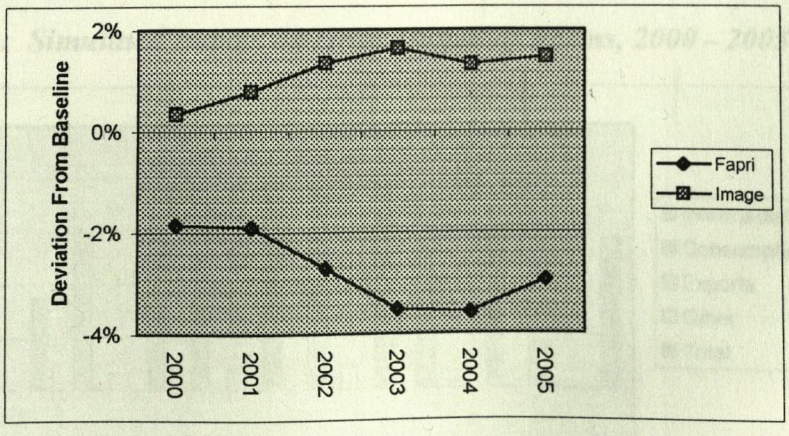


Figure 7.3b:

Deviation of Real Beef Output from Baseline



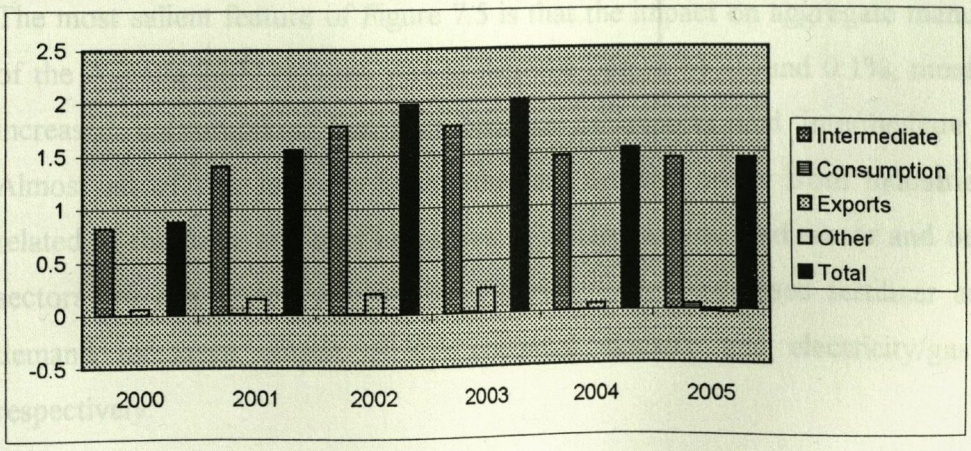
7.4.2.2 Other Industries

The primary mechanisms by which the initial shock to the agricultural industry impacts on the rest of the economy can be divided into supply side and demand side considerations. On the supply side, the principal impact arises from the release of

labour and land from cattle production. On the demand side, there are three principal mechanisms. The first is a change in the price level, which, with the nominal value of the exchange rate *phi* fixed exogenously as the numeraire, is equivalent to a revaluation of the currency. This will result in both substitution towards/away from imports and an decrease/increase in exports. The export effect is of much more significance than the import effect as Ireland is assumed to face an almost-horizontal demand curve for exports, so very small price changes results in relatively large changes in export volume. The Armington elasticities, which govern the degree of substitutability between the domestic and imported variant, are a lot smaller.

The second principal means by which commodity markets other than those directly impacted by the shock are influenced is through changes in household income which causes changes in consumer demand, which in turn impacts on demand for each commodity. Finally, changes in demand for beef and cattle will have downstream affects on the demand for the inputs used in these industries. In figure 7.4 below we illustrate the impact on farm level agricultural gross output. It is important to note that dairy and cattle production constitute a very large share of total farm output, so these two activities they dominate the graph.

Figure 7.4: Simulated Impact on Gross Output of Farms, 2000 - 2005



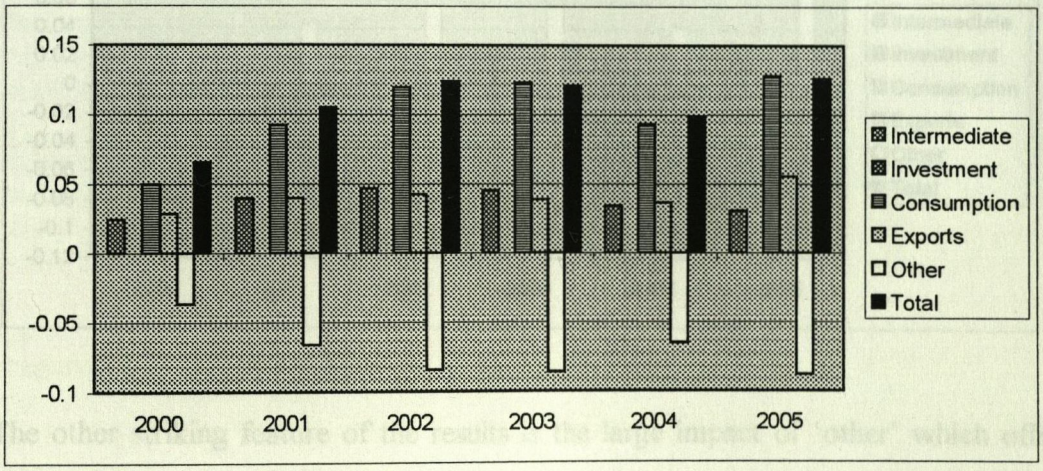
From figure 7.4 we see a sharp rise in output, virtually all of which is sent for further processing so from the perspective of the farm appears as intermediate demand. Farm industries other than those directly affected by the Agenda 2000 reforms

benefit from a significant increase in gross output over and above the baseline figures with both export demand and intermediate demand increasing by a similar magnitude. The increase in export demand is a 'cost-push' increase – most notably as the price of land decreases slightly.

In figure 7.5 below we illustrate the impact on aggregate manufacturing that results from the Agenda 2000 shocks.

Figure 7.5

Simulated Impact on Gross Output of Manufacturing, 2000 - 2005



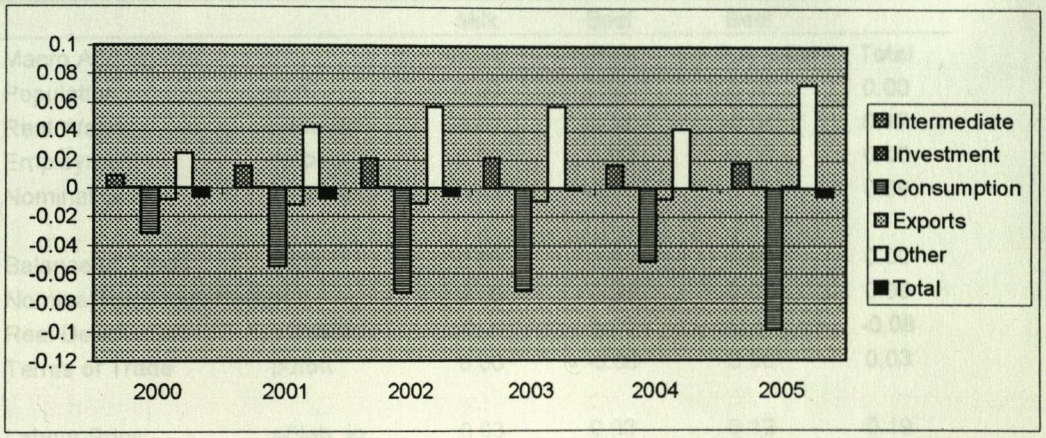
The most salient feature of Figure 7.5 is that the impact on aggregate manufacturing of the Agenda 2000 reforms was to increase output by around 0.1%, mostly due to increased consumption, but also because of exports and intermediate demand. Almost all of this increase in intermediate demand arises from industries closely related to the dairy and beef industries. The farm animal feed sector and other foods sectors are among the primary beneficiaries. Also, increased fertilizer and power demand increases output of the chemical industry and electricity/gas industry respectively.

In figure 7.6 below we illustrate the impact on the aggregate output of services that results from the shocks. It shows that in aggregate the impact on services of the Agenda 2000 reforms are negligible, though this is only due to the fact that a large

fall in consumption is offset by a rise in the 'other' category. The reason for the large fall in consumption is that, while there was only a small reduction in household income, services are much higher proportion of marginal consumption than average consumption. As services are less traded than manufactures, the impact of changes in export volumes of services is negligible.

Figure 7.6

Simulated Impact on Gross Output of Services, 2000 – 2005



The other striking feature of the results is the large impact of 'other' which offsets the reduction in household consumption. The explanation for this lies in the increase in demand for margin services. *Transport* as a margin commodity increases by around 0.05-0.10%, while retail/wholesale as a margin commodity increases by around 0.03-0.08%. This is surprising given that the one area of demand that showed a consistent increase, namely intermediate demand, is assumed to have a zero demand for margin commodities. The answer lies in the fact that the increase in international trade, with both aggregate volumes of exports and imports increasing, resulted in an increase in margin demand.

7.4.3 Breakdown of Results for 2003

In an effort to achieve a better understanding of the results of the simulation, we should break down the results into the impacts of the various shocks. To do this for each of the individual years would be prohibitively time consuming and add little value, so instead we choose a central year in the forecast (2003) and subdivide the

simulation results into the component shocks. In this section we measure three separate policy 'packages'. Firstly, we measure the impact of the decrease in price in beef. In the second simulation we measure the impact of increased direct payments and the extensification requirement. Finally, we measure the impact of the increase in the size of the milk quota. The results are shown in table 7.7.

Table 7.7

Decomposition of Simulation Results for 2003

		Milk	Beef	Beef	
Macro Aggregates		Quota	Price	Dir Pay + Ext	Total
Population	q_h	0.00	0.00	0.00	0.00
Real Wage	realwage	0.02	0.18	-0.04	0.17
Employment	employ_i	0.00	0.00	0.00	0.00
Nominal GDP	w1gdpexp	0.03	-0.11	0.17	0.09
Balance of Trade	delB	0.00	0.00	0.00	0.00
Nominal Exchange Rate	phi	0.00	0.00	0.00	0.00
Real Devaluation	p1realdev	-0.01	0.11	-0.17	-0.08
Terms of Trade	p0toft	0.00	-0.06	0.08	0.03
Labour Price	p0lab_io	0.03	0.03	0.12	0.19
Capital Price	p1cap_i	0.03	-0.25	0.24	0.02
Consumption Price	p3tot_h	0.01	-0.15	0.16	0.02
Investment Price	p2tot_i	0.01	0.01	0.05	0.07
Exports Price	p4tot_d	0.00	-0.08	0.08	0.01
Government Price	p5tot	0.02	-0.01	0.12	0.13
Imports Price	p0imp_c	0.00	-0.02	0.00	-0.02
Real Labour	x1lab_io	0.00	0.00	0.00	0.00
Real Capital	x1cap_i	0.00	0.00	0.00	0.00
Real primary Total	x1prim_i	0.02	0.02	0.00	0.04
Real Final Demands					
Consumption	x3tot_h	0.04	0.00	0.09	0.12
Investment	x2tot_i	-0.02	0.02	-0.14	-0.14
Exports	x4tot_d	0.01	0.02	-0.07	-0.04
Government	x5tot	0.00	0.00	0.00	0.00
Imports	x0cif_c	0.01	0.00	-0.03	-0.03
Nominal Final Demands					
Consumption	w3tot_h	0.05	-0.16	0.25	0.14
Investment	w2tot_i	-0.01	0.02	-0.09	-0.07
Exports	w4tot_d	0.01	-0.06	0.01	-0.03
Government	w5tot	0.02	-0.01	0.12	0.13
Imports	w0cif_c	0.01	-0.02	-0.03	-0.05

The results of the simulation clearly indicate that the change in the milk quota (which was increased by 2.7%) did not have a sizeable effect on the economy. The slight rise in the quantity of milk available reduced the milk price of around 0.6% (not reported in table), which in turn decreased the price of processed dairy products with a consequent rise in export volumes. What is unusual is that, generally, prices in the economy actually rose. This arises because the decrease in dairy milk prices is associated with an increase in the price of cattle, which is brought about due to competition for land, the price of which goes up as more land is demanded to satisfy the increased milk output. The decrease in the beef price results in a real devaluation, which shifts output to exports to ensure that the fixity of the balance of trade constraint is satisfied. The increase in direct payments directly offsets many of the effects of the decrease in the beef price. There is a significant increase in domestic consumption, while aggregate investment fell. While not reported separately, the imposition of extensification has a very small economy-wide impact.

The impact on individual housing groups is shown below. While it is not surprising that farm households are greatest affected by the changes in policy, the fact that much income of farm households is got from off-farm employment is reflected in the fact that the figures for (say) farm households and other rural households are actually very close, because they tend to work in the same (non-farm) industries.

Table 7.8

Disposable Income of Households

	Milk Quota	Beef - Price	Beef – Dir Pay + Ext
Urban Households	0.04	-0.15	0.33
Farm Households	0.04	-0.30	0.41
Other Rural Households	0.04	-0.22	0.40

Finally, the impact on the price of land of each type is shown in table 7.9. As can be seen, the impact of the reforms on land prices is startling, indicating that much of the benefit in the CAP reforms results in increased land prices. In particular, land of wide and limited use increases in price by an aggregate 10%. Land with a very limited use range is only marginally affected by the reforms. For existing farmers

who intend to pass the farm onto other family members on retirement, this is obviously of little consequence. However for a new farmer who has to pay for the land, or for an existing farmer who wishes to extend his farm, he is in essence paying the capitalised value of future subsidies, which is clearly not the intention behind agricultural support.

Table 7.9

Land Prices

	Milk Quota	Beef - Price	Beef – Dir Pay + Ext	Total
Wide Use	1.04	-16.20	27.10	11.94
Limited Use	0.82	-13.00	21.70	9.52
Very Limited Use	0.22	-3.70	6.00	2.52

7.5 Conclusion

The purpose of this chapter was to forecast the economy for each year from 1999 – 2005 so as to create a baseline for each year against which the reforms set out in the Agenda 2000 reform proposals could be analysed. The chapter proceeded to implement the Agenda 2000 shocks in each year. The effects on the gross output of farms (excluding dairy and cattle output) suggest that the reforms gave these enterprises a significant boost, with gross output increasing by almost 2% in 2002. The effects on the gross output of manufacturing and services are largely neutral – this is not because general equilibrium effects 'don't matter', but rather that the effects largely offset each other in this particular set of simulations.

CHAPTER 8

CONCLUSION

8.1 Overview

The structure of this thesis is as follows. We begin with chapter 2 and Chapter 3 which document the construction of the base 1993 version of the model. The former discussed the form of the model code, the technology assumptions, i.e. functional forms, underlying the model and the method used for solving the model. While an understanding of the full model code is only necessary for economists who wish to develop the model further or to investigate its properties in detail, it is useful to have a broad understanding of the coding conventions as important excerpts from the TABLO file are introduced later where relevant. The full TABLO code is shown in appendix 1 at the end of the thesis.

Chapter 3 explained the data requirements for CGE models of the type employed, and explained the process used to reconcile the (at times conflicting) data from the various input-output sources. The chapter continued by explaining in some detail the methods used to extend the existing data set so as to arrive at a detailed breakdown by occupation type, by household type and by land type. A separate section was devoted to issues behind the allocation of subsidies to ensure an adequate modelling of the Common Agricultural Policy. Finally, the choice of model parameters was explained.

Chapter 4 has two principal purposes. The aim of the first section was to employ the model as developed over the previous two chapters to estimate the economy wide impact of the MacSharry reforms of the Common Agriculture Policy on the wider Irish economy. This was done in some detail in an attempt to assess model validity. This exercise raised a number of difficult issues, particularly the need to develop model closures to simulate the relatively intricate workings of the Common

Agricultural Policy. For milk, for example, it proved very difficult to target both output and price, though this was overcome satisfactorily. A very important issue that arose in relation to processing industries was acknowledging that the price change of processed food commodities will not necessarily change by the same amount as the unprocessed commodity. So, for example, a 15% fall in the price of capital is not likely to induce a 15% fall in the price of processed beef. Difficulties such as this are always likely as we move from the crude general equilibrium approximations frequently used when assessing the impact of the CAP towards a much more refined modeling of the principal intervention mechanisms.

The results in themselves indicate that agriculture is a net beneficiary of the reforms in the long run, with cattle/beef production in particular rising sharply. In the long run the impact on other manufacturing industries is negligible, with increased consumption and intermediate demand canceling out a slight fall in exports. Service industries experience a small growth, almost all of which can be explained by increased household consumption.

Chapter 4 also showed that taking into account general equilibrium effects can have a very large bearing on simulation results. Calculating the own output effect of a 1% increase in the price of cattle, we find that the general equilibrium simulation result is –0.54%, while the partial equilibrium simulation result is around 20% larger in magnitude at –0.65%. This result was achieved despite giving the benefit of the doubt to partial equilibrium analysis in two important respects. Firstly, in section 4.4.3 we include 'other food' in the definition of agriculture and assume that partial equilibrium modelers take this sector into account in their analysis - this is not typically the case. Secondly, many partial equilibrium modelers will not take account of changes in agricultural factor markets, and will instead treat land and capital as fixed. The one caveat is that it was necessary to employ an approximation to correct for immobility of factors of production, though we suspect that this approximation is quite robust, and that the results would not be materially affected by removing it. The final aim of this chapter was to conduct a sensitivity analysis on the model results in an effort to ascertain how sensitive simulation results are to key

parameter values and closures. This sensitivity analysis is done in the context of an examination of the impact on the economy of the 2001 Foot and Mouth disease outbreak which paralysed Irish tourism and agriculture for a brief period in 2001. The results of this sensitivity analysis conclude that the model results for this particular simulation are not very sensitive to the choice of macro closure, factor market elasticity or labour market closure, though are very sensitive to the choice of Armington assumption.

Chapter 5 was divided up into a brief discussion of directed and non-directed methods while in section 5.4 we introduced the ESA95 methodology that will form the basis for the compulsory production of annual input-output tables in Europe and compared it with the method employed in this thesis. The evidence seems to be that traditional demand driven or supply driven models (i.e. directed methods) prove to be poor estimators of future input-output tables. Methodologies that do not assume the stability of one or other of the coefficient sets (i.e. non-directed methods) have also proved to be of little benefit. While no empirical tests have been completed on the Monash approach (to our knowledge), its ability to incorporate with ease any data available at the time of construction is of huge benefit. As more data for a particular year becomes available, it can be incorporated into the updated model. In effect, the 'full' input-output data sets as calculated by the statistical agencies can be thought of as the limit of a series of Monash-style updates. The final advantage of this methodology is that we can interpret changes in the input-output coefficients in terms of price effects, income effects, taste and technology effects etc. The method goes beyond the 'dumb' matrix manipulation method of RAS and its descendants.

Chapter 6 had two primary aims, the first of which was to update the 1993 database from 1993 to 1998, while the second was to interpret the technology and taste variables to try and provide a breakdown explaining the nature of Ireland's economic experience over the five-year period under examination.

The former was done via a so-called historical simulation. In many respects the principal difficulty in relation to the historical simulation was in choosing which data

to impose, and at what level of disaggregation the data was to be used. Frequently two pieces of data proved to be inconsistent, either causing the model not to solve at all or for it to diverge rapidly. The second major difficulty was in choosing appropriate closures to ensure that the model converged at a reasonable rate. The explanation for the frequent incidence of the second problem can probably be put down to the fact that the closures used were not familiar in the same way as the usual comparative static simulation closures were. This may be due to the fact that the manipulation of a Cobb-Douglas or CES function with fixed technology is a familiar task for any student of economics, a task which forms the basis of the 'standard' closure. It is not surprising given the complexity of the model that most of the methods finally chosen were arrived at only after a long procedure of trial and error. It was certainly not obvious *a priori* which changes in the model closure would 'calm' the model ensuring it will converge faster, and which would result in the model either converging slower or diverging. The updated input output tables are shown in the appendix. A large part of the macroeconomic change in the economy relates to the large increase in labour supply, which, in hindsight, was not given an adequate treatment in the historical simulation of the model.

The interpretation of the technology and taste variables was done via the decomposition simulation. While this method has proved popular in Australia where it was originally developed, the feasibility of the methodology to explain the type of growth experienced by Ireland over the period from 1993 to 1998 is thrown into doubt by the results presented here. In particular, the performance of the Irish economy over the period in question was dominated by the impact of an increase in FDI that impacted primarily on two industries, namely machinery and chemicals. Had this resulted in a large increase in demand for intermediate products, the CGE/IO framework might have proved more enlightening. However these two industries are highly vertically integrated, and source the main bulk of their inputs from overseas, usually from other branches of the same multi-national. Therefore very little of the story of the success of the Irish economy can be illustrated through the methodology employed in this chapter – of far greater importance are issues such as technology transfer, learning by doing, etc.

Finally, the purpose of chapter 7 was to forecast the economy for each year from 1999 – 2005 so as to create a baseline for each year against which the reforms set out in the Agenda 2000 reform proposals could be analysed. The chapter proceeded to implement the Agenda 2000 shocks in each year. The effects on the gross output of farms (excluding dairy and cattle output) suggest that the reforms gave these enterprises a significant boost, with gross output increasing by almost 2% in 2002. The effects on the gross output of manufacturing and services are largely neutral – this is not because general equilibrium effects 'don't matter', but rather that the effects largely offset each other in this particular set of simulations.

8.2 Issues for Future Research

The potential for future development of the model structure, continued refinement and updating of the data set and dissecting and dissemination of the simulation results is constrained only by the large resource requirements of a credible CGE modelling effort. We will now briefly discuss the main areas of potential research, and suggest which of these options are most relevant for the development of the IMA*GE* model.

Firstly, as updated input-output data becomes available, there will be a large effort required to update the model in a similar manner as detailed in Chapter 6 of this thesis. This will also offer the opportunity to compare the results of the updating methodology employed to the actual published results with the aim of further refining the methodology and identifying any key weaknesses. Also, given that the CSO will be required to provide (approximate) updated tables on an annual basis using the ESA95 method, there will be an interesting comparison between the results provided by this method and those provided by the updated IMAGE model. As the latter is grounded in CGE modelling rather than the matrix manipulation of the former, it provides clear consequences in terms of the implicit changes in taste and technology implied by the updating technique, and in many ways is the intuitively stronger methodology. The MONASH methodology is certainly superior in terms of a meritocracy that places greater value on models that incorporate more relevant

information in the process of updating, all else being equal. A brief comparison of the two methodologies is presented in Chapter 5.

Secondly, two major potential developments in the theoretical structure of the model are, firstly, the incorporation of imperfect competition and secondly the development of a dynamic element to the model. Given the resources available, it is unlikely that both could satisfactorily be incorporated. Choosing between the two is not easy – both are becoming expected of CGE models as standard features, despite the fact that the complexities of the standard perfect competition model are little understood by many modellers.

While the cost of the two is probably very similar in terms of modelling effort, it is our opinion that the benefit of introducing imperfect competition into the IMA*GE* model is likely to greatly exceed the benefit of introducing a dynamic mechanism. The reason is simple – just because a model is static doesn't preclude the possibility of an change in the use of capital. Quite the opposite, we can to varying degrees of complexity allow capital to flow within the economy or just within particular sectors. We can identify fixed capital that is immobile, while allowing mobile capital to chase the highest returns. We can set the aggregate economy wide capital endowment, or fix the interest rate and allow the capital stock to adjust endogenously. What is missing is the direct link between investment and capital, and an explicit modelling of the mechanism by which expectations are formed.

The same cannot be said for imperfect competition. To see that, we should first acknowledge that perfect competition in a CGE model is not in fact really perfect in the strict sense. A perfectly competitive market has an infinite number of potential purchasers at the given price. In a simulation of a CGE model, an outward shift in the supply curve will impact on income, other factor markets, other commodity markets, the balance of payments etc., resulting in various shifts in the demand curve representing consumer behaviour in the original market. Therefore the 'effective' demand curve, which represents the link between the old and new equilibria following the initial supply shock, will only be horizontal by coincidence. Other

than through this mechanism, imperfect competition is entirely absent from the current version of the IMA*GE* model. In summary, while the treatment of capital accumulation within a static model is somewhat clumsy, it is present. A mechanism which recognises imperfect competition is, however, entirely absent. We believe that while the representation of agriculture as perfectly competitive is appropriate, a similar representation of other upstream and down-stream industries is not, though is probably adequate for most purposes.

One clear feature of chapter 7 was the importance of an adequate modelling of the initial impulse. CGE models such as IMA*GE* will never have the credibility of their more flexible partial equilibrium cousins in this regard, but efforts can be made to greatly improve the implementation of real world scenarios into the model.

In particular, much greater effort could be made to independently measure the key behavioural elasticities of the model, particularly the Armington elasticities. As shown in the sensitivity analysis in Chapter 4, the simulation results seem to be very sensitive to these values.

Finally, one obvious area whereby the model could be extended is into the cost of implementing various measures aimed at addressing environmental issues such as nitrate levels, protection of ground water etc. Most obviously, the model could be extended to measure the impact of various reforms aimed at reducing green house gases, a third of which in Ireland is produced on the farm.

8.3 Concluding Comments

This thesis represents a significant development in the application of CGE models to measuring the impact of policy decisions to the Irish economy. Firstly, a CGE model of Ireland now exists at a much more disaggregated industrial level, and which explicitly accounts for multiple labour occupations, land (soil) types, household types and export destinations. It also incorporates a careful treatment of margin commodities that recognises their role as complements rather than potential substitutes. The thesis also projects the base data set forward to produce a fully

consistent model for 1998 based on published data, as well as applying macro forecasts to produce data sets for each from 1999 – 2005. This is a key advance of this thesis, the development of a set of procedures that can be used to update a SAM database without a full set of data for the chosen year, as is typically required. This delay in waiting for some limited elements of the data results in an inordinate delay in producing SAM datasets. The model, by producing a mechanism that additional information can be added in a Bayesian sense to a dataset which already embodies what had previously been known about the target year, will greatly enhance the ability of input-output and CGE modelers to provide up to date analysis for policy makers.

By subdividing the general equilibrium results into those which would be 'picked up' by a partial equilibrium model and those that would not, we have shown that not only is the model important for analysing the economy wide impact of a change in one sector of the economy, but also that the simulated result for the industry which is the original source of the shock is also very significant. This discovery, and the fact that great care had to be taken in actually implementing a simulation leads us to believe that a general equilibrium model is most powerful when used to augment a detailed partial equilibrium simulation. On its own, the precision of the initial shock applied to the relatively clumsy general equilibrium model is frequently inadequate, while a partial equilibrium model on its own ignores the feedback terms which are shown here to be so important.

Much effort was also expended in ensuring an adequate modeling of the principal intervention mechanisms which together form the Common Agricultural Policy. In terms of the MacSharry reforms, the model results show that the aggregate affect of all the components of the reforms indicate that in the short run, household consumption rises due to the increased direct payments, while all the other components of real consumption are largely unaffected. The price of exports decreases significantly due to the fall in value of agricultural produce. This induces a devaluation which increases the output of industries which are heavily export orientated – i.e. manufacturing industries. Therefore labour switches from

agriculture to manufacturing. The price of labour in the short run increase by 0.13% in aggregate, while the price of capital, which is immobile in this time frame, decreases by over 1%.

The main feature of the long run simulation is that most of the impact of both the beef price decrease and increase in subsidies is to land. What happens in the beef price simulation results is that there is a very sharp fall in output of cattle, as capital and labour and all the other inputs that are used to produce cattle are put to more profitable uses. The increasingly cheap factor of production land is substituted for these other commodities. In the long run, what is also notable is that the decline in the price of beef results in a decrease in our terms of trade. This induces a flight of capital and labour, which translates into a fall in output which impacts on all the consumption aggregates. An odd result is that real investment falls by much less than the other aggregates, which can be explained by the fact that the big investors in the model are in manufacturing. A relative increase in demand for manufacturing capital in the model increases investment, even though aggregate capital falls by more. The rise in the importance of investment is at the expense of household consumption which falls further than disposable income. The increase in direct payments simulation on the other hand results in a surge in household consumption, which cancels out some of the increase in exports evident from the price simulation. The increased spending power bids up the price of non-tradeables, resulting in a significant appreciation in the currency (0.06%). The increased demand is met by an increase in capital and labour.

In modeling the Agenda 2000 reforms of the Common Agricultural Policy, a striking feature of the results was the extent to which the policy changes which switched from price support to direct support resulted in increased demand for land, particularly good quality land. This seems to be borne out in practice, with land prices generally rising quickly, even farm land which has little or no prospect of being developed for housing. What was noticeable also was the fact that even the price of land of very limited use raised because of the simulation results. This indicates that many of the policies in relation to farming (Agenda 2000 reforms,

REPS and forestry subsidies) seem to be competing with each other for land, thus driving up the price. In terms of a breakdown of the measures introduced in the Agenda 2000 reform package, many of the effects of the fall in the beef price are directly offset by the increased direct payments. An example of where this does not happen is with real investment, whereby the direct payments results in a decrease in real investment.

APPENDIX 1

TABLO CODE

```
!-------------------------------------------------------------------!
!                    + + +   TABLO FILE   + + +                     !
!                        Chapter 4 Version                          !
!-------------------------------------------------------------------!

! Excerpt 1 of TABLO input file: !
! Definitions of sets !

Set                                                        ! Subscript !
 COM          # Commodities #
    (C1Milk, C2Cattle, C3SheepWool, C4OtherLive, C5Cereals, C6FruitVeg,
     C7RootGreen, C8OtherCrops, C9Forestry, C10Fishing, C11PetCoal,
     C12ElecGas, C13NonMet, C14Chemicals, C15Metal, C16MeatProds,
     C17MilkProds, C18AnimFeed, C19OtherFood, C20BevTob, C21Textiles,
     C22WoodPaper, C23RubPlas, C24Construct, C25TradeMarg, C26LodgCater,
     C27Transport, C28Sheepmeat, C29Commun, C30Credit, C31OtherSers,
     C32Govment, C33Animmeat, C34Dwellings);                  ! c !

Set SRC          # Source of commodities #   (dom,imp);          ! s !
Set IND          # Industries #
    (I1Milk, I2Cattle, I3SheepWool, I4OtherLive, I5Cereals, I6FruitVeg,
     I7RootGreen, I8OtherCrops, I9Forestry, I10Fishing, I11PetCoal,
     I12ElecGas, I13NonMet, I14Chemicals, I15Metal,
     I16MeatProds, I17MilkProds, I18AnimFeed, I19OtherFood,
     I20BevTob, I21Textiles, I22WoodPaper, I23RubPlas, I24Construct,
     I25TradeMarg, I26LodgCater, I27Transport, I28Sheepmeat,
     I29Commun, I30Credit, I31OtherSers, I32Govment,
     I33Animmeat, I34Dwellings);                              ! i !

Set OCC      # Occupation types #    (O1Agri, O2Producers, O3Labourers,
O4TranComm, O5Clerical, O6Finance, O7Service, O8Proftech, O9Others); !o!

Set MAR        # Margin commodities #   (C25TradeMarg,C27Transport); ! m !

Subset MAR is subset of COM;
Set NONMAR    # Non-margin commodities # = COM - MAR;              ! n !

Set HOU        # Households # (H1Urban, H2Farm, H3Otherrural);  !h!
Set LND        # Soil Types # (L1Wideuse, L2limited, L3Vlimited); !l!

Set DES        # Export Destimations # (D1UK, D2ContEur, D3World); !d!
Set EU         # EU Export Destinations # (D1UK, D2ContEur);
Subset EU is subset of DES;
Set NON_EU    # Nonagricultural Commodities # = DES - EU;

Set Reporting  # Reporting #
    (R1Agri, R2Manuf, R3Serv);

Set R1Agri  # Agricultural Industries #
    (C1Milk, C2Cattle, C3SheepWool, C4OtherLive, C5Cereals, C6FruitVeg,
    C7RootGreen, C8OtherCrops);
Subset R1Agri is subset of COM;
```

```
Set R2Manu  # Manufacturing Industries #
    (C9Forestry, C10Fishing, C11PetCoal, C12ElecGas, C13NonMet,
    C14Chemicals, C15Metal, C16MeatProds, C17MilkProds, C18AnimFeed,
    C19OtherFood, C20BevTob, C21Textiles, C22WoodPaper, C23RubPlas);
Subset R2Manu is subset of COM;

Set R3Serv  # Service Industries #
    (C24Construct, C25TradeMarg, C26LodgCater, C27Transport,
    C28SheepMeat, C29Commun, C30Credit, C31OtherSers, C32Govment,
    C33Animmeat, C34Dwellings);
Subset R3Serv is subset of COM;

Set I1Agri  # Agricultural Industries #
    (I1Milk, I2Cattle, I3SheepWool, I4OtherLive, I5Cereals, I6FruitVeg,
    I7RootGreen, I8OtherCrops);
Subset I1Agri is subset of IND;

Set I2Manu  # Manufacturing Industries #
    (I9Forestry, I10Fishing, I11PetCoal, I12ElecGas, I13NonMet,
    I14Chemicals, I15Metal, I16MeatProds, I17MilkProds, I18AnimFeed,
    I19OtherFood, I20BevTob, I21Textiles, I22WoodPaper, I23RubPlas);
Subset I2Manu is subset of IND;

Set I3Serv  # Manufacturing Industries #
    (I24Construct, I25TradeMarg, I26LodgCater, I27Transport,I28SheepMeat,
     I29Commun, I30Credit, I31OtherSers, I32Govment, I33Animmeat,
     I34Dwellings);
Subset I3Serv is subset of IND;

! Excerpt 2 of TABLO input file: !
! Variables relating to commodity flows !

Variable
! Basic Demands for commodities (excluding margin demands) !
(all,c,COM)(all,s,SRC)(all,i,IND)  x1(c,s,i) # Inter basic demands #;
(all,c,COM)(all,s,SRC)(all,i,IND)  x2(c,s,i) # Invest basic demands #;
(all,c,COM)(all,s,SRC)(all,h,HOU)  x3(c,s,h) # Household basic demands #;
(all,c,COM)(all,s,SRC)             x3_h(c,s) # Total Basic demands #;
(all,c,COM)(all,d,DES)             x4(c,d)   # Export basic demands #;
(all,c,COM)(all,s,SRC)             x5(c,s)  # Government basic demands #;
(all,c,COM)(all,s,SRC)             a5(c,s)  # Gov basic demand shifter #;
(change) (all,c,COM)(all,s,SRC)    delx6(c,s) # Inventories demands #;
(all,c,COM)(all,s,SRC)  p0(c,s) # Basic prices by commodity and source #;

! Technical or Taste Change Variables affecting Basic Demands !
(all,c,COM)(all,s,SRC)(all,i,IND)  a1(c,s,i) # Int basic tech change #;
(all,c,COM)(all,s,SRC)(all,i,IND)  a2(c,s,i) # Inv basic tech change #;
(all,c,COM)(all,s,SRC)(all,h,HOU)  a3(c,s,h) # Hh basic taste change #;
(all,c,COM)(all,s,SRC)             f5(c,s)   # Government demand shift #;
(all,c,COM)(all,h,HOU)  w3_s(c,h)# Nominal Personal con. by commodity #;

! Margin Usage on Basic Flows !
(all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
     x1mar(c,s,i,m)# Intermediate margin demand #;
     (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
     x2mar(c,s,i,m) #Investment margin demand #;
(all,c,COM)(all,s,SRC)(all,m,MAR)(all,h,HOU) x3mar(c,s,m,h)#Hh margdem #;
(all,c,COM)(all,s,SRC)(all,m,MAR) x3mar_h(c,s,m)# Tot HH Marg demands #;
(all,c,COM)(all,m,MAR)(all,d,DES) x4mar(c,m,d)  # Exp margin demands #;
(all,c,COM)(all,s,SRC)(all,m,MAR) x5mar(c,s,m)  # Gov margin demands #;
```

```
! Technical Change in Margins Usage !
(all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
          a1mar(c,s,i,m) #Int marg tech chng#;
(all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
          a2mar(c,s,i,m)  # Invest. margin tech change #;
(all,c,COM)(all,s,SRC)(all,m,MAR) a3mar(c,s,m) # Hh marg tech change #;
(all,c,COM)(all,m,MAR)(all,d,DES) a4mar(c,m,d) # xp. marg tech change #;
(all,c,COM)(all,s,SRC)(all,m,MAR) a5mar(c,s,m) # Gov marg tech change #;

! Powers of Commodity Taxes on Basic Flows !
(all,c,COM)(all,s,SRC)(all,i,IND)  t1(c,s,i)  # Power of tax on inter. #;
(all,c,COM)(all,s,SRC)(all,i,IND)  t2(c,s,i)  # Power of tax on invest #;
(all,c,COM)(all,s,SRC)             t3(c,s)    # Power of tax on hh#;
(all,c,COM)(all,d,DES)             t4(c,d)    # Power of tax on export #;
(all,c,COM)(all,s,SRC)             t5(c,s)    # Power of tax on gov #;

! Purchaser's Prices (including margins and taxes) !
(all,c,COM)(all,s,SRC)(all,i,IND) p1(c,s,i) # Purch's price, inter. #;
(all,c,COM)(all,s,SRC)(all,i,IND) p2(c,s,i) # Purch's price, invest. #;
(all,c,COM)(all,s,SRC)(all,h,HOU) p3(c,s,h) # Purch's price, house. #;
(all,c,COM)(all,d,DES)            p4(c,d)   # Purch's price, exp £Ire #;
(all,c,COM)(all,s,SRC)            p5(c,s)   # Purch's price, govern't #;

! Nominal Intermediate Purchase (including margins and taxes) !
(all,c,COM)(all,s,SRC)(all,i,IND) w1(c,s,i) # Nominal Purchase, interm'e
#;

! Excerpt 3 of TABLO input file: !

! Variables relating to usage of labour, occupation o, in industry i !
(all,i,IND)(all,o,OCC)  x1lab(i,o)  # Employment by industry and
occupation #;
(all,i,IND)(all,o,OCC)  p1lab(i,o)  # Labour - Purchasers Prices#;
(all,i,IND)(all,o,OCC)  p0lab(i,o)  # Labour - Basic Price #;
(all,o,OCC)             p1lab_i(o)  # Aggregate Price of Labour by occ#;
(all,i,IND)             p1lab_o(i)  # Aggr' Price of Labour by industry#;
(all,i,IND)             a1lab_o(i)  # Labor augmenting tech change #;
(all,i,IND)(all,o,OCC)  f1lab(i,o)  # Wage shift variable #;

! Variables relating to usage of land !
(all,i,IND)(all,l,LND)  x1lnd(i,l)   # Use of land by Ind and Soil Type#;
(all,i,IND)(all,l,LND)  p1lnd(i,l)   # Net Price of Land #;
(all,i,IND)(all,l,LND)  p0lnd(i,l)  # Return to Landlord #;
(all,i,IND)          x1lnd_l(i)  # Use of land by Ind and Soil Type#;
(all,l,LND)             p1lnd_i(l)   # Net Price of Land #;
(all,i,IND)             p1lnd_l(i)   # Net Price of Land #;
(all,i,IND)          a1lnd_l(i)   # Land augmenting tech change for ind #;
                     a1lnd_il   # Land augmenting technical change #;

! Variables relating to usage of fixed capital in industry i !
(all,i,IND)  x1cap(i)         # Current capital stock #;
(all,i,IND)  p1cap(i)         # Net Price of capital #;
(all,i,IND)  p0cap(i)         # Return to Capitalist #;
(all,i,IND)  a1cap(i)         # Capital augmenting technical change #;

! Variables relating to "Other Costs" !
(all,i,IND)        x1oct(i)  # Demand for "other cost" tickets #;
(all,i,IND)        p1oct(i)  # Price of "other cost" tickets #;
(all,i,IND)        a1oct(i)  # "other cost" ticket augmenting tech.
change#;
(all,i,IND)        f1oct(i)  # Shift in price of "other cost" tickets #;
```

```
! Variables relating to commodity supplies, import duties and stocks !
(all,c,COM)(all,i,IND)  q1(c,i)      # Output by commodity and industry #;
(all,c,COM)             t0imp(c)     # Power of tariff #;
(Change)(all,c,COM)(all,s,SRC)  fx6(c,s)     # Shifter on rule for stocks
#;

! Excerpt 4 of TABLO input file: !
! Variables describing composite commodities !

! Demands for import/domestic commodity composites !
(all,c,COM)(all,i,IND)  x1_s(c,i)  # Inter. use of imp/dom composite #;
(all,c,COM)(all,i,IND)  w1_s(c,i)  # Nom Int use of imp/dom composite #;
(all,c,COM)   w1_si_agri(c)  # Nom Int use of imp/dom composite in agri#;
(all,i,I2MANU)      w1_manu_serv(i) # Nom Int use of services in manu#;
(all,i,I2MANU)      w1_manu_manu(i) # Nom Int use of manu in manu#;
(all,c,COM)(all,i,IND)  x2_s(c,i)  # Inv use of imp/dom composite #;
(all,c,COM)(all,h,HOU)  x3_s(c,h)  # Hhuse of imp/dom composite #;
(all,c,COM)(all,h,HOU)  x3lux(c,h) # Household - supernumerary demands #;
(all,c,COM)(all,h,HOU)  x3sub(c,h) # Household - subsistence demands #;

! Effective Prices of import/domestic commodity composites !
(all,c,COM)(all,i,IND)  p1_s(c,i)  # Price, int imp/dom composite #;
(all,c,COM)(all,i,IND)  p2_s(c,i)  # Price, inv imp/dom composite #;
(all,c,COM)(all,h,HOU)  p3_s(c,h)  # Price, hh imp/dom composite #;

! Technical or Taste Change Variables for import/domestic composites !
(all,c,COM)(all,i,IND)  a1_s(c,i) # Tech change, int imp/dom composite #;
(all,c,COM)(all,i,IND)  a2_s(c,i) # Tech change, inv imp/dom composite #;
(all,c,COM)(all,h,HOU)  a3_s(c,h) # Taste change, hh imp/dom comp #;
(all,h,HOU)             a3tot(h) # Taste change, hh imp/dom comp #;
(all,c,COM)(all,h,HOU)  a3lux(c,h)# Taste change, super demands #;
(all,c,COM)(all,h,HOU)  a3sub(c,h)# Taste change, subsistence demands #;

! Excerpt 5 of TABLO input file: !
! Miscellaneous vector variables !

Variable
(all,h,HOU)  q(h)              # Number of Households #;
(All,h,HOU) utility(h)         # Utility per Household #;
(All,h,HOU) w3lux(h)           # Nominal Supernumerary Expenditure #;
(All,h,HOU) w3tot(h)           # Nominal Household Consumption #;
(All,h,HOU) f3tot(h)           # Shift Term For Consumption #;

(All,h,HOU) p3tot(h)           # Consumer Price Index #;
(All,h,HOU)  x3tot(h)           # Real Household Consumption #;
(all,i,IND)  a1prim(i)         # All factor augmenting technical change #;
f1prim_i  # All factor technical change for purpose of Step 1.4#;
(all,i,IND)  a1tot(i)          # All input augmenting technical change #;
(all,i,IND)  a2tot(i)          # Neutral technical change - investment #;
(all,i,IND)  employ(i)         # Employment by industry #;
(all,c,COM)  f0tax_s(c)        # General sales tax shifter #;
(all,o,OCC)  f1lab_i(o)        # Occupation-specific wage shifter #;
(all,i,IND)  f1lab_o(i)        # Industry-specific wage shifter #;
(all,c,COM)(all,d,DES) f4p(c,d) # Price (upw'd) shift in exp demand #;
(all,c,COM)(all,d,DES) f4q(c,d) # Quantity (right) shift in exp dem #;
(All,c,COM)  p0com(c)          # Output price of locally-produced comm #;
(all,c,COM)  p0dom(c)          # Basic price of dom goods = p0(c,"dom") #;
(all,c,COM)  p0imp(c)          # Basic price of imp goods = p0(c,"imp") #;
(all,i,IND)  p1prim(i)         # Effective £ of prim factor composite #;
(all,i,IND)  p1tot(i)          # Average input/output price #;
```

```
(all,i,IND)  p2tot(i)          # Cost of unit of capital #;
(All,c,COM)(all,d,DES)  pe(c,d) # Basic price of export commodity #;
(all,c,COM)  pf0cif(c)         # C.I.F. foreign currency import prices #;
(all,c,COM)  x0com(c)          # Output of commodities #;
(all,c,COM)  x0dom(c)          # Output of commodities for local market #;
(all,c,COM)  x0imp(c)          # Total supplies of imported goods #;
(all,o,OCC)  x1lab_i(o)        # Employment by occupation #;
(all,l,lnd)  x1lnd_i(l)        # Use of land by soil type #;
(all,i,IND)  x1lab_o(i)        # Effective labour input #;
(all,i,IND)  w1lab_o(i)        # Industry Wage Bill #;
(all,i,IND)  x1prim(i)         # Primary factor composite #;
(all,i,IND)  x1tot(i)          # Activity level or value-added #;
(all,i,IND)  w1tot(i)       # Nominal Activity level or value-added #;
(all,i,IND)  x2tot(i)          # Investment by using industry #;
(all,i,IND) w1sub_cs(i)  # Aggregate payments by way of subs to ag #;

! Excerpt 6 of TABLO input file: !
! Scalar or macro variables !

Variable
(change) delB     # (Balance of trade)/GDP #;
employ_i          # Aggregate employment: wage bill weights #;
f1lab_io          # Overall wage shifter #;
f1tax_csi         # Uniform % change in powers of taxes on int usage #;
f2tax_csi         # Uniform % change in powers of taxes on investment #;
f3tax_cs          # Uniform % change in powers of taxes on hh usage #;
f3tot_h           # Overall Shift Term For Consumption#;
f4tax_trad_d      # Uniform % change in powers of taxes on tradtnl exp #;
f5tax_cs          # Uniform % change in powers of taxes on gov usage #;
f5tot             # Overall shift term for government demands #;
f5tot2            # Ratio between f5tot and x3tot #;
p0cif_c           # Imports price index, C.I.F., £Ire #;
p0gdpexp          # GDP price index, expenditure side #;
p0imp_c           # Duty-paid imports price index, £Ire #;
p0realdev         # Real devaluation #;
p0toft            # Terms of trade #;
p1cap_i           # Average capital rental #;
p0lab_io          # Average nominal wage #;
p2tot_i           # Aggregate investment price index #;
p3tot_h           # Consumer price index #;
p3tot_hs           # Consumer price index - Services#;
p4tot_d           # Exports price index #;
p5tot             # Government price index #;
p6tot             # Inventories price index #;
phi               # Exchange rate, £Ire/$world #;
q_h               # Total Number of households #;
realwage          # Average real wage #;
w0cif_c           # C.I.F. £Ire value of imports #;
(all,c,COM)     w0cif(c)      # C.I.F. £Ire value of imports #;
w0gdpexp          # Nominal GDP from expenditure side #;
w0gdpinc          # Nominal GDP from income side #;
x0gdpinc          # Real GDP from income side #;
p0gdpinc          # Price Index GDP from income side #;
w0imp_c           # Value of imports plus duty #;
w0tar_c           # Aggregate tariff revenue #;
x0tar_c           # Aggregate real tariff revenue #;
w0tax_csi         # Aggregate revenue from all indirect taxes #;
x0tax_csi         # Aggregate real revenue from all indirect taxes #;
w1cap_i           # Aggregate payments to capital #;
w1lab_io          # Aggregate payments to labour #;
x1lab_io          # Aggregate real payments to labour #;
```

```
w1lnd_il        # Aggregate payments to land #;
x1lnd_il        # Aggregate real payments to land #;
w1oct_i         # Aggregate "other cost" ticket payments #;
x1oct_i         # Aggregate real "other cost" ticket payments #;
w1tax_csi       # Aggregate revenue from indirect taxes on intermediate
#;
w1sub_csi       # Aggregate payments by way of subsidies to ag #;
w2tax_csi       # Aggregate revenue from indirect taxes on investment #;
w2tot_i         # Aggregate nominal investment #;
w3tax_csh       # Aggregate revenue from indirect taxes on households #;
w3tot_h         # Nominal total household consumption #;
w4tax_cd        # Aggregate revenue from indirect taxes on export #;
w4tot_d         # £Ire border value of exports #;
w5tax_cs        # Aggregate revenue from indirect taxes on government #;
x1tax_csi       # Aggreg'e real revenue from indirect taxes on inter. #;
x2tax_csi       # Aggre'e real revenue from indirect taxes on invest. #;
x3tax_csh       # Aggr'e real revenue from indirect taxes on houses #;
x4tax_cd        # Aggr'e real revenue from indirect taxes on export #;
x5tax_cs        # Aggr'te real revenue from indirect taxes on gover #;
w5tot           # Aggregate nominal value of government demands #;
w6tot           # Aggregate nominal value of inventories #;
x0cif_c         # Import volume index, C.I.F. weights #;
x0gdpexp        # Real GDP from expenditure side #;
x0imp_c         # Import volume index, duty-paid weights #;
x1cap_i         # Aggregate capital stock, rental weights #;
x1prim_i        # Aggregate output: value-added weights #;
x2tot_i         # Aggregate real investment expenditure #;
x3tot_h         # Real household consumption #;
x4tot_d         # Export volume index #;
x5tot           # Aggregate real government demands #;
x6tot           # Aggregate real inventories #;

! Excerpt 7 of TABLO input file: !
! Data coefficients relating to basic commodity flows !

File  H2DATA  # Data file #;

Coefficient  ! Basic Flows of Commodities!
 (all,c,COM)(all,s,SRC)(all,i,IND) V1BAS(c,s,i) #Inter basic flows #;
 (all,c,COM)(all,s,SRC)(all,i,IND)  V2BAS(c,s,i)#Invest basic flows #;
 (all,c,COM)(all,s,SRC)(all,h,HOU)  V3BAS(c,s,h)#Household basic flows #;
 (all,c,COM)(all,d,DES)             V4BAS(c,d) #Export basic flows #;
 (all,c,COM)(all,s,SRC)             V5BAS(c,s) #Govern basic flows #;
 (all,c,COM)(all,s,SRC)             V6BAS(c,s) #Inventories basic flows #;
Read
 V1BAS from file H2DATA header "1BAS";
 V2BAS from file H2DATA header "2BAS";
 V3BAS from file H2DATA header "3BAS";
 V4BAS from file H2DATA header "4BAS";
 V5BAS from file H2DATA header "5BAS";
 V6BAS from file H2DATA header "6BAS";
Update
 (all,c,COM)(all,s,SRC)(all,i,IND)  V1BAS(c,s,i)  = p0(c,s)*x1(c,s,i);
 (all,c,COM)(all,s,SRC)(all,i,IND)  V2BAS(c,s,i)  = p0(c,s)*x2(c,s,i);
 (all,c,COM)(all,s,SRC)(all,h,HOU)  V3BAS(c,s,h)  = p0(c,s)*x3(c,s,h);
 (all,c,COM)(all,d,DES)             V4BAS(c,d)    = pe(c,d)*x4(c,d);
 (all,c,COM)(all,s,SRC)             V5BAS(c,s)    = p0(c,s)*x5(c,s);

! Why not just define x6(c,s) and be done with it?  Instead, we go to all
the effort of defining a levels variable.  The reason this is done is
because change in inventories can be negative!
```

```
Coefficient (all,c,COM)(all,s,SRC) LEVP0(c,s) # Levels basic prices #;
Formula (Initial) (all,c,COM)(all,s,SRC) LEVP0(c,s) = 1; !arbitrary
setting!
Update    (all,c,COM)(all,s,SRC) LEVP0(c,s) = p0(c,s);
(change) (all,c,COM)(all,s,SRC)
        V6BAS(c,s) = V6BAS(c,s)*p0(c,s)/100 + LEVP0(c,s)*delx6(c,s);

Coefficient  ! Margin Flows!
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
             V1MAR(c,s,i,m)  # Intermediate margins #;
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
             V2MAR(c,s,i,m)  # Investment margins #;
 (all,c,COM)(all,s,SRC)(all,m,MAR)(all,h,HOU)
             V3MAR(c,s,m,h)  # Households margins #;
 (all,c,COM)(all,m,MAR)(all,d,DES)  V4MAR(c,m,d) # Export margins #;
 (all,c,COM)(all,s,SRC)(all,m,MAR)  V5MAR(c,s,m) # Government margins #;
Read
 V1MAR from file H2DATA header "1MAR";
 V2MAR from file H2DATA header "2MAR";
 V3MAR from file H2DATA header "3MAR";
 V4MAR from file H2DATA header "4MAR";
 V5MAR from file H2DATA header "5MAR";
Update
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
                 V1MAR(c,s,i,m)  = p0dom(m)*x1mar(c,s,i,m);
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
                 V2MAR(c,s,i,m)  = p0dom(m)*x2mar(c,s,i,m);
 (all,c,COM)(all,s,SRC)(all,m,MAR)(all,h,HOU)
                 V3MAR(c,s,m,h)   = p0dom(m)*x3mar(c,s,m,h);
 (all,c,COM)(all,m,MAR)(all,d,DES)
                 V4MAR(c,m,d)     = p0dom(m)*x4mar(c,m,d);
 (all,c,COM)(all,s,SRC)(all,m,MAR)
                 V5MAR(c,s,m)     = p0dom(m)*x5mar(c,s,m);

! Excerpt 8 of TABLO input file: !
! Data coefficients relating to commodity taxes !

Coefficient TINY # Small number to prevent singular matrix #;
Formula TINY = 0.000000001;

Coefficient  ! Taxes & Subsidies on Basic Flows!
 (all,c,COM)(all,s,SRC)(all,i,IND) V1TAX(c,s,i) #Taxes on intermediate #;
 (all,c,COM)(all,s,SRC)(all,i,IND)  V2TAX(c,s,i) # Taxes on investment #;
 (all,c,COM)(all,s,SRC)(all,h,HOU)  V3TAX(c,s,h) # Taxes on households #;
 (all,c,COM)(all,d,DES)             V4TAX(c,d)   # Taxes on export #;
 (all,c,COM)(all,s,SRC)             V5TAX(c,s)   # Taxes on government #;

Read
 V1TAX from file H2DATA header "1TAX";
 V2TAX from file H2DATA header "2TAX";
 V3TAX from file H2DATA header "3TAX";
 V4TAX from file H2DATA header "4TAX";
 V5TAX from file H2DATA header "5TAX";

Update (change) (all,c,COM)(all,s,SRC)(all,i,IND)
  V1TAX(c,s,i) = V1TAX(c,s,i)* [x1(c,s,i) + p0(c,s)]/100 +
     [V1BAS(c,s,i)+V1TAX(c,s,i)]*t1(c,s,i)/100;
Update (change) (all,c,COM)(all,s,SRC)(all,i,IND)
  V2TAX(c,s,i) = V2TAX(c,s,i)* [x2(c,s,i) + p0(c,s)]/100 +
     [V2BAS(c,s,i)+V2TAX(c,s,i)]*t2(c,s,i)/100;
Update (change) (all,c,COM)(all,s,SRC)(all,h,HOU)
```

```
  V3TAX(c,s,h) = V3TAX(c,s,h)* [x3(c,s,h) + p0(c,s)]/100 +
    [V3BAS(c,s,h)+V3TAX(c,s,h)]*t3(c,s)/100;

Update (change) (all,c,COM)(all,s,SRC)
  V5TAX(c,s) = V5TAX(c,s)*[x5(c,s) + p0(c,s)]/100 +
    [V5BAS(c,s)+V5TAX(c,s)]*t5(c,s)/100;


! Excerpt 9 of TABLO input file: !
! Data coefficients relating to primary-factor flows !

  ! Primary Factor and Other Industry costs!
Coefficient(all,i,IND)              V1CAP(i)    # Value Added by Capital #;
Coefficient(all,i,IND)              V0CAP(i)    # Received By Capitalist #;

 (all,i,IND)(all,o,OCC)  V1LAB(i,o)  # Value Added by Labour #;
 (all,i,IND)(all,o,OCC)  V0LAB(i,o)  # Received By Labourer #;
 (all,i,IND)(all,l,LND)  V1LND(i,l)  # Value Added by Land #;
 (all,i,IND)(all,l,LND)  V0LND(i,l) # Received By Landowner #;
 (all,i,IND)             V1OCT(i)    # Other cost tickets #;

Read
 V0CAP from file H2DATA header "1CAP";
 V0LAB from file H2DATA header "1LAB";
 V0LND from file H2DATA header "1LND";
 V1OCT from file H2DATA header "1OCT";

Update
 (all,i,IND)             V0CAP(i)   =   p0cap(i)*x1cap(i);
 (all,i,IND)(all,o,OCC)  V0LAB(i,o) =   p0lab(i,o)*x1lab(i,o);
 (all,i,IND)(all,l,LND)  V0LND(i,l) =   p0lnd(i,l)*x1lnd(i,l);
 (all,i,IND)             V1OCT(i)   =   p1oct(i)*x1oct(i);

! Excerpt 9.5 of TABLO input file: !
! Data coefficients relating to Subsidies !
Variable
(all,i,IND)                     t1cap(i)    # Power of subsidy on capital #;
(all,i,IND)(all,o,OCC)          t1lab(i,o)  # Power of subsidy on labour #;
(all,i,IND)(all,l,LND)          t1lnd(i,l)  # Power of subsidy on land#;
(all,c,COM)(all,d,DES)          t4exp(c,d)  # Power of subsidy on exports #;

Variable
(all,i,IND)                     f_t1cap(i)    # Power of subsidy on cap #;
(all,i,IND)(all,o,OCC)          f_t1lab(i,o)  # Power of subsidy on labour #;
(all,i,IND)(all,l,LND)          f_t1lnd(i,l)  # Power of subsidy on land#;
(all,c,COM)(all,d,DES)          f_t4exp(c,d)  # Power of sub on exports #;

Variable
(all,i,IND)      f_subsidy(i) # Power of sub - uniform across all
subsidies#;
                 f_t1cap_i    # Power of sub on capital - uniform #;
                 f_t1lab_io   # Power of sub on labour - uniform #;
(all,o,OCC)      f_t1lab_i(o) #Power of sub on lab - uniform over ind #;
(all,i,ind)      f_t1lab_o(i) # Power of sub on lab - uniform over occ #;
                 f_t1lnd_il   # Power of sub on land - uniform #;
(all,l,LND)      f_t1lnd_i(l) # Power of sub on land - uniform over ind#;
(all,i,IND)      f_t1lnd_l(i) # Power of sub on land - uniform over lnd#;
                 f_t4exp_cd   # Power of sub on exports-uniform #;
(all,d,DES)      f_t4exp_c(d) # Power of sub on exp-uniform over com #;
(all,c,COM)      f_t4exp_d(c) # Power of sub on exp - uniform over des #;
```

```
Coefficient  ! Primary Factor and Other Industry costs!
 (all,i,IND)                    S1CAP(i)     # Capital Subsidy #;
 (all,i,IND)(all,o,OCC)         S1LAB(i,o)   # Labour Subsidy #;
 (all,i,IND)(all,l,LND)         S1LND(i,l)   # Land Subsidy #;
 (all,c,COM)(all,d,DES)         S4EXP(c,d)   # Export Subsidy #;

Read  !Reading in subsidy figures!
 S1CAP from file H2DATA header "EUCP";
 S1LAB from file H2DATA header "EULB";
 S1LND from file H2DATA header "EULN";
 S4EXP from file H2DATA header "EUEX";

Update (change)
(all,i,IND)                  S1CAP(i) = S1CAP(i)*{x1cap(i) + p0cap(i)}/100+
                                        [V0CAP(i) - S1CAP(i)]*t1cap(i)/100;
Update (change)
(all,i,IND)(all,o,OCC) S1LAB(i,o) = S1LAB(i,o)* {x1lab(i,o) +
p0lab(i,o)}/100 +
                                        [V0LAB(i,o) - S1LAB(i,o)]*t1lab(i,o)/100;
Update (change)
(all,i,IND)(all,l,LND) S1LND(i,l) = S1LND(i,l)* {x1lnd(i,l) +
p0lnd(i,l)}/100 +
                                        [V0LND(i,l) - S1LND(i,l)]*t1lnd(i,l)/100;
Update (change) (all,c,COM)(all,d,DES)
 S4EXP(c,d)  = S4EXP(c,d)* [x4(c,d) + pe(c,d)]/100 +
   +[V4BAS(c,d) + V4TAX(c,d) - S4EXP(c,d)]*t4exp(c,d)/100;
Update (change) (all,c,COM)(all,d,DES)
  V4TAX(c,d) = V4TAX(c,d)* [x4(c,d) + pe(c,d)]/100 +
    [V4BAS(c,d) + V4TAX(c,d) - S4EXP(c,d)]*t4(c,d)/100;

Formula
(all,i,IND)                  V1CAP(i)    = V0CAP(i)    - S1CAP(i);
(all,i,IND)(all,o,OCC)       V1LAB(i,o) = V0LAB(i,o) - S1LAB(i,o);
(all,i,IND)(all,l,LND)       V1LND(i,l) = V0LND(i,l) - S1LND(i,l);

Equation E_p1cap  # Purchasers prices - capital #
(all,i,IND)                  p1cap(i)    = p0cap(i) - t1cap(i);
Equation E_p1lab  # Purchasers prices - labour #
(all,i,IND)(all,o,OCC) p1lab(i,o) = p0lab(i,o) - t1lab(i,o);
Equation E_p1lnd  # Purchasers prices - land #
(all,i,IND)(all,l,LND) p1lnd(i,l) = p0lnd(i,l) - t1lnd(i,l);

Equation E_t1cap       # Power of subsidy - capital #
(all,i,IND)       t1cap(i) = f_subsidy(i) + f_t1cap_i + f_t1cap(i);
Equation E_t1lab       # Power of subsidy - labour #
(all,i,IND)(all,o,OCC) t1lab(i,o) = f_subsidy(i)
                  + f_t1lab(i,o) + f_t1lab_i(o) + f_t1lab_o(i) +
f_t1lab_io;
Equation E_t1lnd       # Power of subsidy - land #
(all,i,IND)(all,l,LND)       t1lnd(i,l) = f_subsidy(i)
                  + f_t1lnd(i,l) + f_t1lnd_i(l)+ f_t1lnd_l(i)+f_t1lnd_il;

Equation E_t4exp       # Power of subsidy - exports #
(all,c,com)(all,d,DES)
t4exp(c,d) =       f_t4exp(c,d) + f_t4exp_c(d)+ f_t4exp_d(c)+f_t4exp_cd;

! Excerpt 10 of TABLO input file: !
! Data coefficients relating to commodity outputs and import duties !

Coefficient (all,c,COM)(all,i,IND) MAKE(c,i) # Multiproduction matrix #;
```

```
Read MAKE from file H2DATA header "MAKE";
Update (all,c,COM)(all,i,IND) MAKE(c,i)= p0com(c)*q1(c,i);

Coefficient (all,c,COM) V0TAR(c)  # Tariff revenue #;
Read V0TAR from file H2DATA header "0TAR";
Coefficient (all,c,COM) V0IMP(c) # Total basic-value imports of good c #;
! V0IMP(c) is needed to update V0TAR: it is declared now and defined
later !
Update (change)  (all,c,COM)
    V0TAR(c) = V0TAR(c)*[x0imp(c)+pf0cif(c)+phi]/100 +
V0IMP(c)*t0imp(c)/100;

! Excerpt 11 of TABLO input file: !
! Aggregates and shares of flows at purchasers' prices !

Coefficient ! Flows at Purchasers prices !
(all,c,COM)(all,s,SRC)(all,i,IND) V1PUR(c,s,i) #Inter purch. value #;
(all,c,COM)(all,s,SRC)(all,i,IND) V2PUR(c,s,i)#Investment purch. value #;
(all,c,COM)(all,s,SRC)(all,h,HOU) V3PUR(c,s,h)#Households purch. value #;
 (all,c,COM)(all,d,DES)          V4PUR(c,d) # Export purch. value #;
 (all,c,COM)(all,s,SRC)          V5PUR(c,s) # Government purch. value #;
Formula
 (all,c,COM)(all,s,SRC)(all,i,IND)
   V1PUR(c,s,i)  = V1BAS(c,s,i) + V1TAX(c,s,i) + sum{m,MAR,
V1MAR(c,s,i,m)};
 (all,c,COM)(all,s,SRC)(all,i,IND)
  V2PUR(c,s,i)  = V2BAS(c,s,i)  + V2TAX(c,s,i)  + sum{m,MAR,
V2MAR(c,s,i,m) };
 (all,c,COM)(all,s,SRC)(all,h,HOU)
  V3PUR(c,s,h)  = V3BAS(c,s,h)  + V3TAX(c,s,h)  + sum{m,MAR,
V3MAR(c,s,m,h) };
 (all,c,COM)(all,d,DES)
  V4PUR(c,d)  = V4BAS(c,d) -S4EXP(c,d) +V4TAX(c,d)
+sum{m,MAR,V4MAR(c,m,d) };
 (all,c,COM)(all,s,SRC)
  V5PUR(c,s)    = V5BAS(c,s)    + V5TAX(c,s) + sum{m,MAR, V5MAR(c,s,m) };

Coefficient ! Flows at Purchaser's prices: Domestic + Imported Totals !
 (all,c,COM)(all,i,IND)     V1PUR_S(c,i) # Dom+imp inter. purch. value #;
 (all,c,COM)(all,i,IND)     V2PUR_S(c,i) # Dom+imp invest. purch. value
#;
 (all,c,COM)                V1PUR_SI(c)  # Dom+imp inter. purch. value #;
 (all,c,COM)                V2PUR_SI(c)  # Dom+imp investm't purch. value
#;
 (all,c,COM)(all,h,HOU)     V3PUR_S(c,h) # Dom+imp house. purch. value #;
Formula
 (all,c,COM)(all,i,IND)     V1PUR_S(c,i)  = sum{s,SRC, V1PUR(c,s,i) };
 (all,c,COM)(all,i,IND)     V2PUR_S(c,i)  = sum{s,SRC, V2PUR(c,s,i) };
 (all,c,COM)                V1PUR_SI(c)   = sum{i,IND, V1PUR_S(c,i) };
 (all,c,COM)                V2PUR_SI(c)   = sum{i,IND, V2PUR_S(c,i) };
 (all,c,COM) (all,h,HOU)    V3PUR_S(c,h)  = sum{s,SRC, V3PUR(c,s,h) };

Coefficient ! Source Shares in Flows at Purchaser's prices !
(all,c,COM)(all,s,SRC)(all,i,IND) S1(c,s,i) #Intermediate source share #;
(all,c,COM)(all,s,SRC)(all,i,IND)  S2(c,s,i) #Investment source shares #;
(all,c,COM)(all,s,SRC)(all,h,HOU)  S3(c,s,h) #Households source shares #;
Zerodivide Default 0.5;
Formula
 (all,c,COM)(all,s,SRC)(all,i,IND)  S1(c,s,i)  = V1PUR(c,s,i) /
V1PUR_S(c,i);
 (all,c,COM)(all,s,SRC)(all,i,IND)  S2(c,s,i)  = V2PUR(c,s,i) /
```

```
V2PUR_S(c,i);
 (all,c,COM)(all,s,SRC)(all,h,HOU)  S3(c,s,h)  = V3PUR(c,s,h) /
V3PUR_S(c,h);
Zerodivide Off;

! Excerpt 12 of TABLO input file: !
! Cost and usage aggregates !

Coefficient  ! Industry-Specific Cost Totals !
 (all,i,IND)  V1LAB_O(i)  # Total labour bill in industry i #;
 (all,i,IND)  V0LAB_O(i)   # Total labour bill in industry i #;
 (all,o,OCC)  V1LAB_I(o)  # Total wages, occupation o #;
 (all,o,OCC)  V0LAB_I(o)  # Total wages, occupation o #;

 (all,i,IND)  V1LND_L(i)  # Total rent bill in industry i#;
 (all,i,IND)  V0LND_L(i)   # Total rent bill in industry i#;
 (all,l,LND)  V1LND_I(l)  # Total rent bill in land type l#;
 (all,l,LND)  V0LND_I(l)  # Total rent bill in land type l#;

 (all,i,IND)  V1PRIM(i)   # Total factor input to industry i#;
 (all,i,IND)  S1LAB_O(i)  # Total Labour Subsidy by Industry #;
 (all,i,IND)  S1LND_L(i)  # Total Land Subsidy by Industry #;
 (all,i,IND)  V1TOT(i)    # Total cost of industry i #;
 (all,i,IND)  V2TOT(i)    # Total capital created for industry i #;
 (all,c,COM)(all,s,SRC)(all,m,MAR) V3MAR_H(c,s,m)# For use below #;
 (all,c,COM)(all,s,SRC)            V3BAS_H(c,s) # For use below #;

Formula
 (all,i,IND)  V1LAB_O(i) = sum{o,OCC,  V1LAB(i,o) };
 (all,i,IND)  V0LAB_O(i) = sum{o,OCC,  V0LAB(i,o) };
 (all,i,IND)  V1LND_L(i) = sum{l,LND,  V1LND(i,l) };
 (all,i,IND)  V0LND_L(i)  = sum{l,LND, V0LND(i,l) };
 (all,o,OCC)  V1LAB_I(o)  = sum{i,IND,  V1LAB(i,o) };
 (all,o,OCC)  V0LAB_I(o)  = sum{i,IND,  V0LAB(i,o) };
 (all,i,IND)  V1PRIM(i)   = V1LAB_O(i)+ V1CAP(i) + V1LND_L(i);

 (all,i,IND)  S1LAB_O(i)  = sum{o,OCC,  S1LAB(i,o) };
 (all,i,IND)  S1LND_L(i)  = sum{l,LND,  S1LND(i,l) };

 (all,i,IND)  V1TOT(i) = V1PRIM(i) + V1OCT(i)+ sum{c,COM, V1PUR_S(c,i) };
 (all,i,IND)  V2TOT(i)    = sum{c,COM,  V2PUR_S(c,i) };
 (all,l,LND)  V1LND_I(l)  = sum{i,IND,  V1LND(i,l) };
 (all,l,LND)  V0LND_I(l)  = sum{i,IND,  V0LND(i,l) };
 (all,c,COM)(all,s,SRC)(all,m,MAR)
V3MAR_H(c,s,m)=sum(h,HOU,V3MAR(c,s,m,h));
 (all,c,COM)(all,s,SRC)            V3BAS_H(c,s)=sum(h,HOU,V3BAS(c,s,h));

Coefficient (all,c,COM) MARSALES(c) # Total usage for margins purposes #;
Formula (all,m,MAR) MARSALES(m) =
   sum{c,COM, sum[d,DES,V4MAR(c,m,d)] +
              sum{s,SRC, V3MAR_H(c,s,m) + V5MAR(c,s,m) +
              sum{i,IND, V1MAR(c,s,i,m) + V2MAR(c,s,i,m) }}};
Formula (all,n,NONMAR) MARSALES(n) = 0.0;

Coefficient (all,c,COM) DOMSALES(c) # Total sales to local market #;
Formula (all,c,COM) DOMSALES(c) = sum{i,IND, V1BAS(c,"dom",i) +
V2BAS(c,"dom",i)}+V3BAS_H(c,"dom")+V5BAS(c,"dom")+V6BAS(c,"dom")+
MARSALES(c);

Coefficient (all,c,COM) SALES(c) # Total sales of domestic commodities #;
Formula (all,c,COM) SALES(c) = DOMSALES(c)+ Sum{d,DES,V4BAS(c,d)};
```

```
Formula (all,c,COM) V0IMP(c) = sum{i,IND, V1BAS(c,"imp",i) +
V2BAS(c,"imp",i) } + V3BAS_H(c,"imp") + V5BAS(c,"imp") + V6BAS(c,"imp");

Coefficient (all,c,COM) V0CIF(c) # Total ex-duty imports of good c #;
Formula (all,c,COM) V0CIF(c) = V0IMP(c) - V0TAR(c);

! Excerpt 13 of TABLO input file: !
! Income-Side Components of GDP !

Coefficient ! Total indirect tax revenues !
 V1TAX_CSI  # Total intermediate tax revenue #;
 V2TAX_CSI  # Total investment tax revenue #;
 V3TAX_CSH  # Total households tax revenue #;
 V4TAX_CD # Total export tax revenue #;
 V5TAX_CS   # Total government tax revenue #;
 V0TAR_C    # Total tariff revenue #;
 V0TAX_CSI  # Total indirect tax revenue #;
Formula
 V1TAX_CSI  = sum{c,COM, sum{s,SRC, sum{i,IND, V1TAX(c,s,i) }}};
 V2TAX_CSI  = sum{c,COM, sum{s,SRC, sum{i,IND, V2TAX(c,s,i) }}};
 V3TAX_CSH  = sum{c,COM, sum{s,SRC, sum{h,HOU, V3TAX(c,s,h) }}};
 V4TAX_CD= sum{c,COM, sum{d,DES,              V4TAX(c,d)}};
 V5TAX_CS   = sum{c,COM, sum{s,SRC,              V5TAX(c,s) }};
 V0TAR_C    = sum{c,COM,                         V0TAR(c) };
V0TAX_CSI = V1TAX_CSI +V2TAX_CSI +V3TAX_CSH +V4TAX_CD +V5TAX_CS +V0TAR_C;

Coefficient ! All-Industry Factor Cost Aggregates !
  V1CAP_I   # Total payments to capital - high #
  V1LAB_IO  # Total payments to labour #;
  V0LAB_IO  # Total payments to labour #;
  V1LND_IL  # Total payments to land #;
  V1OCT_I   # Total other cost ticket payments #;
  V1PRIM_I  # Total primary factor payments#;
  V0GDPINC  # Nominal GDP at market prices from income side #;
Formula
  V1CAP_I   = sum{i,IND, V1CAP(i) };
  V1LAB_IO  = sum{i,IND, V1LAB_O(i) };
  V0LAB_IO  = sum{i,IND, V0LAB_O(i) };
  V1LND_IL  = sum{i,IND, V1LND_L(i) };
  V1OCT_I   = sum{i,IND, V1OCT(i) };
  V1PRIM_I  = V1LAB_IO + V1CAP_I + V1LND_IL;

  V0GDPINC  = V1CAP_I + V1LAB_IO + V1LND_IL + V1OCT_I  + (V0TAX_CSI) ;

! Excerpt 14 of TABLO input file: !
! Expenditure-side components of GDP !

Coefficient ! Expenditure Aggregates at Purchaser's Prices !
 V0CIF_C  # Total £Ire import costs, excluding tariffs #;
 V0IMP_C  # Total basic-value imports (includes tariffs) #;
 V2TOT_I  # Total investment usage #;
(all,h,HOU)  V3TOT(h)# Total purchases by each household type #;
 V3TOT_H  # Total purchases by all households #;
 V4TOT_D  # Total export earnings #;
 V5TOT    # Total value of government demands #;
 V6TOT    # Total value of inventories #;
 V0GDPEXP # Nominal GDP from expenditure side #;
 EXP_REFUND # Cost of Primary Subsidies Met by EU #;
Formula
 V0CIF_C   = sum{c,COM, V0CIF(c) };
```

```
 V0IMP_C    = sum{c,COM, V0IMP(c) };
 V2TOT_I    = sum{i,IND, V2TOT(i) };
(all,h,HOU)  V3TOT(h)=sum{c,COM, V3PUR_S(c,h)};
 V3TOT_H    = sum{h,HOU, V3TOT(h) };
 V4TOT_D    = sum[d,DES,sum{c,COM, V4PUR(c,d) }];
 V5TOT      = sum{c,COM, sum{s,SRC, V5PUR(c,s)}};
 V6TOT      = sum{c,COM, sum{s,SRC, V6BAS(c,s)}};
 EXP_REFUND = sum{c,COM, sum{d,DES, S4EXP(c,d)}};

 V0GDPEXP  = V3TOT_H + V2TOT_I + V5TOT + V6TOT
        + (V4TOT_D + EXP_REFUND - V0CIF_C);

! Excerpt 15A - Labour - of TABLO input file: !
! Occupational composition of labour demand !
!$  Problem: for each industry i, minimize labour cost    !
!$          sum{o,OCC, P1LAB(i,o)*X1LAB(i,o) }            !
!$   such that  X1LAB_O(i) = CES( All,o,OCC: X1LAB(i,o) ) !

Coefficient (all,i,IND) SIGMA1LAB(i) # CES substitution between skill
types #;
Read SIGMA1LAB from file H2DATA header "SLAB";

Equation E_x1lab  # Demand for labour by industry and skill group #
(all,i,IND)(all,o,OCC)  x1lab(i,o) = x1lab_o(i)
   - SIGMA1LAB(i)*[p1lab(i,o) - p1lab_o(i)];

Equation E_p1lab_o  # Price to each industry of labour composite #
(all,i,IND) [TINY+V1LAB_O(i)]*p1lab_o(i) = sum{o,OCC,
V1LAB(i,o)*p1lab(i,o) };

Equation E_p1lab_i  #Price of labour occupation (employers perspective) #
(all,o,OCC) [TINY+V1LAB_I(o)]*p1lab_i(o) =
                  sum{i,IND, V1LAB(i,o)*p1lab(i,o) };

! Excerpt 15B - Land - of TABLO input file: !
! Soil composition of land demand !
!$  Problem: for each industry i, minimize land cost    !
!$          sum{l,LND, P1LND(i,l)*X1LND(i,l) }          !
!$   such that  X1LND_L(i) = CES( All,l,LND: X1LND(i,l) ) !

Coefficient (all,i,IND) SIGMA1LND(i) # CES substitution between soil
types #;
Read SIGMA1LND from file H2DATA header "SLND";

Equation E_x1lnd  # Demand for land by industry and soil type #
(all,i,IND)(all,l,LND)  x1lnd(i,l) = x1lnd_l(i)
     - SIGMA1LND(i)*[p1lnd(i,l)- p1lnd_l(i) ];

Equation E_p1lnd_l  # Price to each industry of land composite #
(all,i,IND) [TINY + V1LND_L(i)]*p1lnd_l(i) =
               sum{l,LND, V1LND(i,l)*p1lnd(i,l) };

Equation E_p1lnd_i  # Price to each industry of land composite#
(all,L,LND)[TINY+V1LND_I(L)]*p1lnd_i(l)=sum{i,IND, V1LND(i,l)*p1lnd(i,l)
};

! Excerpt 16 of TABLO input file: !
! Primary factor proportions !
!$  X1PRIM(i) =                  !
!$    CES( X1LAB_O(i)/A1LAB_O(i), X1CAP(i)/A1CAP(i),
X1LND_L(i)/A1LND_L(i) ) !
```

```
Coefficient (all,i,IND) SIGMA1PRIM(i) # CES substitution, primary factors
#;
Read SIGMA1PRIM from file H2DATA header "P028";

Equation E_x1lab_o  # Industry demands for effective labour #
(all,i,IND)  x1lab_o(i) - a1lab_o(i) =
 x1prim(i)- SIGMA1PRIM(i)*[p1lab_o(i)+ a1lab_o(i) - p1prim(i)];

Equation E_x1cap  # Industry demands for capital #
(all,i,IND)  x1cap(i) - a1cap(i) =
  x1prim(i) - SIGMA1PRIM(i)*[p1cap(i)+ a1cap(i) - p1prim(i)];

Equation E_x1lnd_l  # Industry demands for land #
(all,i,IND)  x1lnd_l(i) - a1lnd_l(i) -a1lnd_il = x1prim(i) -
   SIGMA1PRIM(i)*[p1lnd_l(i)+a1lnd_l(i)+a1lnd_il - p1prim(i)];

!added in a1lnd_il!
Equation E_p1prim  # Effective price term for factor demand equations #
(all,i,IND) [V1PRIM(i) + TINY]*p1prim(i) = V1LAB_o(i)*  [p1lab_o(i) +
a1lab_o(i)] + V1CAP(i)  *  [p1cap(i)+ a1cap(i)] + V1LND_L(i)*
[p1lnd_l(i) + a1lnd_l(i)+a1lnd_il];

! Excerpt 17 of TABLO input file: !
! Import/domestic composition of intermediate demands !
!$  X1_S(c,i) = CES( All,s,SRC: X1(c,s,i)/A1(c,s,i) ) !

Coefficient (all,c,COM) SIGMA1(c) # Armington elasticities: intermediate
#;
Read SIGMA1 from file H2DATA header "1ARM";

Equation E_x1  # Source-specific commodity demands #
(all,c,COM)(all,s,SRC)(all,i,IND) x1(c,s,i)-a1(c,s,i)
= x1_s(c,i) - SIGMA1(c)*[p1(c,s,i)+a1(c,s,i)- p1_s(c,i)];

Equation E_w1  # Source-specific commodity demands #
(all,c,COM)(all,s,SRC)(all,i,IND) w1(c,s,i) = x1(c,s,i) + p1(c,s,i);

Equation E_p1_s  # Effective price of commodity composite #
(all,c,COM)(all,i,IND) p1_s(c,i) = sum{s,SRC, S1(c,s,i)*[p1(c,s,i) +
a1(c,s,i)] };

! Excerpt 18 of TABLO input file: !
! Top nest of industry input demands !
!$  X1TOT(i) = MIN( All,c,COM: X1_S(c,i)/[A1_S(c,s,i)*A1TOT(i)],   !
!$                             X1PRIM(i)/[A1PRIM(i)*A1TOT(i)],     !
!$                             X1OCT(i)/[A1OCT(i)*A1TOT(i)] )   !

Equation E_x1_s  # Demands for commodity composites#
(all,c,COM)(all,i,IND) x1_s(c,i) - [a1_s(c,i) + altot(i) ] = x1tot(i);

Equation E_w1_s  # Nominal Demands for commodity composites#
(all,c,COM)(all,i,IND)
      w1_s(c,i) = x1_s(c,i) + p1_s(c,i);

Equation E_w1_si_agri  # Demands for commodity composites in agriculture#
(all,c,COM)  {sum[i,I1AGRI,V1PUR_S(c,i)] + TINY}* w1_si_agri(c)
               = {sum(i,I1AGRI,V1PUR_S(c,i) * w1_s(c,i))};

Equation E_w1_manu_serv  # Demands for services in manufacturing#
(all,i,I2MANU)  {sum[c,R3SERV,V1PUR_S(c,i)] + TINY}* w1_manu_serv(i)
```

```
                = {sum(c,R3SERV,V1PUR_S(c,i) * w1_s(c,i))};

Equation E_w1_manu_manu  # Demands for manufacturing in manufacturing#
(all,i,I2MANU)  {sum[c,R2MANU,V1PUR_S(c,i)] + TINY}* w1_manu_manu(i)
                = {sum(c,R2MANU,V1PUR_S(c,i) * w1_s(c,i))};

Equation E_x1prim  # Demands for primary factor composite #
(all,i,IND)  x1prim(i) - [a1prim(i) + f1prim_i + a1tot(i)] = x1tot(i);

Equation E_x1oct  # Demands for other cost tickets #
(all,i,IND)  x1oct(i) - [a1oct(i) + a1tot(i)] = x1tot(i);

Equation E_p1tot  # Zero pure profits in production #
(all,i,IND)
V1TOT(i)*[p1tot(i)-a1tot(i)] =
 sum{c,COM,  V1PUR_S(c,i)  *[p1_s(c,i) + a1_s(c,i) ] }
          +  V1PRIM(i)     *[p1prim(i) + a1prim(i) + f1prim_i]
          +  V1OCT(i)      *[p1oct(i) + a1oct(i)];

Variable (all,i,IND) milkper(i);
Equation E_milkper
(all,i,IND) V1TOT(i)*milkper(i) = V1PUR_S("C1Milk",i) * p1_s("C1Milk",i);

Variable (all,i,IND) milkper2(i);
Equation E_milkper2
(all,i,IND) (V2TOT(i)+TINY)*milkper2(i) =
V2PUR_S("C1Milk",i)*p2_s("C1Milk",i);

! Treatment of CAP subsidies !
Variable
(all,i,IND) w1sub_lnd(i) # Nominal value of land subsidies #;
(all,c,COM) w1sub_exp(c) # Nominal value of land subsidies #;
(all,i,IND) lnd_slack(i);
(all,i,IND) lnd_shock(i);
(all,c,COM) exp_slack(c);
(all,c,COM) exp_shock(c);

Equation  E_w1sub_lnd # Direct Agricultural Subsidy Payments #
(all,i,IND) [TINY + S1LND_L(i)]*w1sub_lnd(i)
    = sum{l, LND, S1LND(i,l) * [x1lnd(i,l) + p0lnd(i,l)]
                        + (V0LND(i,l) - S1LND(i,l)) * t1lnd(i,l)};
Equation  E_w1sub_exp # Indirect Agricultural Subsidy Payments #
(all,c,COM)  [TINY + S4EXP(c,"D3World")]*w1sub_exp(c)
    = S4EXP(c,"D3World")* [x4(c,"D3World") + pe(c,"D3World")] +
 [V4BAS(c,"D3World")+V4TAX(c,"D3World")-
S4EXP(c,"D3World")]*t4exp(c,"D3World");

Equation  E_lnd_slack
(all,i,IND) w1sub_lnd(i) = x1lnd_l(i) + lnd_slack(i);
Equation  E_exp_slack
(all,c,COM) w1sub_exp(c) = x4(c,"D3World") + exp_slack(c);

! Excerpt 19A of TABLO input file: !
! Output mix of commodities !

Coefficient (all,i,IND) SIGMA1OUT(i) # CET transformation elasticities #;
Read SIGMA1OUT from file H2DATA header "SCET";

Equation E_q1  # Supplies of commodities by industries #
(all,c,COM)(all,i,IND)
q1(c,i) = x1tot(i) + SIGMA1OUT(i)*[p0com(c) - p1tot(i)];
```

```
Equation E_w1tot # Historical simulation add in #
(all,i,IND) w1tot(i) = p1tot(i) + x1tot(i);

Coefficient
 (all,i,IND) MAKE_C(i) # All production by industry i #;
 (all,c,COM) MAKE_I(c) # Total production of commodities #;
Formula
 (all,i,IND) MAKE_C(i) = sum{c,COM, MAKE(c,i) };
 (all,c,COM) MAKE_I(c) = sum{i,IND, MAKE(c,i) };

Equation E_x1tot # Average price received by industries #
(all,i,IND) MAKE_C(i)*p1tot(i) = sum{c,COM, MAKE(c,i)*p0com(c) };

Equation E_x0com # Total output of commodities #
(all,c,COM) MAKE_I(c)*x0com(c) = sum{i,IND, MAKE(c,i)*q1(c,i) };

! Excerpt 19B of TABLO input file: !
! CET between outputs for local and export markets !

Coefficient
 (all, c,COM)(all,d,DES) EXPSHR(c,d)
          # share of sales going to each export market #;
 (all, c,COM) EXPSHR_D(c) # share going to all export markets #;
 (all, c,COM) TAU(c) # 1/elast of transformation, exportable/locally used
#;
Zerodivide Default 0.5;
Formula
 (all,c,COM)(all,d,DES) EXPSHR(c,d) = V4BAS(c,d)/SALES(c);
 (all,c,COM)            EXPSHR_D(c) = sum{d,DES,EXPSHR(c,d)};

! if zero, p0dom = pe, and CET is nullified !
(all,c,COM) TAU(c) = 0.0; !=> elasticity of transformation = infinity!
Zerodivide Off;

!e.g.  Domestic Machines increase in price by 12%, but the overseas
market
sees an increase of only 2%.  If TAU=0 this would not happen.  If
TAU=0.1, this would result in an increase in supply to the domestic
market!

Equation E_x0dom  # supply of commodities to export market #
 (all,c,COM)(all,d,DES) TAU(c)*[x0dom(c) - x4(c,d)] = p0dom(c) - pe(c,d);

Equation E_pe    # supply of commodities to domestic market # (all,c,COM)
  x0com(c) = [1.0-EXPSHR_D(c)]*x0dom(c) + sum{d,DES,EXPSHR(c,d)*
x4(c,d)};

Equation E_p0com  # Zero pure profits in transformation # (all,c,COM)
  p0com(c) = [1.0-EXPSHR_D(c)]*p0dom(c) + sum{d,DES,EXPSHR(c,d)*
pe(c,d)};

! Map between vector and matrix forms of basic price variables !

Equation E_p0dom  # Basic price of domestic goods = p0(c,"dom") #
 (all,c,COM) p0dom(c) = p0(c,"dom");

Equation E_p0imp  # Basic price of imported goods = p0(c,"imp") #
 (all,c,COM) p0imp(c) = p0(c,"imp");

! Excerpt 20 of TABLO input file: !
```

```
! Investment demands !
!$  X2_S(c,i) = CES( All,s,SRC: X2(c,s,i)/A2(c,s,i) ) !

Coefficient (all,c,COM) SIGMA2(c) # Armington elasticities: investment #;
Read SIGMA2 from file H2DATA header "2ARM";

Equation E_x2  # Source-specific commodity demands #
(all,c,COM)(all,s,SRC)(all,i,IND)
x2(c,s,i)-a2(c,s,i) = x2_s(c,i) - SIGMA2(c)*[p2(c,s,i)+a2(c,s,i) -
p2_s(c,i)];

Equation E_p2_s  # Effective price of commodity composite #
(all,c,COM)(all,i,IND)
p2_s(c,i) = sum{s,SRC, S2(c,s,i)*[p2(c,s,i)+a2(c,s,i)] };

! Investment top nest !
!$  X2TOT(i) = MIN( All,c,COM: X2_S(c,i)/[A2_S(c,s,i)*A2TOT(i)] ) !

Equation E_x2_s  # Demands for commodity composites #
(all,c,COM)(all,i,IND)  x2_s(c,i) - [a2_s(c,i) + a2tot(i)] = x2tot(i);

Equation E_p2tot  # Zero pure profits in investment #
(all,i,IND) [TINY + V2TOT(i)]*(p2tot(i) - a2tot(i)) =
 sum{c,COM,  V2PUR_S(c,i)  *[p2_s(c,i)+a2_s(c,i)] };

! Excerpt 21 - 23 of TABLO input file: !
Coefficient (all,c,COM) SIGMA3(c) # Armington elasticities: households #;
Read SIGMA3 from file H2DATA header "3ARM";

Equation E_x3  # Source-specific commodity demands #
(all,c,COM)(all,s,SRC)(all,h,HOU)
x3(c,s,h)-a3(c,s,h) = x3_s(c,h) - SIGMA3(c)*[ p3(c,s,h)+a3(c,s,h) -
p3_s(c,h)];

Equation E_p3_s  # Effective price of commodity composite #
(all,c,COM)(all,h,HOU) p3_s(c,h) = sum{s,SRC,
S3(c,s,h)*[p3(c,s,h)+a3(c,s,h)]};

Coefficient (all,h,HOU) FRISCH(h) #Frisch LES 'parameter'= -(total/lux)
#;
Read  FRISCH from file H2DATA header "P021";
Update (change)(all,h,HOU) FRISCH(h) = FRISCH(h)*[w3tot(h)-
w3lux(h)]/100.0;

Coefficient (all,c,COM)(all,h,HOU) EPS(c,h) # H'hold expenditure
elasticities #;
Read  EPS from file H2data header "XPEL";
Update (change) (all,c,COM)(all,h,HOU)
      EPS(c,h) = EPS(c,h)*[x3lux(c,h)-x3_s(c,h)+w3tot(h)-
w3lux(h)]/100.0;

Coefficient (all,c,COM)(all,h,HOU) S3_S(c,h) #H'hold average budget
shares#;
Formula      (all,c,COM)(all,h, HOU) S3_S(c,h) = V3PUR_S(c,h)/V3TOT(h);

Coefficient (all,c,COM)(all,h,HOU) B3LUX(c,h)
 # Ratio, (supernumerary expenditure/total expenditure), by commodity #;
Formula (all,c,COM)(all,h,HOU) B3LUX(c,h) = -EPS(c,h)/FRISCH(h);

Coefficient (all,c,COM)(all,h,HOU) S3LUX(c,h) # Marg h'hold budget
shares#;
```

```
Formula      (all,c,COM)(all,h,HOU) S3LUX(c,h) = EPS(c,h)*S3_S(c,h);

! Excerpt 23 of TABLO input file: !
! Commodity composition of household demand !
Equation E_x3sub  # Subsistence demand for composite commodities #
 (all,c,COM)(all,h,HOU) x3sub(c,h) = q(h) + a3sub(c,h);

Equation E_x3lux  # Luxury demand for composite commodities #
 (all,c,COM)(all,h,HOU) x3lux(c,h) + p3_s(c,h) = w3lux(h) + a3lux(c,h);

Equation E_w3_s  # Luxury demand for composite commodities #
 (all,c,com)(all,h,HOU) w3_s(c,h) = p3_s(c,h)+ x3_s(c,h);

Equation E_x3_s  # Total household demand for composite commodities #
(all,c,COM)(all,h,HOU)
       x3_s(c,h) = B3LUX(c,h)*x3lux(c,h) + [1-B3LUX(c,h)]*x3sub(c,h);

Equation E_utility  # Change in utility disregarding taste change terms #
 (all,h,HOU) utility(h) + q(h) = sum{c,COM, S3LUX(c,h)*x3lux(c,h) };

Equation E_a3lux  # Default setting for luxury taste shifter #
(all,c,COM)(all,h,HOU) a3lux(c,h)=a3sub(c,h)-sum{k,COM,
S3LUX(k,h)*a3sub(k,h)};

Equation E_a3sub  # Default setting for subsistence taste shifter #
(all,c,COM)(all,h,HOU) a3sub(c,h)=a3_s(c,h)-sum{k,COM,S3_S(k,h)*a3_s(k,h)
};

Equation E_x3_h # Total Consumption Demands #
(All,c,COM)(All,s,SRC)(TINY + V3BAS_H(c,s))*x3_h(c,s) =
 Sum(h,HOU, V3BAS(c,s,h)*x3(c,s,h));

Equation E_x3mar_h # Total Consumption Demands #
(All,c,COM)(All,s,SRC)(All,m,MAR)(TINY + V3MAR_H(c,s,m))*x3mar_h(c,s,m) =
 Sum(h,HOU, V3MAR(c,s,m,h)*x3mar(c,s,m,h)) ;

! Excerpt 24 of TABLO input file: !
! Export and government demands !

Variable
(all,c,COM)(all,d,DES) f4pshift(c,d); f4pgen;
(all,c,COM)            f4p_d(c);
(all,c,COM)            w4_d(c)  # Nominal Exp target for each commodity
#;

Equation E_w4_d
(all,c,COM)      sum{d,DES, V4PUR(c,d) + TINY} * w4_d(c) =
                   sum[d,DES, V4PUR(c,d) *{ x4(c,d) + p4(c,d) }];
Equation E_f4pshift
(all,c,COM)(all,d,DES) f4pshift(c,d) = f4p_d(c)+ f4p(c,d) + f4pgen;

!Coefficient (all,c,COM)(all,d,DES) EXP_ELAST(c,d)
  # Export demand elasticities: typical value -20.0.  1&2 = -5.0 #;
Read EXP_ELAST from file H2DATA header "P018";!

Equation E_x4  # Trad'l export demand functions # (all,c,COM)(all,d,DES)
  p4(c,d) - phi - f4pshift(c,d) = -0.5 * {x4(c,d) - f4q(c,d)};

Equation E_x5  # Government demands shifter#
(all,c,COM)(all,s,SRC) x5(c,s) = a5(c,s);
```

```
Equation E_a5  # Government demands shifter#
(all,c,COM)(all,s,SRC) a5(c,s) = f5(c,s) + f5tot;

Equation E_f5tot # Overall government demands shift #
 f5tot = x3tot_h + f5tot2;

! Excerpt 25 of TABLO input file: !
! Margin demands !

Equation E_x1mar  # Margins to producers #
(all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
   x1mar(c,s,i,m)  = x1(c,s,i) + a1mar(c,s,i,m);

Equation E_x2mar  # Margins to capital creators #
(all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
   x2mar(c,s,i,m)  = x2(c,s,i) + a2mar(c,s,i,m);

Equation E_x3mar  # Margins to households #
(all,c,COM)(all,s,SRC)(all,m,MAR)(all,h,HOU) x3mar(c,s,m,h)= x3(c,s,h)+
a3mar(c,s,m);

Equation E_x4mar  # Margins to exports #
(all,c,COM)(all,m,MAR)(all,d,DES) x4mar(c,m,d)  = x4(c,d) + a4mar(c,m,d);

Equation E_x5mar  # Margins to government users #
(all,c,COM)(all,s,SRC)(all,m,MAR) x5mar(c,s,m)  = x5(c,s) + a5mar(c,s,m);

! Excerpt 26 of TABLO input file: !
! The price system !

Equation E_p1 # Purchasers prices - producers #
(all,c,COM)(all,s,SRC)(all,i,IND)
[V1PUR(c,s,i)+TINY]*p1(c,s,i) = [V1BAS(c,s,i)+V1TAX(c,s,i)]*[p0(c,s)+
t1(c,s,i)] + sum{m,MAR, V1MAR(c,s,i,m)*[p0dom(m)+a1mar(c,s,i,m)] };

Equation E_p2 # Purchasers prices - capital creators #
(all,c,COM)(all,s,SRC)(all,i,IND)
[V2PUR(c,s,i)+TINY]*p2(c,s,i) = [V2BAS(c,s,i)+V2TAX(c,s,i)]*[p0(c,s)+
t2(c,s,i)] + sum{m,MAR, V2MAR(c,s,i,m)*[p0dom(m)+a2mar(c,s,i,m)] };

Equation E_p3 # Purchasers prices - households #
(all,c,COM)(all,s,SRC)(all,h,HOU)
[V3PUR(c,s,h)+TINY]*p3(c,s,h) = [V3BAS(c,s,h)+V3TAX(c,s,h)]*[p0(c,s)+
t3(c,s)] + sum{m,MAR, V3MAR(c,s,m,h)*[p0dom(m)+a3mar(c,s,m)] };

Equation E_p4 # Zero pure profits in exporting #
(all,c,COM)(all,d,DES)    [V4PUR(c,d)+TINY]*p4(c,d) =
[V4BAS(c,d) + V4TAX(c,d) - S4EXP(c,d) + TINY] * [pe(c,d)+ t4(c,d) -
t4exp(c,d)] + sum{m,MAR, V4MAR(c,m,d)*[p0dom(m)+a4mar(c,m,d)] };
! DES: I assume that p0dom is the purchase of the margin commodity
composite. Therefore export destinations does not come into it.!

Equation E_p5 # Zero pure profits in distribution of government #
(all,c,COM)(all,s,SRC)
[V5PUR(c,s)+TINY]*p5(c,s) = [V5BAS(c,s)+V5TAX(c,s)]*[p0(c,s)+ t5(c,s)]
+ sum{m,MAR, V5MAR(c,s,m)*[p0dom(m)+a5mar(c,s,m)] };

Equation E_p0A # Zero pure profits in importing #
(all,c,COM) p0(c,"imp") = pf0cif(c) + phi + t0imp(c);

! Excerpt 27 of TABLO input file: !
```

```
! Market clearing equations !

Equation E_p0B # Demand equals supply for non margin commodities #
(all,n,NONMAR)
  DOMSALES(n)*x0dom(n) =
  sum{i,IND,    V1BAS(n,"dom",i)*x1(n,"dom",i)
  +             V2BAS(n,"dom",i)*x2(n,"dom",i) }
  +             V3BAS_H(n,"dom")*x3_h(n,"dom")
  +             V5BAS(n,"dom")*x5(n,"dom")    ! note exports omitted !
  +             100*LEVP0(n,"dom")*delx6(n,"dom");

Equation E_p0C # Demand equals supply for margin commodities #
(all,m,MAR)
  DOMSALES(m)*x0dom(m) =                ! basic part first !
     sum{i,IND,  V1BAS(m,"dom",i)*x1(m,"dom",i)
  +              V2BAS(m,"dom",i)*x2(m,"dom",i) }
  +              V3BAS_H(m,"dom")*x3_h(m,"dom")
  +              V5BAS(m,"dom")*x5(m,"dom")    ! note exports omitted !
  +              100*LEVP0(m,"dom")*delx6(m,"dom")    ! now margin part !
  +  sum{c,COM,   sum[d,DES,V4MAR(c,m,d)*x4mar(c,m,d)]
                              ! note nesting of sum parentheses !
  +  sum{s,SRC,  V3MAR_H(c,s,m)*x3mar_h(c,s,m)
  +              V5MAR(c,s,m)*x5mar(c,s,m)
  +  sum{i,IND,  V1MAR(c,s,i,m)*x1mar(c,s,i,m)
  +              V2MAR(c,s,i,m)*x2mar(c,s,i,m) }}};

Equation E_x0imp # Import volumes #
(all,c,COM)
   [Tiny + V0IMP(c)]*x0imp(c) =
    sum{i,IND, V1BAS(c,"imp",i)*x1(c,"imp",i)
 +             V2BAS(c,"imp",i)*x2(c,"imp",i) }
 +             V3BAS_H(c,"imp")*x3_h(c,"imp")
 +             V5BAS(c,"imp")*x5(c,"imp")
 +             100*LEVP0(c,"imp")*delx6(c,"imp");

Equation E_x1lab_i # Demand equals supply for labour of each skill #
(all,o,OCC) V0LAB_I(o)*x1lab_i(o)=sum{i,IND,V0LAB(i,o)*x1lab(i,o) };

Equation E_x1lnd_i # Demand equals supply for land of each soil #
(all,l,LND) V0LND_I(l)*x1lnd_i(l)=sum{i,IND,V0LND(i,l)*x1lnd(i,l) };

! Excerpt 28 of TABLO input file: !
! Tax rate equations !

Equation
E_t1  # Power of tax on sales to intermediate #
  (all,c,COM)(all,s,SRC)(all,i,IND)  t1(c,s,i)  = f0tax_s(c) + f1tax_csi;
E_t2  # Power of tax on sales to investment #
  (all,c,COM)(all,s,SRC)(all,i,IND)  t2(c,s,i)  = f0tax_s(c) + f2tax_csi;
E_t3  # Power of tax on sales to households #
  (all,c,COM)(all,s,SRC)             t3(c,s)    = f0tax_s(c) + f3tax_cs;
E_t4 # Power of tax on sales to traditional exports #
  (all,c,COM)(all,d,DES)             t4(c,d)    = f0tax_s(c) +
f4tax_trad_d;
E_t5  # Power of tax on sales to government #
  (all,c,COM)(all,s,SRC)             t5(c,s)    = f0tax_s(c) + f5tax_cs;

! Excerpt 29 of TABLO input file: !
! Indirect tax revenue !

Equation
```

```
E_w1tax_csi # Revenue from indirect taxes on flows to intermediate #
[TINY + V1TAX_CSI]*w1tax_csi = sum{c,COM, sum{s,SRC,
sum{i,IND,V1TAX(c,s,i)
    *[p0(c,s)+x1(c,s,i)]+[V1TAX(c,s,i)+V1BAS(c,s,i)]*t1(c,s,i) }}};

Equation  E_w1sub_cs # Industry Subsidy Payments #
(all,i,Ind) [S1CAP(i) + S1LAB_O(i) + S1LND_L(i) + TINY]*w1sub_cs(i)
  = S1CAP(i) * [x1cap(i) + p0cap(i)] +(V0CAP(i) - S1CAP(i))*t1cap(i)
 + sum{o,OCC,S1LAB(i,o)*[x1lab(i,o)+p0lab(i,o)]+(V0LAB(i,o)-S1LAB(i,o))*
t1lab(i,o)} + sum{l,LND,S1LND(i,l) * [x1lnd(i,l)+p0lnd(i,l)]
  + (V0LND(i,l) - S1LND(i,l)) * t1lnd(i,l)};

Equation  E_w1sub_csi # Direct Agricultural Subsidy Payments #
[TINY + sum{i,I1AGRI, S1CAP(i) + S1LAB_O(i) + S1LND_L(i)}]*w1sub_csi
 = sum[i,I1AGRI,[S1CAP(i) * [x1cap(i) + p0cap(i)]+(V0CAP(i) -
S1CAP(i))*t1cap(i) + sum {o,OCC,S1LAB(i,o)*[x1lab(i,o)+p0lab(i,o)]
 + (V0LAB(i,o)-S1LAB(i,o))*t1lab(i,o)}
 + sum {l,LND,S1LND(i,l)*[x1lnd(i,l)+p0lnd(i,l)]
                  + (V0LND(i,l)-S1LND(i,l))*t1lnd(i,l)}]];

Variable  wtotalsub #total subsidy payments#;
Equation  E_wtotalsub # Aggregate Economy Subsidy Payments #
[TINY + sum{c,COM, sum{d,DES,S4EXP(c,d)}}
        + sum{i,IND, S1CAP(i) + S1LAB_O(i) + S1LND_L(i)}]*wtotalsub
 = sum[i,IND,[S1CAP(i) * [x1cap(i) + p0cap(i)]+(V0CAP(i) -
S1CAP(i))*t1cap(i) + sum{o,OCC,S1LAB(i,o)* [x1lab(i,o)+p0lab(i,o)]
+ (V0LAB(i,o)-S1LAB(i,o))*t1lab(i,o)} + sum{l,LND,S1LND(i,l)*
[x1lnd(i,l)+p0lnd(i,l)] + (V0LND(i,l)-S1LND(i,l))*t1lnd(i,l)}]]
+  sum{c,COM, sum{d,DES,S4EXP(c,d) * {x4(c,d) + pe(c,d)} +
+[V4BAS(c,d) + V4TAX(c,d) - S4EXP(c,d)]*t4exp(c,d)}};

Variable (all,c,COM) wvalexp(c)#Nominal value of export subsidies#;
Equation E_wvalexp  #Nominal value of export subsidies#
(all,c,COM) [TINY + S4EXP(c,"D3World")]*wvalexp(c)
= S4EXP(c,"D3World")*x4(c,"D3World") +[V4BAS(c,"D3World")+
V4TAX(c,"D3World")-S4EXP(c,"D3World")]*t4exp(c,"D3World");

E_w2tax_csi # Revenue from indirect taxes on flows to investment #
[TINY + V2TAX_CSI]*w2tax_csi = sum{c,COM, sum{s,SRC, sum{i,IND,
 V2TAX(c,s,i)*[p0(c,s)+x2(c,s,i)]+[V2TAX(c,s,i)+V2BAS(c,s,i)]*t2(c,s,i)
}}};

E_w3tax_csh # Revenue from indirect taxes on flows to households #
[TINY + V3TAX_CSH]*w3tax_csh = sum{c,COM, sum{s,SRC, sum{h,HOU,
 V3TAX(c,s,h)*[p0(c,s)+ x3(c,s,h)]+[V3TAX(c,s,h)+V3BAS(c,s,h)]*t3(c,s)
}}};

E_w4tax_cd # Revenue from indirect taxes on exports #
  [TINY + V4TAX_CD]*w4tax_cd = sum[d,DES,{sum(c,COM,
    V4TAX(c,d)*[pe(c,d) + x4(c,d)] + [V4TAX(c,d)+ V4BAS(c,d)]*t4(c,d)
)}];

E_w5tax_cs # Revenue from indirect taxes on flows to government #
  [TINY + V5TAX_CS]*w5tax_cs = sum{c,COM, sum{s,SRC,
     V5TAX(c,s)*[p0(c,s)+ x5(c,s)] + [V5TAX(c,s)+V5BAS(c,s)]*t5(c,s) }};

E_w0tar_c # Tariff revenue #
  [TINY + V0TAR_C]*w0tar_c = sum{c,COM,
    V0TAR(c)*[pf0cif(c) + phi + x0imp(c)] + V0IMP(c)*t0imp(c) };

E_x1tax_csi # Revenue from indirect taxes on flows to intermediate #
```

```
[TINY + V1TAX_CSI]*x1tax_csi = sum{c,COM, sum{s,SRC,
sum{i,IND,V1TAX(c,s,i)
    *[x1(c,s,i)]+[V1TAX(c,s,i)+V1BAS(c,s,i)]*t1(c,s,i) }}};

E_x2tax_csi # Revenue from indirect taxes on flows to investment #
  [TINY + V2TAX_CSI]*x2tax_csi = sum{c,COM, sum{s,SRC, sum{i,IND,
    V2TAX(c,s,i)*[x2(c,s,i)]+[V2TAX(c,s,i)+V2BAS(c,s,i)]*t2(c,s,i) }}};

E_x3tax_csh # Revenue from indirect taxes on flows to households #
  [TINY + V3TAX_CSH]*x3tax_csh = sum{c,COM, sum{s,SRC, sum{h,HOU,
    V3TAX(c,s,h)*[x3(c,s,h)] + [V3TAX(c,s,h)+V3BAS(c,s,h)]*t3(c,s) }}};

E_x4tax_cd # Revenue from indirect taxes on exports #
  [TINY + V4TAX_CD]*x4tax_cd = sum[d,DES,{sum(c,COM,
    V4TAX(c,d)*[x4(c,d)] + [V4TAX(c,d)+ V4BAS(c,d)]*t4(c,d) )}];

E_x5tax_cs # Revenue from indirect taxes on flows to government #
  [TINY + V5TAX_CS]*x5tax_cs = sum{c,COM, sum{s,SRC,
      V5TAX(c,s)*[x5(c,s)] + [V5TAX(c,s)+V5BAS(c,s)]*t5(c,s) }};

E_x0tar_c # Tariff revenue #
  [TINY+V0TAR_C]*x0tar_c = sum{c,COM,
    V0TAR(c)*[x0imp(c)] + V0IMP(c)*t0imp(c) };


! Excerpt 30 of TABLO input file: !
! Factor incomes and GDP from Income Side!

Equation
E_w1lnd_il  # Aggregate payments to land #
V1LND_IL*w1lnd_il=sum{i,IND,sum{l,LND,
V1LND(i,l)*[x1lnd(i,l)+p1lnd(i,l)]}};
E_x1lnd_il  # Aggregate real payments to land #
V1LND_IL*x1lnd_il = sum{i,IND, sum{l,LND, V1LND(i,l)*x1lnd(i,l) }};

E_w1lab_io  # Aggregate payments to labour #
V1LAB_IO*w1lab_io=sum{i,IND,sum{o,OCC,
V1LAB(i,o)*[x1lab(i,o)+p1lab(i,o)]}};

E_x1lab_io  # Aggregate real payments to labour #
 V1LAB_IO*x1lab_io = sum{i,IND, sum{o,OCC, V1LAB(i,o)*x1lab(i,o)}};

E_w1lab_o  # Aggregate payments to labour in each industry#
(all,i,IND) w1lab_o(i) = p1lab_o(i) + x1lab_o(i);

E_w1cap_i  # Aggregate payments to capital #
  V1CAP_I*w1cap_i = sum{i,IND, V1CAP(i)*[x1cap(i)+p1cap(i)] };
E_w1oct_i  # Aggregate other cost ticket payments #
  [V1OCT_I + TINY]*w1oct_i = sum{i,IND, V1OCT(i)*[x1oct(i)+p1oct(i)] };
E_x1oct_i  # Aggregate real other cost ticket payments #
  [V1OCT_I + TINY]*x1oct_i = sum{i,IND, V1OCT(i)*x1oct(i) };
E_w0tax_csi  # Aggregate value of indirect taxes #
  V0TAX_CSI*w0tax_csi = V1TAX_CSI*w1tax_csi + V2TAX_CSI*w2tax_csi +
 V3TAX_CSH*w3tax_csh +V4TAX_CD*w4tax_cd +V5TAX_CS*w5tax_cs
+V0TAR_C*w0tar_c;
E_x0tax_csi  # Aggregate value of indirect taxes #
  V0TAX_CSI*x0tax_csi = V1TAX_CSI*x1tax_csi + V2TAX_CSI*x2tax_csi +
 V3TAX_CSH*x3tax_csh +V4TAX_CD*x4tax_cd +V5TAX_CS*x5tax_cs
+V0TAR_C*x0tar_c;

!  GDP from the income side:!
```

```
E_p0gdpinc  # Aggregate nominal GDP from income side #
  V0GDPINC*p0gdpinc = sum{l,LND, V1LND_I(l)*p1lnd_i(l)} + V1CAP_I*p1cap_i
   + sum{o,OCC, V1LAB_I(o)*p1lab_i(o)} + sum{i,IND, V1OCT(i)*p1oct(i)}
                     + V0TAX_CSI* (w0tax_csi - x0tax_csi)
  + sum{i,IND, V1CAP(i)*p0cap(i)}
  + sum{i,IND, {sum{o,OCC, V1LAB(i,o)*p0lab(i,o)}}}
  + sum{i,IND, {sum{l,LND, V1LND(i,l)*p0lnd(i,l)}}};


E_x0gdpinc  # Aggregate real GDP from income side #
  V0GDPINC*x0gdpinc = V1LND_IL*x1lnd_il
                    + V1CAP_I*x1cap_i
                    + V1LAB_IO*x1lab_io
                    + V1OCT_I*x1oct_i
                    + (V0TAX_CSI*x0tax_csi );

E_w0gdpinc  # Aggregate real GDP from income side #
  w0gdpinc = p0gdpinc + x0gdpinc ;

! Excerpt 31 of TABLO input file: !
! GDP expenditure aggregates !

E_x2tot_i  # Total real investment #
  V2TOT_I*x2tot_i = sum{i,IND, V2TOT(i)*x2tot(i) };
E_p2tot_i  # Investment price index #
  V2TOT_I*p2tot_i = sum{i,IND, V2TOT(i)*p2tot(i) };
E_w2tot_i  # Total nominal investment #
  w2tot_i = x2tot_i + p2tot_i;

E_x3tot # real consumption #
(All,h,HOU) V3TOT(h)*x3tot(h) = Sum(c,COM, Sum(s,SRC,
V3PUR(c,s,h)*x3(c,s,h)));
E_p3tot # consumer price index #
(All,h,HOU) V3TOT(h)*{p3tot(h)-a3tot(h)} =
       Sum(c,COM, V3PUR_S(c,h)*{p3_s(c,h)+a3_s(c,h)});
E_w3tot # household budget constraint #
(All,h,HOU) w3tot(h) = x3tot(h) + p3tot(h);

E_x3tot_h # real consumption #
 V3TOT_H*x3tot_h = Sum(h,HOU, V3TOT(h)*x3tot(h));
E_p3tot_h # consumer price index #
 V3TOT_H*p3tot_h = Sum(h,HOU, V3TOT(h)*p3tot(h));
E_p3tot_hs # consumer price index - services#
 V3TOT_H*p3tot_hs = sum[h,HOU,Sum{c,COM, Sum[s,SRC,
V3PUR(c,s,h)*p3(c,s,h)]}];
E_w3tot_h # nominal consumption #
 w3tot_h = x3tot_h + p3tot_h;

! This is all x4tot_d is needed for. !
E_x4tot_d     # Export volume index #
[V4TOT_D+EXP_REFUND]*x4tot_d = sum[d,DES,sum{c,COM,
                [V4PUR(c,d)+S4EXP(c,d)]*x4(c,d)}];
E_p4tot_d     # Exports price index, £Ire #
  V4TOT_D*p4tot_d = sum[d,DES,sum{c,COM, V4PUR(c,d)*p4(c,d) }];
Variable p4gdp;
         w4gdp;
Equation
E_p4gdp  # Exports price index, £Ire #
[V4TOT_D+EXP_REFUND]*p4gdp = sum[d,DES,sum{c,COM,
            {V4PUR(c,d)+S4EXP(c,d)}*{p4(c,d)+t4exp(c,d)}}];
E_w4tot_d     # £Ire border value of exports #
```

```
  w4tot_d = x4tot_d + p4tot_d;
E_w4gdp
  w4gdp    = x4tot_d + p4gdp;

E_x5tot     # Aggregate real government demands #
  V5TOT*x5tot = sum{c,COM, sum{s,SRC, V5PUR(c,s)*x5(c,s) }};
E_p5tot     # Government price index #
  V5TOT*p5tot = sum{c,COM, sum{s,SRC, V5PUR(c,s)*p5(c,s) }};
E_w5tot     # Aggregate nominal value of government demands #
  w5tot = x5tot + p5tot;

E_x6tot     # Inventories volume index #
  V6TOT*x6tot = 100*sum{c,COM, sum{s,SRC, LEVP0(c,s)*delx6(c,s) }};
E_p6tot     # Inventories price index #
  [TINY+V6TOT]*p6tot = sum{c,COM, sum{s,SRC, V6BAS(c,s)*p0(c,s) }};
E_w6tot     # Aggregate nominal value of inventories #
  w6tot = x6tot + p6tot;

E_x0cif_c  # Import volume index, C.I.F. weights #
  V0CIF_C*x0cif_c = sum{c,COM, V0CIF(c)*x0imp(c) };
E_p0cif_c  # Imports price index, £Ire C.I.F. #
  V0CIF_C*p0cif_c = sum{c,COM, V0CIF(c)*[phi+pf0cif(c)] };
E_w0cif_c  # Value of imports, £Ire C.I.F. #
  w0cif_c = x0cif_c + p0cif_c;

!Imported services!
Variable     w0cif_serv  # Import volume index for services, C.I.F.
weights #;
Equation     E_w0cif_serv  # Value of imported services, £Ire C.I.F. #
    sum{c,R3SERV, V0CIF(c)}*w0cif_serv =
        sum{c,R3SERV, V0CIF(c)*(x0imp(c)+phi+pf0cif(c))};

!Imported Intermediates!
Variable       w0cif_c_int;
Equation     E_w0cif_c_int  # Import volume index, C.I.F. weights #
sum{c,COM, sum{i,IND, V1PUR(c,"imp",i)}}* w0cif_c_int =
sum{c,COM, sum{i,IND, V1PUR(c,"imp",i)  * w1(c,"imp",i)}};

!Imported GFCF!
Variable       w0cif_c_gfcf;
Equation     E_w0cif_c_gfcf  # Import volume index, C.I.F. weights #
sum{c,COM, sum{i,IND, V2PUR(c,"imp",i)}}* w0cif_c_gfcf =
sum{c,COM, sum{i,IND, V2PUR(c,"imp",i)  * [x2(c,"imp",i) +
p2(c,"imp",i)]}};

Equation  E_w0cif  # Value of imported commodities, £Ire C.I.F. #
(all,c,COM)  w0cif(c) = x0imp(c) + pf0cif(c);

Variable x1gdpexp;
         p1gdpexp;
         w1gdpexp;

Equation
E_x1gdpexp  # Real GDP, expenditure side #
V0GDPEXP*x1gdpexp = V3TOT_h*x3tot_h + V2TOT_I*x2tot_i + V5TOT*x5tot
  + V6TOT*x6tot + V4TOT_D*x4tot_d - V0CIF_C*x0cif_c;

E_p1gdpexp  # Price index for GDP, expenditure side #
  V0GDPEXP*p1gdpexp = V3TOT_h*p3tot_h + V2TOT_I*p2tot_i + V5TOT*p5tot
  + V6TOT*p6tot + V4TOT_D*p4tot_d - V0CIF_C*p0cif_c;
```

```
E_w1gdpexp  # Nominal GDP from expenditure side #
  w1gdpexp = x1gdpexp + p1gdpexp;

E_x0gdpexp  # Real GDP, expenditure side #
V0GDPEXP*x0gdpexp = V3TOT_h*x3tot_h + V2TOT_I*x2tot_i + V5TOT*x5tot
  + V6TOT*x6tot + [V4TOT_D+EXP_REFUND]*[w4gdp-p4gdp] - V0CIF_C*x0cif_c;

E_p0gdpexp  # Price index for GDP, expenditure side #
  V0GDPEXP*p0gdpexp = V3TOT_h*p3tot_h + V2TOT_I*p2tot_i + V5TOT*p5tot
  + V6TOT*p6tot + [V4TOT_D+EXP_REFUND]*[p4gdp] - V0CIF_C*p0cif_c
 + sum{i,IND, {          V1CAP(i) * t1cap(i)}}
 + sum{i,IND, {sum{o,OCC, V1LAB(i,o) * t1lab(i,o)}}}
 + sum{i,IND, {sum{l,LND, V1LND(i,l) * t1lnd(i,l)}}};

E_w0gdpexp  # Nominal GDP from expenditure side #
  w0gdpexp = x0gdpexp + p0gdpexp;

! Excerpt 32 of TABLO input file: !
! Trade balance and other aggregates !

Equation
E_delB      # (Balance of trade)/GDP #
  100*V0GDPEXP*delB = V4TOT_D*w4tot_d - V0CIF_C*w0cif_c
                    -(V4TOT_D-V0CIF_C)*w0gdpexp;

E_x0imp_c  # Import volume index, duty paid weights #
  V0IMP_C*x0imp_c = sum{c,COM, V0IMP(c)*x0imp(c) };
E_p0imp_c  # Duty paid imports price index #
  V0IMP_C*p0imp_c = sum{c,COM, V0IMP(c)*p0(c,"imp") };
E_w0imp_c  # Value of imports (duty paid) #
  w0imp_c = x0imp_c + p0imp_c;

E_x1cap_i  # Aggregate usage of capital,rental weights #
  V1CAP_I*x1cap_i = sum{i,IND, V1CAP(i)*x1cap(i) };
E_p1cap_i  # Average capital rental #
  V1CAP_I*p1cap_i = sum{i,IND, V1CAP(i)*p1cap(i) };

Equation E_employ # Employment by industry #
(all,i,IND) [V0LAB_O(i) + S1LAB_O(i) + TINY]*employ(i)
            = sum{o,OCC, V0LAB(i,o)*x1lab(i,o) };

E_employ_i  # Aggregate employment, total wage bill weights #
  [V0LAB_IO + TINY]*employ_i= sum{i,IND, V0LAB_O(i)*employ(i) };

E_p0lab_io  # Average nominal wage #
  V1LAB_IO*p0lab_io = sum{i,IND, sum{o,OCC, V1LAB(i,o)*p1lab(i,o) }};

E_realwage  # Average real wage #
  realwage = p0lab_io - p3tot_h;

E_x1prim_i  # Aggregate output: value-added weights #
  V1PRIM_I*x1prim_i = sum{i,IND, V1PRIM(i)*x1tot(i) };

E_p0toft  # Terms of trade #
  p0toft = p4tot_d - p0cif_c;

E_p0realdev  # Real devaluation #
  p0realdev =  p0cif_c - p0gdpexp;

! Excerpt 33 of TABLO input file: !
! Investment equations !
```

```
Variable
(all,i,IND)  finv(i)    # Investment shifter #;
(all,i,IND)  ffinv(i)   # Investment shifter #;
             ffinv_i    # Investment shifter #;
(all,i,IND)  rlcap(i)   # Current rates of return on fixed capital #;
             omega    # Economy-wide "rate of return" #;

Equation E_rlcap # Definition of rates of return to capital #
(all,i,IND) rlcap(i) = 2.0*(p0cap(i) - p2tot(i));

Equation E_x2totA # Investment rule #
(all,i,ENDOGINV)
x2tot(i) - x1cap(i) = finv(i) + 0.33*[rlcap(i) - omega];

Equation E_x2totB # Investment in exogenous industries #
(all,i,EXOGINV) x2tot(i) - x2tot_i = finv(i);

Equation E_finv # Investment shifter #
(all,i,ind)  finv(i) = ffinv(i) + ffinv_i ;

! Excerpt 34 of TABLO input file: !
! Indexing and other equations !

Equation E_p0lab # Flexible setting of money wages #
(all,i,IND)(all,o,OCC)
p0lab(i,o)= p3tot_h + f1lab_io + f1lab_o(i) + f1lab_i(o) + f1lab(i,o);

Variable       f1lnd_il;
(all,l,LND)    f1lnd_i(l);
(all,i,IND)    f1lnd_l(i);

Equation E_p0lnd # Flexible setting of land rents #
(all,i,IND)(all,l,LND)
p0lnd(i,l)= omega + f1lnd_il + f1lnd_l(i) + f1lnd_i(l);

Equation E_p1oct # Indexing of prices of "other cost" tickets #
(all,i,IND) p1oct(i) = p0gdpexp + f1oct(i); ! assumes full indexation !

Variable    (All,h,HOU) wdispinc(h) # post-tax h'hold income #;

Equation E_f3tot # consumption function #
(All,h,HOU)
 w3tot(h) = f3tot(h) + f3tot_h + wdispinc(h);

E_delx6 # possible rule for stocks #
(all,c,COM)(all,s,SRC)
100*LEVP0(c,s)*delx6(c,s)=V6BAS(c,s)*x0com(c)+fx6(c,s);

! Excerpt 35 of TABLO input file: !
! Decomposition of Fan !

Set FANCAT # parts of Fan decomposition #
  (LocalMarket, ImportShare, Export, Total);

Variable
(all,c,COM) x0loc(c)  # real percent change in LOCSALES (dom+imp)  #;
(change)(all,c,COM)(all,f,FANCAT) fandecomp(c,f) # Fan decomposition #;

Coefficient
 (all,c,COM) LOCSALES(c)  # Total local sales of dom + imp commodity c #;
```

```
 (all,c,COM) INITSALES(c) # Initial volume of SALES at final prices #;
Formula
 (all,c,COM) LOCSALES(c) = DOMSALES(c) + V0IMP(c);
 (initial) (all,c,COM) INITSALES(c) = SALES(c);
Update
  (all,c,COM) INITSALES(c) = p0com(c);

Equation E_x0loc # %growth in local market #
(all,c,COM) LOCSALES(c)*x0loc(c) =
 DOMSALES(c)*x0dom(c) + V0IMP(c)*x0imp(c);

Equation E_fandecompA # growth in local market effect #
(all,c,COM)  INITSALES(c)*fandecomp(c,"LocalMarket") =
DOMSALES(c)*x0loc(c);
! The local market effect is the % change in output that would have
occurred if local sales of the domestic product had followed dom+imp
sales (x0loc) !

Equation E_fandecompB # export effect #
(all,c,COM) INITSALES(c)*fandecomp(c,"Export") =
sum{d,DES,V4BAS(c,d)*x4(c,d)};

Equation E_fandecompC # import leakage effect - via residual #
(all,c,COM) fandecomp(c,"Total") =
fandecomp(c,"LocalMarket") + fandecomp(c,"ImportShare") +
fandecomp(c,"Export");

Equation E_fandecompD # Fan total = x0com #
(all,c,COM) INITSALES(c)*fandecomp(c,"Total") = SALES(c)*x0com(c);

! Excerpt 36 of TABLO input file: !
! Data for Checking Identities !
! Excerpt 36 of TABLO input file: !
! Data for Checking Identities !

File (new) SUMMARY  # Summary and checking data #;

Coefficient                    ! coefficients for checking !
 (all,i,IND) PURE_PROFITS(i) # COSTS-MAKE_C : should be zero #;
 (all,c,COM) LOST_GOODS(c)   # SALES-MAKE_I : should be zero #;
             EPSTOT;
Formula
 (all,i,IND) PURE_PROFITS(i) = V1TOT(i) - MAKE_C(i);
 (all,c,COM) LOST_GOODS(c)   = SALES(c) - MAKE_I(c);
             EPSTOT          = sum{c,COM, sum[h,HOU,S3_S(c,h)*EPS(c,h)]};
Write
PURE_PROFITS to file SUMMARY header "PURE" longname "COSTS-MAKE_C: should
= 0";
LOST_GOODS to file SUMMARY header "LOST"longname"SALES-MAKE_I: should=0";
EPSTOT to file SUMMARY header "ETOT" longname "Average Engel elast:
should = h";

! Excerpt 37 of TABLO input file: !
! Components of GDP from income and expenditure sides !

Set EXPMAC # Expenditure Aggregates #
 (Consumption, Investment, Government, Stocks, Exports, Imports);
Coefficient (all,e,EXPMAC)  EXPGDP(e) # Expenditure Aggregates #;
Formula
 EXPGDP("Consumption") = V3TOT_H;
 EXPGDP("Investment")  = V2TOT_I;
```

```
 EXPGDP("Government")   = V5TOT;
 EXPGDP("Stocks")       = V6TOT;
 EXPGDP("Exports")      = V4TOT_D;
 EXPGDP("Imports")      = -V0CIF_C;
Write EXPGDP to file SUMMARY header "EMAC" longname "Expenditure
Aggregates";

Set INCMAC # Income Aggts # (Land, Labour, Capital, OCT, IndTaxes);
Coefficient (all,i,INCMAC)  INCGDP(i) # Income Aggregates #;
Formula
 INCGDP("Land")      = V1LND_IL;
 INCGDP("Labour")    = V1LAB_IO;
 INCGDP("Capital")   = V1CAP_I;
 INCGDP("OCT")       = V1OCT_I;
 INCGDP("IndTaxes") = V0TAX_CSI;
Write INCGDP to file SUMMARY header "IMAC" longname "Income Aggregates";

Set TAXMAC # Tax Aggregates #
  (Intermediate,Investment,Consumption,Exports,Government,Tariff);
Coefficient (all,t,TAXMAC)  TAX(t) # Tax Aggregates #;
Formula
 TAX("Intermediate") = V1TAX_CSI;
 TAX("Investment")   = V2TAX_CSI;
 TAX("Consumption")  = V3TAX_CSH;
 TAX("Exports")      = V4TAX_CD;
 TAX("Government")   = V5TAX_CS;
 TAX("Tariff")       = V0TAR_C;
Write TAX to file SUMMARY header "TMAC" longname "Tax Aggregates";

! Excerpt 38 of TABLO input file: !
! Matrix of Industry Costs !

Set COSTCAT # Cost Categories #
(IntDom, IntImp, Margin, IndTax, Lab, Cap, Lnd, SLab,SCap,SLnd, OCT);!co!
Coefficient (all,i,IND)(all,co,COSTCAT) COSTMAT(i,co);
Formula
(all,i,IND) COSTMAT(i,"IntDom") = sum{c,COM, V1BAS(c,"dom",i)};
(all,i,IND) COSTMAT(i,"IntImp") = sum{c,COM, V1BAS(c,"imp",i)};
(all,i,IND) COSTMAT(i,"Margin") =
            sum{c,COM, sum{s,SRC, sum{m,MAR, V1MAR(c,s,i,m)}}};
(all,i,IND) COSTMAT(i,"IndTax") = sum{c,COM, sum{s,SRC, V1TAX(c,s,i)}};
(all,i,IND) COSTMAT(i,"Lab") =V0LAB_O(i);
(all,i,IND) COSTMAT(i,"Cap") =V0CAP(i);
(all,i,IND) COSTMAT(i,"Lnd") =V0LND_L(i);
(all,i,IND) COSTMAT(i,"SLab") = - S1LAB_O(i);
(all,i,IND) COSTMAT(i,"SCap") = - S1CAP(i);
(all,i,IND) COSTMAT(i,"SLnd") = - S1LND_L(i);
(all,i,IND) COSTMAT(i,"Oct") =V1OCT(i);
Write COSTMAT to file SUMMARY header "CSTM" longname "Cost Matrix";
Formula (all,i,IND)(all,co,COSTCAT) ! convert to % shares and re-write !
            COSTMAT(i,co)= 100*COSTMAT(i,co)/(TINY+V1TOT(i));
Write COSTMAT to file SUMMARY header "COSH" longname "Cost Share Matrix";
Write S1 to file SUMMARY header "c5S1" longname "S1";
Write S2 to file SUMMARY header "c5S2" longname "S2";
Write S3 to file SUMMARY header "c5S3" longname "S3";
Write B3LUX to file SUMMARY header "c5b3" longname "B3";
Write S3LUX to file SUMMARY header "s3lu" longname "S3LUX";
Write V1PUR to file summary header "V1pu" longname "v1pur";
Write V2PUR to file summary header "V2pu" longname "v2pur";
Write V3PUR to file summary header "V3pu" longname "v3pur";
```

```
! Excerpt 39 of TABLO input file: !
! Matrix of domestic commodity sales with total imports !

Set ! Subscript !
SALECAT # SALE Categories #
(Interm, Invest, HouseH, Export, GovGE, Stocks,Margins, Total, Imports);

Coefficient (all,c,COM)(all,sa,SALECAT) SALEMAT(c,sa);

Formula
(all,c,COM) SALEMAT(c,"Interm") = sum{i,IND, V1BAS(c,"dom",i)};
(all,c,COM) SALEMAT(c,"Invest") = sum{i,IND, V2BAS(c,"dom",i)};
(all,c,COM) SALEMAT(c,"HouseH") = sum{h,HOU, V3BAS(c,"dom",h)};
(all,c,COM) SALEMAT(c,"Export") = sum{d,DES, V4BAS(c,d)};
(all,c,COM) SALEMAT(c,"GovGE")  = V5BAS(c,"dom");
(all,c,COM) SALEMAT(c,"Stocks") = V6BAS(c,"dom");
(all,c,COM) SALEMAT(c,"Margins")= MARSALES(c);
(all,c,COM) SALEMAT(c,"Total")  = SALES(c);
(all,c,COM) SALEMAT(c,"Imports")= V0IMP(c);
write SALEMAT to file SUMMARY header "SLSM" longname
    "Matrix of domestic commodity sales with total imports";

Formula
 (all,c,COM)(all,sa,SALECAT) SALEMAT(c,sa) =
100*SALEMAT(c,sa)/[TINY+SALES(c)];
 (all,c,COM) SALEMAT(c,"Imports")=
100*V0IMP(c)/[TINY+DOMSALES(c)+V0IMP(c)];
Write SALEMAT to file SUMMARY header "SLSH" longname
    "market shares for domestic goods with total import share";

! Excerpt 40 of TABLO input file: !
! Weight Vectors for use in aggregation and other calculations !
Write
V1TOT     to file SUMMARY header "1TOT" longname "Industry Output";
V2TOT     to file SUMMARY header "2TOT" longname "Investment by Industry";
V1PUR_SI  to file SUMMARY header "1PUR" longname "Int Usage by com at PP";
V2PUR_SI  to file SUMMARY header "2PUR" longname "Inv Usage by com at PP";
V3PUR_S   to file SUMMARY header "3PUR" longname "Con at Purch.Prices";
V4PUR     to file SUMMARY header "4PUR" longname "Exp at Purchasers
Prices";
V0LAB_O   to file SUMMARY header "LAB1" longname "Industry Wages";
V1CAP     to file SUMMARY header "1CAP" longname "Capital Rentals";
V1PRIM    to file SUMMARY header "VLAD" longname "Industry Factor Cost";

! Excerpt 41 of TABLO input file: !
! Income Mapping Variables !
Variable
(All,o,OCC)(All,h,HOU) w1labinc(o,h)
          # labour income from occ (o) to households (h) #;
(All,o,OCC)    w1lab_i(o)     # Total Labour Bill (o) #;
(All,h,HOU)    w1labinc_o(h)    # Total Wages to Households (h) #;
avetax_h         # Average Tax Factor: avedispwager - avewager #;


Coefficient (All,o,OCC)(All,h,HOU)
V1LABINC(o,h) # labour income from occ (o) to households (h) #;
Read V1LABINC From File H2DATA Header "LINC";
Update (All,o,OCC)(All,h,HOU)
V1LABINC(o,h) = w1labinc(o,h);
```

```
Coefficient
(All,o,OCC) V1LABINC_H(o) # subtotal labour income to households (o) #;
(All,h,HOU) V1LABINC_O(h) # total wage income to h'lds (h) #;
Formula
(All,o,OCC) V1LABINC_H(o) = Sum(h,HOU, V1LABINC(o,h));
(All,h,HOU) V1LABINC_O(h) = Sum(o,OCC, V1LABINC(o,h));


! Excerpt 41 of TABLO input file: !
! Declare Income Mapping Data Coeffients and Associated Variables !
! Read in and Update Income Mapping Data Coeffients !

Coefficient
VGOSSAV # Capital Account: Gov #;
VGOSGOV # GOS income to gov + GOS transfers to gov #;
VGOSROW # GOS income to ROW + GOS transfers to ROW #;
VGOSTAX # corporation tax #;
VGOVGOS # interest on public debt #;
VGOVROW # GOV transfers to ROW #;
VROWGOS # GOS from ROW #;
VROWGOV # transfers from ROW to gov #;
(All,h,HOU) VGOSHOU(h)                  # GOS to households #;
(All,h,HOU) VGOVHOU(h)                  # gov transfers to households #;
(All,h,HOU) VHOUGOV(h)                  # income tax + h'hold transfers to
gov #;
(All,h,HOU) VHOUROW(h)                  # household transfers to ROW #;
(All,h,HOU) VROWHOU(h)                  # ROW transfers to households #;
(All,hto,HOU)(All,hfrom,HOU)
      VHOUHOU(hto,hfrom)                  # intra-h'hold trnsfrs  #;
(All,i,IND) GOVSHRINV(i) # gov share of investment by industry #;

Variable
wgosgov # GOS income to gov + GOS transfers to gov #;
wgosrow # GOS income to ROW + GOS transfers to ROW #;
wgostax # corporation tax #;
wgovgos # interest on public debt #;
wgovrow # GOV transfers to ROW #;
wrowgos # GOS from ROW #;
wrowgov # transfers from ROW to gov #;
wgossav    # retained earnings #;
(All,h,HOU) wgoshou(h)      # GOS to households #;
(All,h,HOU) wgovhou(h)      # gov transfers to households #;
(All,h,HOU) whougov(h)      # income tax + h'hold transfers to gov #;
(All,h,HOU) whourow(h)      # household transfers to ROW #;
(All,h,HOU) wrowhou(h)      # ROW transfers to households #;
(All,hto,HOU)(All,hfrom,HOU)
      whouhou(hto,hfrom) # intra-h'hold trnsfrs  #;

Read
GOVSHRINV From File H2DATA Header "GVSH"; !gov shares of investment!
VGOSGOV From File H2DATA Header "VGSG"; !GOS inc to gov+GOS trn to gov!
VGOSHOU From File H2DATA Header "VGSH"; !GOS to households!
VGOSROW From File H2DATA Header "VGSR"; !GOS inc to ROW+GOS trn to ROW!
VGOSTAX From File H2DATA Header "VGST"; !GOS (corporations) tax!
VGOVGOS From File H2DATA Header "VGVS"; !interest on public debt!
VGOVHOU From File H2DATA Header "VGVH"; !gov transfers to households!
VGOVROW From File H2DATA Header "VGVR"; !GOV transfers to ROW!
VHOUGOV From File H2DATA Header "VHGV"; !income tax + hous trnsfrs to
gov!
VHOUHOU From File H2DATA Header "VHOH"; !intra-household transfers!
```

```
VHOUROW From File H2DATA Header "VHRW"; !household transfers to ROW!
VROWGOS From File H2DATA Header "VRGS"; !GOS from ROW!
VROWGOV From File H2DATA Header "VRGV"; !transfers from ROW to gov!
VROWHOU From File H2DATA Header "VRWH"; !ROW transfers to households!

Update
VGOSGOV = wgosgov;
VGOSROW = wgosrow;
VGOSTAX = wgostax;
VGOVGOS = wgovgos;
VGOVROW = wgovrow;
VROWGOS = wrowgos;
VROWGOV = wrowgov;
(All,h,HOU) VGOSHOU(h) = wgoshou(h);
(All,h,HOU) VGOVHOU(h) = wgovhou(h);
(All,h,HOU) VHOUGOV(h) = whougov(h);
(All,h,HOU) VHOUROW(h) = whourow(h);
(All,h,HOU) VROWHOU(h) = wrowhou(h);
(All,hto,HOU)(All,hfrom,HOU)
            VHOUHOU(hto,hfrom) = whouhou(hto,hfrom);
(All,i,IND) GOVSHRINV(i) = 0;

! Excerpt 42 of TABLO input file: !
! Work out total GOS (row) income !

Equation E_wgovgos # interest on public debt # wgovgos = w0gdpexp;
 !  temporary default assumption !

Equation E_wrowgos # GOS from ROW # wrowgos = w0gdpexp; !  default
assumption !

Coefficient VGOS # Total GOS #;
Formula     VGOS = sum{i,IND, S1CAP(i) + S1LAB_O(i) + S1LND_L(i)} +
V1CAP_I + V1LND_IL + V1OCT_I + VROWGOS + VGOVGOS;
Variable    wgos # Total GOS #;
Equation  E_wgos # GOS from income side #
VGOS*wgos =  V1CAP_I*w1cap_i
+ V1LND_IL*w1lnd_il + V1OCT_I*w1oct_i + VROWGOS*wrowgos + VGOVGOS*wgovgos
+ sum[i,IND, [S1CAP(i)* {x1cap(i)+p0cap(i)}+(V0CAP(i)-S1CAP(i))*t1cap(i)
+ sum {o,OCC,S1LAB(i,o)*{x1lab(i,o)+p0lab(i,o)}
                          +[V0LAB(i,o)-S1LAB(i,o)]*t1lab(i,o)}
+ sum {l,LND,S1LND(i,l)*{x1lnd(i,l)+p0lnd(i,l)}
                          +[V0LND(i,l)-S1LND(i,l)]*t1lnd(i,l)}]];

! All terms on RHS come from main model, except for wrowgos and wgovgos !
! Excerpt 43 of TABLO input file: !
! given total GOS income from row total, apportion the corresponding
column !

! Find how much GOS is left once corporation tax is taken out !
Coefficient VGOS_POSTTAX # VGOS less VGOSTAX #;
Formula     VGOS_POSTTAX = VGOS - VGOSTAX;
Variable    wgos_posttax # VGOS less VGOSTAX #;
Equation  E_wgos_posttax # VGOS less VGOSTAX #
VGOS_POSTTAX*wgos_posttax = VGOS*wgos - VGOSTAX*wgostax;

Coefficient GOSTAXRATE # ad valorem GOS Tax #;
Formula     GOSTAXRATE = VGOSTAX/VGOS;

Variable fgostax # ad valorem rate of corporation tax #;
Equation  E_wgostax # corporation tax # wgostax = fgostax + wgos;
```

```
! Remaining GOS goes to:
  government    VGOSGOV
  ROW           VGOSROW
  households    VGOSHOU
  retained earnings : capital account (VGOSSAV)
We assume the first three move in proportion to VGOS_POSTTAX, the
final will be a residual !

Equation  E_wgosgov # GOS to gov # wgosgov = wgos_posttax;
Equation  E_wgosrow # GOS to ROW # wgosrow = wgos_posttax;
Equation  E_wgoshou # GOS to households #
(All,h,HOU)      wgoshou(h) = wgos_posttax;

Formula VGOSSAV = VGOS - Sum(h,HOU, VGOSHOU(h))
                - VGOSGOV - VGOSTAX - VGOSROW;
Equation E_wgossav # find VGOSSAV as residual #
VGOS*wgos = Sum(h,HOU, VGOSHOU(h)*wgoshou(h)) +
   VGOSGOV*wgosgov + VGOSTAX*wgostax + VGOSROW*wgosrow + VGOSSAV*wgossav;

! Define useful addup variable !
Coefficient VGOSHOU_H # total GOS to households #;
Formula     VGOSHOU_H = Sum(h,HOU, VGOSHOU(h));
Variable    wgoshou_h # total GOS to households #;
Equation  E_wgoshou_h # total GOS to households #
VGOSHOU_H*wgoshou_h = Sum(h,HOU, VGOSHOU(h)*wgoshou(h));

! Excerpt 44 of TABLO input file: !
! Wages row is given already by main model !
! now fill in wages column !
! Distribute labour income between households and ROW !

Equation E_w1lab_i # all-industry labour bills #
(All,o,OCC) (TINY+V1LAB_I(o))*w1lab_i(o) =
 Sum(i,IND, V1LAB(i,o)*{p1lab(i,o)+x1lab(i,o)});

Variable (All,o,OCC) labslack(o) # employment rate #;

Equation E_w1labinc # labour income to households #
(All,o,OCC)(All,h,HOU)
w1labinc(o,h) = q(h) + w1lab_i(o) + labslack(o);

!  Assumption of above equation is that labour income (by HYTPE and occ)
 is proportional to population(HYTPE) and to wages(occ) and
that the constant of proportionality (labslack) is independent of HYTPE.
Think of labslack(occ) as the 'employment rate' - same for all HOU.
It is determined by the next equation !

! Implicit data assumption
Imagine matrix V showing wage income by  IND, OCC and HOU
ie              V(i,o,h)
we have only two subtotals of this
V1LABINC(o,h) and V1LAB(i,o) [ignoring migrants]

for o we have

V1LABINC(h) and V1LAB(i) [ignoring migrants]

It is a necessary feature of the data base that the sums of these
vectors are equal (See CHECK3 formula). Say Sum = T.
```

```
to find (for each o) the full V(i,h) matrix we assume

V(i,h) = V(i)*V(h)/T

or, in the full notation

V(i,o,h) = V1LABINC(o,h)*V1LAB(i,o)/T(o)

where T(o) = V1LABINC_H(o) = V1LAB_I(o);

Of interest is the subtotal  over OCC

V(i,h) = Sum(o,OCC,  V1LABINC(o,h)*V1LAB(i,o)/T(o)    )

!

Coefficient (All,o,OCC) VLABROW(o) # wages to ROW #;
Formula     (All,o,OCC) VLABROW(o) =V1LAB_I(o) - V1LABINC_H(o);
Variable    (All,o,OCC) wlabrow(o) # wages to ROW #;
Equation E_wlabrow # wages to ROW #
  (All,o,OCC) wlabrow(o) = w1lab_i(o);


Coefficient VLABROW_O # wages to ROW #;
Formula     VLABROW_O = Sum(o,OCC, VLABROW(o));
Variable    wlabrow_o # wages to ROW #;
Equation E_wlabrow_o # wages to ROW #
   VLABROW_O*wlabrow_o = Sum(o,OCC, VLABROW(o)*wlabrow(o));

Equation E_labslack # adding up constraint #
(All,o,OCC)(TINY+V1LAB_I(o))*w1lab_i(o) = VLABROW(o)*wlabrow(o)
     + Sum(h,HOU, V1LABINC(o,h)*w1labinc(o,h));

Equation E_w1labinc_o # total labour income to households #
(All,h,HOU)
(TINY+V1LABINC_O(h))*w1labinc_o(h) =
  Sum(o,OCC, V1LABINC(o,h)*w1labinc(o,h));


! Excerpt 45 of TABLO input file: !
! Fill in household row (income) !
! Find total household (pre-tax) income !

Coefficient (All,h,HOU) VHOUSINC(h) # pre-tax h'hold income #;
Formula     (All,h,HOU) VHOUSINC(h) = VGOSHOU(h)
+ V1LABINC_O(h)
+ Sum(hfrom,HOU, VHOUHOU(h,hfrom)) + VGOVHOU(h) + VROWHOU(h);

Variable    (All,h,HOU) whousinc(h) # pre-tax h'hold income #;
Equation E_whousinc # pre-tax household income #
(All,h,HOU)
VHOUSINC(h)*whousinc(h) = VGOSHOU(h)*wgoshou(h)
  + V1LABINC_O(h)*w1labinc_o(h)
    + Sum(hfrom,HOU, VHOUHOU(h,hfrom)*whouhou(h,hfrom))
      + VGOVHOU(h)*wgovhou(h) + VROWHOU(h)*wrowhou(h);
! RHS variables wgoshou and w1labinc_o already determined above.
the remainder, wgovhou, whouhou and  wrowhou, determined as follows !

Variable whousinc_h  # total pre-tax h'hold income #;
Equation E_whousinc_h # total pre-tax household income #
Sum(h,HOU, VHOUSINC(h)*{whousinc(h) - whousinc_h}) = 0;
```

```
Equation E_wgovhou # gov transfers to households #
(All,h,HOU) wgovhou(h) = w0gdpexp; ! default assumption !

Equation E_wrowhou # ROW transfers to households #
(All,h,HOU) wrowhou(h) = w0gdpexp; ! default assumption !

Equation E_whouhou # inter-household transfers #
(All,hto,HOU)(All,hfrom,HOU)
        whouhou(hto,hfrom) = wdispinc(hfrom);
! ie, transfer proportional to post-tax donor income !

! Excerpt 46 of TABLO input file: !
! Apportion household col (expenditure) !

! First, find total household (post-tax) income !
! by taking income tax away from whousinc !

Coefficient (All,h,HOU) VDISPINC(h) # post-tax h'hold income #;
Formula     (All,h,HOU)
 VDISPINC(h) = VHOUSINC(h) -  VHOUGOV(h);
Equation E_wdispinc # post-tax household income #
(All,h,HOU) VDISPINC(h)*wdispinc(h) =
    VHOUSINC(h)*whousinc(h) - VHOUGOV(h)*whougov(h);

Variable wdispinc_h  # total post-tax h'hold income #;
Equation E_wdispinc_h # total post-tax h'hold income #
Sum(h,HOU, VDISPINC(h)*{wdispinc(h) - wdispinc_h}) = 0;

Equation E_q # rule of population growth #
(All,h,HOU) q(h) = q_h;

Equation E_avetax_h  # average tax factor #
   wdispinc_h = whousinc_h + avetax_h;

Variable
(All,h,HOU) f_inctaxrate(h)    # income tax shifter: by income  #;
            f_inctaxrate_h     # income tax shifter: overall #;

Equation E_whougovA # households to gov: income taxes and transfers #
whougov("H1Urban") = (28.2/16.3)*whousinc("H1Urban")
                + f_inctaxrate("H1Urban") + f_inctaxrate_h;

Equation E_whougovB # households to gov: income taxes and transfers #
whougov("H2Farm") = (27.0/13.3)*whousinc("H2Farm")
                + f_inctaxrate("H2Farm") + f_inctaxrate_h;

Equation E_whougovC # households to gov: income taxes and transfers #
whougov("H3Otherrural") = (26.9/13.2)*whousinc("H3Otherrural")
                + f_inctaxrate("H3Otherrural") + f_inctaxrate_h;

! note: f_inctaxrate(h), and  f_inctaxrate_h
  are % changes in ad valorem rates !

!  normally  f_inctaxrate_h exogenous; whousinc(h)
given from model, so this determines whougov.  ALTERNATIVELY, shocked
 f_inctaxrate_h, with f_inctaxrate(h) endogenous  total whougov
now determined by additional fiscal restriction (eg, total whougov fixed
) !

Variable f_gosinctax # fgostax - f_inctaxrate_h #;
```

```
Equation E_f_gosinctax # fgostax - f_inctaxrate_h #
     f_gosinctax = fgostax - f_inctaxrate_h;

Equation E_whourow # household transfers to ROW #
(All,h,HOU) whourow(h) = wdispinc(h); ! default rule !

! Find Household Savings as residual !

Coefficient (All,h,HOU) VHOUSAV(h) # household saving #;
Formula     (All,h,HOU) VHOUSAV(h) = VHOUSINC(h)
 - V3TOT(h) - Sum(hto,HOU, VHOUHOU(hto,h)) - VHOUGOV(h) - VHOUROW(h);

Variable (All,h,HOU) whousav(h) # household saving #;
Equation E_whousav # household saving #
(All,h,HOU) VHOUSAV(h)*whousav(h) =
   VHOUSINC(h)*whousinc(h) - V3TOT(h)*w3tot(h) -Sum(hto,HOU,
VHOUHOU(hto,h)*whouhou(hto,h) )       - VHOUGOV(h)*whougov(h) -
VHOUROW(h)*whourow(h);

Variable   whousav_h # household saving #;
Equation E_whousav_h # total household saving #
   sum[h,HOU,VHOUSAV(h)]*whousav_h = sum(h,HOU,VHOUSAV(h)*whousav(h)) ;

! Excerpt 47 of TABLO input file: !
! Fill in government row (income) !

! Apart from VROWGOV, all entries are already determined !

Equation E_wrowgov # transfers from ROW to gov #
         wrowgov = w0gdpexp; !  default rule !

Coefficient VINCGOV # government income #;
Formula     VINCGOV = V0TAX_CSI + VGOSGOV + VGOSTAX +
              Sum(h,HOU, VHOUGOV(h)) + VROWGOV;

Variable wincgov # government income #;
Equation E_wincgov # government income #
VINCGOV*wincgov = V0TAX_CSI*w0tax_csi + VGOSGOV*wgosgov + VGOSTAX*wgostax
  + Sum(h,HOU, VHOUGOV(h)*whougov(h)) + VROWGOV*wrowgov;

! Excerpt 48 of TABLO input file: !
! Find current gov expenditure and capital gov expenditure !
! Hence find gov saving - might be negative in levels !

Coefficient VGOVCUR # current gov expenditure #;
Formula     VGOVCUR = V5TOT + VGOVGOS  + VGOVROW
+ Sum(h,HOU, VGOVHOU(h) );
Variable    wgovcur # current gov expenditure #;
Equation  E_wgovcur # current gov expenditure #
VGOVCUR*wgovcur = V5TOT*w5tot + VGOVGOS*wgovgos + VGOVROW*wgovrow
+ Sum(h,HOU, VGOVHOU(h)*wgovhou(h));

Equation E_wgovrow # GOV transfers to ROW #
wgovrow = w0gdpexp; ! default rule !

Coefficient VGOVCAP # investment gov expenditure #;
Formula     VGOVCAP = Sum(i,IND, GOVSHRINV(i)*V2TOT(i) );
Variable    wgovcap # investment gov expenditure #;
Equation  E_wgovcap # investment gov expenditure #
[VGOVCAP + TINY]*wgovcap =
        Sum(i,IND, GOVSHRINV(i)*V2TOT(i)*{p2tot(i) + x2tot(i)} );
```

```
Coefficient VGOVEXP # total gov expenditure #;
Formula     VGOVEXP = VGOVCUR + VGOVCAP;
Variable    wgovexp # total gov expenditure #;
Equation  E_WGOVEXP # total gov expenditure #
VGOVEXP*wGOVEXP = VGOVCUR*wgovcur + VGOVCAP*wgovcap;

Coefficient VGOVSAV # gov (income - expenditure) #;
Formula     VGOVSAV = VINCGOV - VGOVEXP;
Variable    wgovsav # gov (income - expenditure) #;
Equation  E_wgovsav # gov (income - expenditure) #
     VGOVSAV*wgovsav = VINCGOV*wincgov - VGOVEXP*wgovexp;


Variable (Change)   delsgovsav # gov (income - expenditure)/GDP#;
Equation  E_delsgovsav # gov (income - expenditure)/GDP #
     100*V0GDPEXP*delsgovsav = VGOVSAV*wgovsav - V0GDPEXP*w0gdpexp;

Variable realgovsav # real gov (income - expenditure)#;
Equation  E_realgovsav # real gov (income - expenditure)#
     realgovsav = wgovsav - p0gdpexp;

! Excerpt 49 of TABLO input file: !
! Find investment private expenditure !
! Private investment finance requirement is just the negative of this !

Coefficient VPRIVCAP # investment private expenditure #;
Formula     VPRIVCAP = V2TOT_I - VGOVCAP + V6TOT ;
Variable    wprivcap # investment private expenditure #;
Equation  E_wprivcap # investment private expenditure #
   VPRIVCAP*wprivcap = V2TOT_I*w2tot_i - VGOVCAP*wgovcap+ V6TOT*w6tot ;

! Excerpt 50 of TABLO input file: !
! Find ROW row and column sums !

Coefficient VROWEXP # total ROW expenditure #;
Formula VROWEXP = V4TOT_D + VROWGOV + VROWGOS
          + Sum(h,HOU, VROWHOU(h));
Variable    wrowexp # total ROW expenditure #;
Equation  E_wrowexp # total ROW expenditure #
VROWEXP*wrowexp =  V4TOT_D*w4tot_d + VROWGOV*wrowgov + VROWGOS*wrowgos
       + Sum(h,HOU, VROWHOU(h)*wrowhou(h));

Coefficient VINCROW # total ROW income #;
Formula VINCROW =  Sum(h,HOU, VHOUROW(h)) + VGOVROW + V0CIF_C + VGOSROW +
VLABROW_O;
Variable    wincrow # total ROW income #;
Equation  E_wincrow # total ROW income #
VINCROW*wincrow = Sum(h,HOU, VHOUROW(h)*whourow(h)) + VGOVROW*wgovrow +
V0CIF_C*w0cif_c + VGOSROW*wgosrow + VLABROW_O*wlabrow_o;

Coefficient VROWSAV # ROW (income - expenditure) #;
Formula     VROWSAV = VINCROW - VROWEXP;
Variable    wrowsav # ROW (income - expenditure) #;
Equation  E_wrowsav # ROW (income - expenditure) #
    VROWSAV*wrowsav = VINCROW*wincrow - VROWEXP*wrowexp;

! Excerpt 51 of TABLO input file: !
! Check Accounting !
! It is a mathematical necessity that the sum of all saving = 0 !
! Check if this is so, both in levels and in changes !
```

```
Coefficient VSAMCHECK # Global (income - expenditure) #;
Formula VSAMCHECK = Sum(h,HOU, VHOUSAV(h))
              + VGOSSAV + VGOVSAV - VPRIVCAP + VROWSAV;

Variable     wsamcheck # Global (income - expenditure) #;
Equation  E_wsamcheck # Global (income - expenditure) #
V0GDPEXP*wsamcheck = Sum(h,HOU, VHOUSAV(h)*whousav(h))
+ VGOSSAV*wgossav + VGOVSAV*wgovsav - VPRIVCAP*wprivcap +
VROWSAV*wrowsav;
! note wsamcheck is expressed as a % of GDP: it should be tiny !

Set SAVINGS # Income Aggts # (HOU, GOS, GOV, ROW, CAP);
Coefficient  (all,sa,SAVINGS) SAVING(sa) # Income Aggregates #;
Formula
 SAVING("HOU")      =   Sum{h,HOU, VHOUSAV(h)};
 SAVING("GOS")      =   VGOSSAV;
 SAVING("GOV")      =   VGOVSAV;
 SAVING("ROW")      =   VROWSAV;
 SAVING("CAP")      =   - VPRIVCAP;
Write SAVING to file SUMMARY header "SAVE" longname "Saving";

Display
 V0GDPEXP;  V0GDPINC;   VGOS; VGOSGOV;    VGOSHOU_H;  VGOS_POSTTAX;
 VGOSROW;   VGOSSAV;    VGOSTAX;          VGOVCAP;    VGOVCUR;
 VGOVEXP;   VGOVGOS;    VGOVROW;          VGOVSAV;    VHOUSAV ;
 VHOUSINC;  VINCGOV;    VINCROW;          VLABROW;    VPRIVCAP;
 VROWEXP;   VROWGOS;    ROWGOV;           ROWSAV;     SAMCHECK;
 V0TAX_CSI; V0CIF_C;    V1TOT;            V1LND_L;    V3TOT_H;
 V2TOT_I;   V4TOT_D;    V5TOT;            V6TOT;      V1LND_IL;
 V1CAP_I;   V1LAB_IO;   V1OCT_I;          V1BAS;      V2BAS;
 V3BAS;     V4BAS;      V1PUR_S;          V1PRIM;     V1OCT;

Coefficient (All,h,HOU) INCTAXRATE(h) # tax rates #;
Formula     (All,h,HOU) INCTAXRATE(h) = VHOUGOV(h)/(TINY + VHOUSINC(h));
Display
 INCTAXRATE;
 GOSTAXRATE;

! Additional Reporting Variables !

! 1:  Output of Commodities !
Variable
 x0com_agri # output of agriculture #;
 x0com_manu # output of manufacturing #;
 x0com_serv # output of services #;

 p0com_agri # output of agriculture #;
 p0com_manu # output of manufacturing #;
 p0com_serv # output of services #;

 p0dom_agri # output of agriculture #;
 p0dom_manu # output of manufacturing #;
 p0dom_serv # output of services #;

Equation  E_x0com_agri # output by industry type #
sum(c,R1Agri,Make_I(c)) * x0com_agri= sum(c,R1Agri, Make_I(c) *
x0com(c));
Equation  E_x0com_manu # output by industry type #
sum(c,R2Manu,Make_I(c)) * x0com_manu= sum(c,R2Manu, Make_I(c) *
x0com(c));
```

```
Equation  E_x0com_serv # output by industry type #
sum(c,R3Serv,Make_I(c)) * x0com_serv= sum(c,R3Serv, Make_I(c) *
x0com(c));

Equation  E_p0com_agri # output by industry type #
sum(c,R1Agri,Make_I(c)) * p0com_agri= sum(c,R1Agri, Make_I(c) *
p0com(c));
Equation  E_p0com_manu # output by industry type #
sum(c,R2Manu,Make_I(c)) * p0com_manu= sum(c,R2Manu, Make_I(c) *
p0com(c));
Equation  E_p0com_serv # output by industry type #
sum(c,R3Serv,Make_I(c)) * p0com_serv= sum(c,R3Serv, Make_I(c) *
p0com(c));

Equation  E_p0dom_agri # output by industry type #
sum(c,R1Agri,Make_I(c)) * p0dom_agri= sum(c,R1Agri, Make_I(c) *
p0dom(c));
Equation  E_p0dom_manu # output by industry type #
sum(c,R2Manu,Make_I(c)) * p0dom_manu= sum(c,R2Manu, Make_I(c) *
p0dom(c));
Equation  E_p0dom_serv # output by industry type #
sum(c,R3Serv,Make_I(c)) * p0dom_serv= sum(c,R3Serv, Make_I(c) *
p0dom(c));
```

Appendix 2.1: Agro_IO: Ireland 1993 Input-Output 33 Branch Transactions at Basic Prices for Domestic and Import Flows Combined

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Milk	(1)	3.3	4.7	0.8	7.0													1059.3
Cattle	(2)																1115.5	
Sheep+Wool	(3)																164.0	
Pigs,Poul.Hors	(4)												0.0	0.0		0.1	295.8	
Wheat,Bar.Oats	(5)					5.8												
Fruit + Veg	(6)											0.0	0.1	0.1		0.6		
Root+Green	(7)							1.2					0.0	0.0		0.1		
Other Crops	(8)				2.0				0.3						0.8			
Forestry	(9)																	
Fishing	(10)																	
Petrol.+Coal	(11)	5.6	7.4	1.1	0.9	0.8	0.8	0.6	0.1	0.5	0.9	25.4	31.4	4.1	9.4	3.1	6.2	0.8
Elec.,Gas,Wat	(12)	13.2	17.5	2.5	2.1	1.9	1.8	1.4	0.3			1.1	220.1	27.7	64.9	69.3	31.6	22.9
Non-Met.Min.	(13)	1.6	2.4	0.5	0.3		0.3	0.1	0.0			0.8	38.1	87.9	14.0	9.1	0.2	4.3
Chemicals	(14)	31.5	79.6	12.9	3.1	14.5	6.7	10.5	1.2			0.5	9.5	10.3	98.9	13.3		2.3
Metal,Eng.,Veh.	(15)	1.4	2.3	0.4	0.3	0.0	0.2	0.1	0.0	0.1	0.1	2.5	57.4	25.7	15.8	354.6	11.3	16.9
Meat	(16)	0.9	1.3	0.2	1.9							0.0	0.2	0.1	0.4	1.0	280.0	0.4
Milk Prods.	(17)	14.5	20.9	3.5	31.0							0.0	0.2	0.1	0.4	1.1	0.3	351.2
Farm Anim.Feed	(18)	72.9	105.2	17.8	156.1													
Other Food nes	(19)											0.0	0.1	0.2	2.3	0.7	5.1	42.1
Beverag.+Tobac	(20)					2.4									1.1			
Textil.Cloth.Lea.	(21)	0.1	0.1	0.0	0.0		0.0	0.0	0.0		0.1			0.2	0.1	0.2		
Wood+Paper	(22)	1.2	1.9	0.4	0.3		0.2	0.1	0.0			0.1	1.1	10.4	24.4	66.7	30.5	28.2
Rubb.Plast.,O.M	(23)	0.7	1.0	0.2	0.1		0.1	0.0	0.0			0.2	2.6	5.3	16.1	63.2	14.1	17.0
Construction	(24)	21.2	31.2	5.0	5.2	1.8		1.3	0.4			0.5	90.6	10.6	14.2	20.2	4.6	10.7
Trade Marg.+Rep	(25)	48.0	85.1	15.2	25.9	11.2	11.2	7.0	2.4	2.7	6.0	0.2	72.2	39.0	85.7	241.7	50.0	90.4
Lodging+Cater.	(26)											0.1	1.2	0.9	2.8	7.3	1.0	2.6
Inland Transpt.	(27)	1.2	2.1	0.1	0.1	0.2	0.1	0.3	0.1	0.9	2.6	0.5	0.9	24.4	15.2	59.8	20.4	5.1
Mar.,Air,Aux.Tr.	(28)	0.3	0.5	0.0	0.0	0.1	0.0	0.1	0.0		0.6	0.6	1.1	29.3	18.0	50.2	21.9	5.4
Communications	(29)	6.2	10.8	0.5	0.3	1.1	0.7	1.3	0.3	0.0	0.1	0.4	7.8	6.5	9.4	52.3	5.1	4.8
Credit+Insur.	(30)	67.5	84.0	15.6	8.3	11.2	7.4	7.5	1.9	0.8	1.5	1.4	14.7	34.4	341.9	247.8	21.8	41.4
Other Mkt.Serv.	(31)	15.0	26.0	1.2	0.6	2.5	1.7	3.1	0.8	6.0	6.8	4.5	24.4	25.9	72.7	670.7	19.7	50.9
Gener.Publ.Serv.	(32)											0.1	0.9	0.7	2.1	5.4	0.7	2.0
Other Non-Mkt.S	(33)	2.3	4.0	0.2	0.1	0.4	0.3	0.5	0.1			0.1	0.9	0.7	2.2	5.6	0.8	2.1
TOTAL DOMESTIC		308.3	487.8	78.2	245.5	53.8	31.5	34.9	8.0	11.0	18.4	39.1	575.4	344.5	813.0	1943.8	2100.5	1760.7
Merch.Imports		70.2	128.6	21.3	56.0	15.5	11.4	11.3	2.2	2.7	6.2	170.3	163.0	185.6	736.3	3442.7	99.1	114.2
Invis. Imports		4.4	7.6	0.4	0.2	0.7	0.5	0.9	0.2				15.9	17.4	47.2	476.6	12.7	32.7
Indirect Taxes		33.9	33.2	3.9	3.2	6.1	2.6	2.3	0.4	3.5	6.4	3.3	51.0	22.9	20.4	85.8	18.5	17.6
less Subsidies		-46.0	-202.9	-181.2	-1.6	-0.4	-0.3	-0.3	-0.1			-13.9	-0.2	-3.8	-24.3	-84.8	-10.6	-37.6
Total Labour Costs		38.4	57.3	15.7	33.8	8.5	3.8	14.1	2.3	25.4	17.9	13.6	310.0	305.2	396.3	1300.5	160.3	154.3
Net Profits		618.4	679.5	214.8	34.1	29.3	44.3	19.3	7.4	12.5	96.8	54.7	178.0	106.8	1667.9	923.4	33.7	115.7
Depreciation		104.3	157.4	23.1	19.0	16.5	12.9	11.0	2.6	0.5	29.9	11.2	100.8	47.0	206.5	249.9	29.7	34.5
TOTAL INPUT		1131.9	1348.5	176.2	390.1	130.2	106.6	93.6	23.0	55.5	175.6	278.3	1393.8	1025.7	3863.2	8337.7	2443.9	2192.2
Househ. Income		643.5	716.9	225.1	56.1	34.9	46.8	28.5	8.9	29.0	108.5	63.6	380.2	206.3	370.4	910.4	106.9	108.5
Governm.Income		1.2	-149.8	-171.9	13.3	8.7	3.6	6.9	1.1	12.4	12.6	-5.9	158.5	135.2	289.3	539.1	66.7	44.4
Savings		104.3	157.4	23.1	19.0	16.5	12.9	11.0	2.6	0.5	29.9	11.2	100.8	51.2	272.7	286.5	31.0	39.1
Gross National Prod		749.0	724.5	76.3	88.4	60.2	63.3	46.4	12.6	41.8	150.9	68.9	639.5	392.7	932.4	1736.0	204.6	191.9
Imports+Outflows		74.6	136.2	21.7	56.2	16.2	11.9	12.2	2.4	2.7	6.2	170.3	178.9	288.5	2117.9	4657.9	138.8	239.5
Employment(thous.)		34.0	57.0	17.2	3.4	3.1	3.3	2.5	0.6	1.9	3.1	0.6	10.8	16.7	15.8	69.9	11.4	7.5

Appendix 2.1 Continued

		(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	Total
Milk	(1)		44.3															1119.3
Cattle	(2)																	1115.5
Sheep+Wool	(3)				3.2													167.2
Pigs,Poul.Hors	(4)		2.3			0.0		0.0	0.4	0.1	0.1	0.3	0.1	0.1	1.3	0.2	0.9	301.7
Wheat,Bar.Oats	(5)	25.4	37.6	35.7														104.5
Fruit + Veg	(6)		5.6	0.1		0.1	0.1	0.4	4.2	0.8	0.6	3.1	0.9	1.2	13.6	2.4	9.2	43.0
Root+Green	(7)		54.6	0.0		0.0	0.0	0.1	0.7	0.1	0.1	0.6	0.2	0.2	2.4	0.4	1.6	62.4
Other Crops	(8)	9.6																12.6
Forestry	(9)					18.7												18.7
Fishing	(10)		60.0															60.0
Petrol.+Coal	(11)	0.4	1.9	0.6	1.0	1.0	0.8	14.4	9.6	1.4	1.1	23.8	3.7	2.8	15.6	7.0	5.3	189.2
Elec.,Gas,Wat	(12)	5.8	24.1	12.1	13.3	18.6	18.2	29.5	83.2	32.3	4.8	9.6	16.5	9.1	116.8	39.9	29.2	941.4
Non-Met.Min.	(13)	2.6	10.8	19.5	0.5	2.4	7.6	379.0	0.1	16.9	0.4			3.8	19.2	6.3	3.6	632.3
Chemicals	(14)	2.0	8.5	4.1	4.6	18.1	14.5	31.0	1.8	5.6	0.6	2.2	0.0		119.4	5.7	27.4	540.1
Metal,Eng.,Veh.	(15)		10.5	13.1	6.4	52.3	17.5	125.4	56.9	3.2	35.8	33.6	0.6	4.2	11.3	17.5	16.3	893.7
Meat	(16)	6.0	24.9	0.5	23.8	2.4	0.2	0.2	7.2	0.4	1.1	5.3	1.6	2.1	17.5	5.4	38.0	422.8
Milk Prods.	(17)	23.4	97.3	34.2	0.2	0.3	0.2	0.2	7.7	0.5	1.1	13.8	1.7	2.2	13.3	4.5	14.2	637.9
Farm Anim.Feed	(18)	112.4																464.3
Other Food nes	(19)		39.9	28.6	0.5	0.2	0.1	0.1	4.3	0.3	0.7	10.1	1.0	1.3	11.1	8.6	20.5	177.7
Beverag.+Tobac	(20)	0.2	0.8	41.1					31.6	0.2	1.1	7.3	1.0	1.8	9.6	1.8	4.6	104.5
Textil.Cloth.Lea.	(21)	0.1	0.3		13.3	1.9	1.5	0.6	1.6	0.6	0.1	1.1	0.5	0.0	1.1	3.4	0.7	27.4
Wood+Paper	(22)	8.7	36.0	14.0	4.7	133.7	17.8	85.9	35.5	9.0	4.9	3.5	11.5	28.5	133.4	24.9	74.0	791.5
Rubb.Plast.,O.M	(23)	2.8	11.7	11.3	5.2	8.9	18.9	20.3	19.6	1.6	1.4	0.9	1.1	1.0	12.8	7.2	12.4	257.4
Construction	(24)	2.3	9.4	0.5	3.2	7.5	4.3		141.4	76.1	35.9	38.1	234.6	24.4	210.4	275.7	39.5	1320.5
Trade Marg.+Rep	(25)	23.4	97.2	34.6	45.4	60.9	27.6	360.8	179.4	24.7	57.0	7.0	13.1	22.3	117.7	32.4	11.5	1908.7
Lodging+Cater.	(26)	1.2	5.0	3.2	0.9	2.0	1.0	1.3	17.5	1.3	3.1	24.2	4.5	12.8	30.3	8.7	11.0	144.1
Inland Transpt.	(27)	4.9	20.1	9.3	7.6	15.5	10.1	30.1	173.1	1.2	24.0	21.2	3.0	1.3	11.4	6.7	4.5	477.4
Mar.,Air,Aux.Tr.	(28)	5.7	23.6	11.4	7.3	18.3	12.3		33.4	4.3	9.8	155.8		0.5	0.3	8.4	0.0	418.9
Communications	(29)	1.3	5.5	3.2	4.9	11.1	5.9	13.6	69.1	33.5	10.1	13.0	126.0	55.9	99.5	89.2	36.2	685.5
Credit+Insur.	(30)	6.6	105.8	72.6	20.7	53.4	26.1	111.6	359.3	71.6	25.4	20.0	34.5	183.0	308.1	106.5	18.7	2433.0
Other Mkt.Serv.	(31)	9.0	435.8	57.9	21.8	42.4	26.1	96.2	361.7	87.9	26.2	51.9	21.1	206.3	301.9	83.8	605.8	3368.2
Gener.Publ.Serv.	(32)		4.7	2.4	0.7	1.5	0.7		74.9	33.4	8.2	15.8	7.8	33.0	119.5	4.9	37.3	356.6
Other Non-Mkt.S	(33)		4.9	2.5	0.7	1.6	0.8	0.7	0.6		0.1	0.1	0.1	7.2	72.4	8.4	36.3	156.3
TOTAL DOMESTIC		253.6	1182.7	412.1	189.6	472.8	212.1	1301.4	1674.8	406.8	253.7	462.0	484.8	605.0	1769.6	759.7	1058.7	20354.0
Merch.Imports		147.9	404.0	135.2	302.2	294.4	269.0	831.1	241.8	33.6	61.4	85.7	8.4	15.1	243.5	68.1	144.8	8522.8
Invis. Imports		4.8	323.7	36.8	13.0	27.6	12.6	72.1	300.4	77.1	26.3	264.8	22.0	152.3	188.8	90.0	29.1	2258.6
Indirect Taxes		5.0	27.0	10.8	13.1	13.8	7.9	87.9	114.1	15.9	88.2	47.6	44.7	133.4	208.8	105.9	157.7	1396.6
less Subsidies		-1.6	-8.7	-0.3	-9.1	-5.4	-11.7	-0.3	-237.1	-1.7	0.0	-6.1		-1.6	-34.9			-926.4
Total Labour Costs		30.3	296.7	161.0	243.2	406.1	217.7	1231.7	1893.7	511.8	262.4	386.6	281.0	1009.4	1897.7	1637.1	2699.0	16022.5
Net Profits		35.4	346.8	321.3	45.1	147.6	78.4	311.0	1104.2	207.1	146.0	58.1	134.6	830.9	2109.1			10712.1
Depreciation		6.0	58.8	26.6	24.1	44.7	34.3	36.6	177.3	60.3	50.9	66.5	149.3	252.4	908.2	71.6	133.3	3157.4
TOTAL INPUT		481.3	2631.0	1103.4	821.1	1401.4	820.1	3871.6	5269.1	1311.0	888.8	1365.2	1124.9	2996.9	7290.8	2732.3	4222.7	61497.6
Househ. Income		22.1	216.8	126.6	161.7	274.9	147.3	879.4	1504.6	384.4	206.8	266.4	205.0	861.0	2122.2	1068.2	1761.0	14252.6
Governm.Income		17.2	153.8	96.4	92.8	163.3	79.2	621.0	909.0	262.3	228.7	195.6	205.7	764.0	1434.3	674.8	1095.8	7959.2
Savings		7.4	72.5	39.4	25.8	50.5	37.4	81.4	336.5	90.2	72.0	74.9	162.1	372.2	908.2	71.6	133.3	3705.1
Gross National Prod.		46.7	443.2	262.4	280.3	488.6	263.8	1581.9	2750.1	736.9	507.5	536.9	572.8	1997.2	4464.8	1814.5	2990.1	25916.9
Imports+Outflows		181.0	1005.1	429.0	351.2	440.0	344.2	988.3	844.2	167.4	127.6	366.4	67.3	394.7	1056.4	158.1	173.9	15226.7
Employment(thous.)		1.6	17.3	5.5	20.4	21.9	12.5	73.3	197.4	57.1	30.9	17.3	21.5	42.8	121.6	75.5	158.1	1133.4

Appendix 2.2: Matrix of Occupation Use by Industry

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	26	28	29	30	31	32	33
MALE TOTAL EMPLOYED	32.0	53.6	16.2	3.1	2.8	3.0	2.3	0.5	1.7	2.8	0.4	7.8	12.1	11.4	50.5	8.2	5.4	1.2	12.5	4.0	14.7	15.8	9.0	69.9	115.9	21.1	24.7	13.8	17.2	25.1	45.0	51.3	65.6
FEMALE TOTAL EMPLOYED	3.0	5.0	1.5	0.3	0.3	0.3	0.2	0.0	0.2	0.3	0.2	3.0	4.6	4.4	19.4	3.2	2.1	0.5	4.8	1.5	5.7	6.1	3.5	3.4	81.5	36.0	6.2	3.5	4.3	17.6	76.6	24.2	92.5
TOTAL EMPLOYED	34.9	58.5	17.7	3.4	3.1	3.3	2.5	0.6	1.9	3.1	0.6	10.8	16.7	15.8	69.9	11.4	7.5	1.6	17.3	5.5	20.4	21.9	12.5	73.3	197.4	57.1	30.9	17.3	21.5	42.8	121.6	75.5	158.1
Male Agricultural Workers	31.7	49.7	15.1	3.1	2.8	3.0	2.2	0.5	1.7	2.7	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.3	0.0	0.0	0.0	0.1	0.7	0.9	3.8
Female Agricultural Workers	2.7	4.2	1.3	0.3	0.2	0.2	0.2	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.3
Total Agricultural Workers	34.4	53.9	16.4	3.3	3.0	3.2	2.4	0.5	1.8	3.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.4	0.0	0.0	0.0	0.1	0.8	1.0	4.1
Male Producers, Makers, Repairers	0.0	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	4.7	7.3	6.9	30.5	5.0	3.3	0.7	7.6	2.4	8.9	9.6	5.5	45.8	15.2	0.9	5.0	2.8	3.5	3.3	2.0	1.9	5.0
Female Producers, Makers, Repairers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.6	2.4	2.3	10.2	1.7	1.1	0.2	2.5	0.8	3.0	3.2	1.8	0.5	1.0	0.2	0.1	0.0	0.1	0.2	0.4	0.1	1.7
Total Producers, Makers, Repairers	0.0	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	6.3	9.7	9.2	40.7	6.6	4.4	0.9	10.1	3.2	11.9	12.7	7.3	46.3	16.2	1.1	5.1	2.8	3.6	3.5	2.4	2.0	6.6
Male Labourers & Unskilled	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5	0.5	2.2	0.4	0.2	0.1	0.5	0.2	0.6	0.7	0.4	12.6	1.6	0.2	0.9	0.5	0.6	0.4	0.5	1.4	2.6
Female Labourers & Unskilled	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.1	0.1	0.0				0.0	0.0	0.0	0.2
Total Labourers & Unskilled	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.6	0.5	2.4	0.4	0.3	0.1	0.6	0.2	0.7	0.7	0.4	12.7	1.7	0.2	0.9	0.5	0.6	0.4	0.5	1.4	2.7
Male Transport & Communication	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.0	1.0	4.3	0.7	0.5	0.1	1.1	0.3	1.2	1.3	0.8	3.0	10.1	0.4	13.6	7.6	9.5	2.2	0.8	1.9	1.5
Female Transport & Communication	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	1.0	0.2	0.1	0.0	0.2	0.1	0.3	0.3	0.2	0.0	1.1	0.1	1.4	0.8	1.0	0.2	0.1	0.2	0.5
Total Transport & Communication	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.3	1.2	5.3	0.9	0.6	0.1	1.3	0.4	1.5	1.6	0.9	3.0	11.2	0.5	14.9	8.3	10.4	2.4	1.0	2.1	2.0
Clerical Workers																																	
Male Clerical Workers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.3	1.3	0.2	0.1	0.0	0.3	0.1	0.4	0.4	0.2	0.7	6.9	0.6	2.1	1.2	1.5	1.5	1.3	9.4	2.1
Female	0.2	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.1	1.0	4.6	0.8	0.5	0.1	1.1	0.4	1.4	1.5	0.8	2.2	28.6	6.3	3.1	1.7	2.2	6.2	13.4	18.2	14.2
Total	0.2	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.4	1.3	6.0	1.0	0.6	0.1	1.5	0.5	1.7	1.9	1.1	2.9	35.4	6.9	5.2	2.9	3.6	7.7	14.7	27.6	16.3
Commerce, Insurance and Finance																																	
Male	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5	0.5	2.0	0.3	0.2	0.0	0.5	0.2	0.6	0.6	0.4	0.2	61.6	0.2	0.3	0.1	0.2	13.4	0.4	0.0	4.7
Female	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.6	0.1	0.1	0.0	0.2	0.1	0.2	0.2	0.1	0.0	41.9	0.2	0.4	0.2	0.3	9.1	0.5	0.0	4.4
Total	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.6	0.6	2.7	0.4	0.3	0.1	0.7	0.2	0.8	0.8	0.5	0.2	103.6	0.4	0.7	0.4	0.5	22.4	0.8	0.0	9.0
Service Workers																																	
Male	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.5	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0.1	1.4	1.5	1.7	0.8	0.5	0.6	0.3	3.7	14.4	33.2
Female	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.1	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.2	2.4	5.3	0.7	0.4	0.5	0.5	11.2	2.1	60.0
Total	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.8	0.1	0.1	0.0	0.2	0.1	0.2	0.2	0.1	1.6	4.0	7.0	1.5	0.8	1.1	0.9	14.9	16.5	93.2
Professional and technical workers																																	
Male	0.0	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.1	1.1	4.8	0.8	0.5	0.1	1.2	0.4	1.4	1.5	0.9	4.2	7.7	16.1	0.7	0.4	0.5	1.7	34.3	5.8	6.8
Female	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.4	1.6	0.3	0.2	0.0	0.4	0.1	0.5	0.5	0.3	0.3	4.0	23.5	0.2	0.1	0.2	0.9	50.1	1.9	8.3
Total	0.0	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.0	1.5	1.4	6.4	1.0	0.7	0.1	1.6	0.5	1.9	2.0	1.1	4.5	11.7	39.6	0.9	0.5	0.6	2.5	84.4	7.7	15.1
Other Males	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.1	1.1	4.8	0.8	0.5	0.1	1.2	0.4	1.4	1.5	0.8	1.8	10.8	0.6	1.3	0.7	0.9	2.3	1.2	15.7	6.0
Other Females	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.9	0.1	0.1	0.0	0.2	0.1	0.3	0.3	0.2	0.1	2.3	0.4	0.3	0.2	0.2	0.5	0.8	1.5	3.0
Other Total	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.3	1.3	5.6	0.9	0.6	0.1	1.4	0.4	1.6	1.8	1.0	1.9	13.2	0.9	1.6	0.9	1.1	2.9	2.0	17.2	9.0
Male Unemployed	0.3	2.6	0.7	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	1.0	1.6	1.5	6.7	1.1	0.7	0.2	1.7	0.5	2.0	2.1	1.2	24.3	10.4	1.1	1.7	1.0	1.2	2.2	2.4	1.1	13.9
Female Unemployed	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.6	0.5	2.4	0.4	0.3	0.1	0.6	0.2	0.7	0.7	0.4	0.6	6.1	1.5	0.4	0.2	0.2	1.3	3.2	0.3	13.7
Total Unemployed	0.4	2.9	0.8	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	1.4	2.2	2.1	9.1	1.5	1.0	0.2	2.2	0.7	2.6	2.8	1.6	24.9	16.5	2.6	2.1	1.2	1.5	3.6	5.6	1.5	27.6

Appendix 2.3: Matching of Transfer Payments in NIE24 to sub-totals in Table 4.4.1

NIE24 Transfer Payment List	*Table 4.4.1 Transfer Payment List*
National debt interest:	National debt interest:
paid to residents	paid to residents
paid to the rest of the world	paid to the rest of the world
Higher education	Education Expenditure
Secondary education	Education Expenditure
Other education	Education Expenditure
Scholarships and prizes	Education Expenditure
Old age n.c. pensions	Old Age Payments
Child benefit	Child benefits
Unemployment assistance	Unemployment assistance
Widows' and orphans' n.c. pensions	Old Age Payments
Redundancy payments	Income Related Payments
Occupational injuries benefit	Old Age Payments
Free travel, electricity, telephone rental,television and radio licences for old age pensioners, etc.	Old Age Payments
Disability benefit	Old Age Payments
Unemployment benefit	Unemployment benefit
Retirement pensions	Old Age Payments
Old age (contributory) pensions	Old Age Payments
Widows'(contributory) pensions	Old Age Payments
Invalidity pensions	Old Age Payments
Treatment benefit	Health benefits
Pay-related benefit	Income Related Payments
Other social insurance etc.	Income Related Payments
less Social insurance payments to the rest of the world	Other
Rehabilitation etc. of disabled persons	Health benefits
Section 65 of the Health Act,1953	Health benefits
Payments for medical goods supplied to households by pharmacists	Health benefits
Domiciliary care for handicapped children	Child benefits
Supplementary welfare allowance	Income Related Payments
Subsidies for drug purchases	Health benefits
Transport services for school children	Child benefits
Local government housing rental deficit *	Housing Benefits
Other social payments	Other
Transfers to the rest of the world	Transfers to the rest of the world
Social assistance allowance	Income Related Payments
Social employment scheme	Income Related Payments
Family income supplement	Income Related Payments
Enterprise allowance scheme	Income Related Payments
FAS allowances	Income Related Payments
Lone Parents Allowance	Child benefits
Pre-retirement Allowance	Old Age Payments
Employment Support Services	Income Related Payments
Other transfer payments	Income Related Payments

Appendix 2.4: Industry/Commodity Mappings

CSO List (41 sector)	*Ag-IO List (33-Sector)*	*Export Margin Mapping*	*HH Expenditure Mapping*
Agriculture Forestry,Fishing (1)	Milk (1)	Agri- products and Live Animals	Food
"	Cattle(2)	Agri- products and Live Animals	N.A.
"	Sheep+ Wool(3)	Agri- products and Live Animals	N.A.
"	Pigs,Poultry,Horses(4)	Agri- products and Live Animals	Food
"	Wheat,Barley,Oats(5)	Agri- products and Live Animals	N.A.
"	Fruit+ Vegetables(6)	Foodstuffs and Animal fodder	Food
"	Root+ Green(7)	Agri- products and Live Animals	Food
"	Other Crops(8)	Agri- products and Live Animals	Food
"	Forestry(9)	Other	Non-Durables
"	Fishing(10)	Agri- products and Live Animals	Food
Coal(2)	Petroleum+Coal(11)	Other	Fuel
Petrol.+ Natural Gas(3)	"	Other	Fuel
Electr.,Gas,Water (4)	Electr.,Gas,Water (12)	Other	Non-Durables
Non-Metall.Minr.Prods(6)	Non-Metall.Minls(13)	Other	Non-Durables
Chemical Prods.(7)	Chemicals(14)	Chemicals & Fertilisers	Durables
Metals+ Ores (5)	Metal,Engin.,Vehic.(15)	Other	Food
Metal Prods.ex.mach.(8)			Food
Agric.+ Indust.Mach. (9)			N.A.
Office Machines (10)			Food
Electrical Goods (11)			Drink
Motor Vehicles (12)			Clothing
Other Transport Equipm.(13)			Non-Durables
Meat+ Meat Prods.(14)	Meat (16)	Foodstuffs and Animal fodder	Non-Durables
Milk+ Dairy Prods.(15)	Milk Products (17)	Foodstuffs and Animal fodder	N.A.
Other Food Products (16)	Farm Animal Feed(18)	Foodstuffs and Animal fodder	N.A.
	Other Food Prods	Foodstuffs and Animal fodder	Services
Beverages(17)	Beverages+ Tobacco (20)	Foodstuffs and Animal fodder	Transport
Tobacco Prods.(18)			Transport
Textiles,Clothing(19)	Textiles,Cloth.,Leat(21)	Other	Services
Leather+ Footwear(20)		Other	Services
Wood Prods.,Furniture(21)	Wood+ Paper(22)	Other	Services
Paper+ Printing Prods.(22)		Other	Services
Rubber+ Plastic Products(23)	Rubber,Plast.	Other	Services
Other Manufact.Prods.(24)		Other	Housing
Build.+ Construct.(25)	Const (24)	Other	Food
Repair+ Recov.Servs.(26)	Trade Margin(25)	Other	N.A.
Wholesale+ Retail Trade (27)		Other	N.A.
Lodging+Catering Services(28)	Lodging+ Catering (26)	Other	Food
Inland Transport (29)	Inland Transport (27)	Other	N.A.
Maritime+ Air Transport(30)	Marine,Air Transpt.	Other	Food
Auxiliary Transport (31)		Other	Food
Communic. Servs. (32)	Communications(29)	Other	Food
Credit+ Insurance (33)	Credit+ Insurance (30)	Other	Non-Durables
Business Services(34)	Oth Market Services(31)	Other	Food
Rent.of Immov.Goods(35)			Fuel
Other Market Services(36)			Fuel
General Public Services			Non-Durables
Non-market Health Services			Non-Durables
Other Non-Market Services			Durables
			Food

Appendix 3.1: 1998 Domestic Intermediate Flows, Basic Prices

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1 C1Milk	3.43	5	1	8	0	0	0	0	0	0	0	0	0	0	0	0	1066.86
2 C2Cattle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	997.3	0
3 C3SheepWool	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	161.1	0
4 C4OtherLive	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0	0.07	321.2	0
5 C5Cereals	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0
6 C6FruitVeg	0	0	0	0	0	0	0	0	0	0	0.07	0.06	0.08	0	0.77	0	0
7 C7RootGreen	0	0	0	0	0	0	2	0	0	0	0	0.01	0.01	0	0.13	0	0
8 C8OtherCrops	0	0	0	3	0	0	0	0	0	0	0	0	0	1.76	0	0	0
9 C9Forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 C10Fishing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 C11PetCoal	16.15	23	3	3	2	3	1	0	1	0.91	113.2	90.25	21.03	42.45	8.62	12.98	1.87
12 C12ElecGas	17.85	26	3	3	2	4	2	0	0	0	1.43	284.32	45.37	106.63	98.83	32.93	22.23
13 C13NonMet	2.02	3	1	0	0	0	0	0	0	0	1.14	51.98	154.89	24.66	14.14	0.23	4.5
14 C14Chemicals	34.44	95	14	4	10	10	10	2	0	0	0.57	15.63	20.85	209.63	22.6	0	2.78
15 C15Metal	0.43	1	0	0	0	0	0	0	0	0.13	1.86	33.48	19.25	10.14	168.49	4.44	6.36
16 C16MeatProds	0.92	1	0	2	0	0	0	0	0	0	0.02	0.19	0.19	0.58	1.31	261.86	0.31
17 C17MilkProds	14.09	22	3	33	0	0	0	0	0	0	0.03	0.22	0.21	0.71	1.58	0.34	311.59
18 C18AnimFeed	77.01	121	19	181	0	0	0	0	0	0	0	0	0	0	0	0	0
19 C19OtherFood	0	0	0	0	0	0	0	0	0	0	0.01	0.14	0.43	4.29	1.02	5.96	45.48
20 C20BevTob	0	0	0	0	3	0	0	0	0	0	0	0	0	1.89	0	0	0
21 C21Textiles	0.17	0	0	0	0	0	0	0	0	0.05	0	0	0.43	0.19	0.5	0	0
22 C22WoodPaper	1.6	3	0	0	0	0	0	0	0	0	0.19	1.58	19.11	44.94	106.73	35.4	30.45
23 C23RubPlas	0.91	2	0	0	0	0	0	0	0	0	0.21	4.4	13.75	41.31	131.76	20.85	21.1
24 C24Construct	32.3	52	8	9	2	0	2	1	0	0	0.88	327.13	25.5	100.57	82.71	8.02	13.89
25 C25TradeMarg	60.71	117	19	36	9	20	7	4	4	5.97	0.35	238.13	85.25	555.1	905.46	80.07	107.57
26 C26LodgCater	0	0	0	0	0	0	0	0	0	0	0.2	3.73	1.97	17.63	26.11	1.52	3.01
27 C27InlndTran	1.45	3	0	0	0	0	0	0	1	2.57	0.77	3.02	53.7	99.38	225.65	32.89	6.08
28 C28OtherTran	0.35	1	0	0	0	0	0	0	0	0.53	0.91	3.61	62.14	112.55	181.91	34.02	6.26
29 C29Commun	7.6	14	1	0	1	1	1	0	0	0.1	0.52	25.1	13.85	59.25	191.06	8.02	5.56
30 C30Credit	82.76	112	19	11	9	13	8	3	1	1.38	1.99	45.9	71.21	2097.38	879.13	33.12	46.66
31 C31OtherSers	18.3	35	2	1	2	3	3	1	9	6.35	6.39	49.48	34.63	289.45	1515.97	19.38	37.29
32 C32PublServ	0	0	0	0	0	0	0	0	0	0	0.15	3.08	1.6	14.57	21.59	1.26	2.49
33 C33ONonMkt	2.76	5	0	0	0	0	0	0	0	0	0.14	3.21	1.62	15.05	22.33	1.3	2.58
34 C34Dwellings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	375.25	641	95	296	49	56	37	12	16	17.98	131.03	1184.66	647.11	3850.11	4608.5	2074.2	1744.89

Appendix 3.1 continued

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	Total
1 C1Milk	1066.86	0	34.51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1119.3
2 C2Cattle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	997
3 C3SheepWool	0	0	0	0	2.94	0	0	0	0	0	0	0	0	0	0	0	0	0	164.(
4 C4OtherLive	0	0	2.5	0	0	0.01	0	0.07	0.69	0.13	0.13	0.62	0.15	0.25	1.85	0.29	1.13	0	329.(
5 C5Cereals	0	25.75	14.66	37.24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	87.3
6 C6FruitVeg	0	0	2.99	0.07	0	0.16	0.18	0.83	8.48	1.77	1.37	7.76	1.94	3.16	23.28	3.71	13.96	0	70.6
7 C7RootGreen	0	0	30.46	0.01	0	0.02	0.02	0.18	1.54	0.29	0.27	1.41	0.36	0.58	4.21	0.68	2.54	0	44.4
8 C8OtherCrops	0	11.47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.8
9 C9Forestry	0	0	0	0	0	36.96	0	0	0	0	0	0	0	0	0	0	0	0	36.9
10 C10Fishing	0	0	11.58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11.5
11 C11PetCoal	1.87	1.14	4.04	1.62	1.79	3.42	2.06	75.1	52.87	5.33	10.44	135.84	12.85	12.43	45.25	16.86	14.36	0	739.4
12 C12ElecGas	22.23	6.63	21.75	17.07	10.12	28.71	21.73	61.49	161.82	67.72	9.96	22.95	34.32	23.36	192.46	58.84	42.56	0	1430.7
13 C13NonMet	4.5	3.12	10.26	29.42	0.37	3.89	9.65	838.14	0.26	38.26	0.85	0	0	10.12	34.53	9.75	5.57	0	1252.9
14 C14Chemicals	2.78	3.01	9.9	7.44	4.42	33.58	21.06	72.37	3.46	11.65	1.23	5.22	0.02	0	217.81	9.31	46.52	0	897.9
15 C15Metal	6.36	0	3.42	7.65	2.38	44.5	7.75	92.7	42.19	3.87	35.45	38.64	0.49	8.04	6.47	9.97	8.49	0	557.7
16 C16MeatProds	0.31	6.19	20.33	0.6	16.4	3.4	0.16	0.37	12.73	0.81	2	11.51	2.94	4.78	25.95	7.24	50.09	0	434.7
17 C17MilkProds	311.59	25.28	82.12	45.64	0.12	0.48	0.19	0.46	13.81	0.95	2.35	31.38	3.53	5.36	20.88	6.3	19.6	0	64
18 C18AnimFeed	0	129.42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	527.7
19 C19OtherFood	45.48	0	41.85	45.56	0.38	0.32	0.12	0.32	9.14	0.6	1.54	26.5	2.36	3.7	20.04	13.9	33.34	0	257.(
20 C20BevTob	0	0.22	0.72	69.22	0	0	0	0	64.69	0.53	2.44	18.29	2.24	4.95	16.6	2.72	7.12	0	194.1
21 C21Textiles	0	0.1	0.35	0	27.91	6.31	4.72	2.71	6.31	3.52	0.3	3.88	1.43	0.11	3.78	9.56	2.26	0	74.9
22 C22WoodPaper	30.45	11.13	36.71	23.35	4.04	249.35	23.73	213.14	78.52	21.21	11.49	9.31	26.76	82.11	244.86	40.55	118.84	0	1439
23 C23RubPlas	21.1	4.6	15.32	20.59	5.84	18.15	35.76	60.75	55.43	4.27	3.86	2.61	2.91	3.4	28.48	13.67	25.11	0	537.3
24 C24Construct	13.89	2.95	21.68	0.94	4.12	66.37	7	0	319.26	185.28	86.98	105.93	568.1	72.8	402.61	472	66.8	3257.88	6303.8
25 C25TradeMarg	107.57	27.89	205.43	58.49	54.19	495.22	40.77	797.7	369.98	54.92	125.98	17.65	28.86	60.74	205.69	50.58	17.74	0	4867.3
26 C26LodgCater	3.01	1.39	10.21	5.22	1.05	15.76	1.37	2.73	34.65	2.75	6.57	55.93	9.63	33.3	50.7	13.01	16.36	0	314.8
27 C27InlndTran	6.08	5.82	42.83	15.84	9.15	126.73	15.03	66.94	359.65	2.64	48.55	54.13	6.71	3.54	20.04	10.49	6.97	0	1225.5
28 C28OtherTran	6.26	6.55	48.25	18.66	8.39	143.83	17.55	0	42.16	5.02	12.52	215.04	0	1.18	0.42	12.66	0.01	0	935.4
29 C29Commun	5.56	1.53	11.31	5.26	5.75	88	8.45	29.37	128.83	67.03	21.69	32.24	250.76	136.98	156.68	125.5	54.49	0	1454.1
30 C30Credit	46.66	7.44	211.7	116.19	23.41	411.34	36.43	233.71	701.95	150.86	53.27	48.17	72.34	471.41	509.91	157.74	27.34	0	6668.7
31 C31OtherSers	37.29	6.82	549.95	60.35	16.29	211.84	25.21	126.8	445.19	115.8	36.02	78.79	28.62	337.3	329.1	79.16	828.35	0	5307.4
32 C32PublServ	2.49	0	10.47	4.31	0.86	12.95	1.14	0	164.07	78.87	19.19	42.61	18.19	95.17	221.62	3.81	61.19	0	779
33 C33ONonMkt	2.58	0	10.83	4.47	0.88	13.41	1.17	1.71	1.37	0	0.28	0.13	0.12	20.66	133.67	13.81	59.26	0	317.7
34 C34Dwellings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total	1744.89	288.45	1466.12	595.19	200.8	2014.71	281.23	2677.6	3079.04	824.07	494.73	966.55	1075.63	1395.44	2916.89	1142.13	1530.02	3257.88	40042

Appendix 3.2: 1998 Imported Intermediate Flows, Basic Prices

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1 C1Milk	6.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75
2 C2Cattle	0	10.57	0	0	0	0	0	0	0	0	0	0	0	0	0	2.93	0
3 C3SheepWool	0	0	1.93	0	0	0	0	0	0	0	0	0	0	0	0	0.65	0
4 C4OtherLive	0	0	0	10.58	0	0	0	0	0	0	0	0	0	0	0	21.61	0
5 C5Cereals	0	0	0	0	3.91	0	0	0	0	0	0	0	0	0	0	0	0
6 C6FruitVeg	0	0	0	0	0	4.83	0	0	0	0	0	0	0	0	0	0	0
7 C7RootGreen	0	0	0	0	0	0	2.34	0	0	0	0	0	0	0	0	0	0
8 C8OtherCrops	0	0	0	0	0	0	0	1.29	0	0	0	0	0	3.52	0	0	0
9 C9Forestry	0	0	0	0	0	0	0	0	3.54	0	0	0	0	0	0	0	0
10 C10Fishing	0	0	0	0	0	0	0	0	0	5.94	0	0	0	0	0	0	0
11 C11PetCoal	7.05	10.2	1.37	1.26	0.66	1.39	0.62	0.18	0	0	159.94	34.93	22.16	29.84	2.31	3.83	0.9
12 C12ElecGas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 C13NonMet	0.19	0.32	0.05	0.04	0	0.04	0.01	0.02	0	0	0	10.41	110.64	12.88	18.28	0	2.95
14 C14Chemicals	28.59	78.6	11.78	3.05	8.58	8.58	8.03	1.31	0	0	0	63.8	56.53	1263.09	36.15	0	9.1
15 C15Metal	10.73	18.18	3.13	2.55	0.08	2.46	0.64	0.4	0	0	4.06	176.73	94.91	108.93	7879.08	57.86	71.23
16 C16MeatProds	0.06	0.1	0.01	0.15	0	0	0	0	0	0	0	0	0	0	0	0	0
17 C17MilkProds	1.95	3.07	0.49	4.63	0	0	0	0	0	0	0	0	0	0	0	0	63.33
18 C18AnimFeed	16.64	26.13	4.09	39.18	0	0	0	0	0	0	0	0	0	0	0	0	0
19 C19OtherFood	0	0	0	0	0	0	0	0	0	0	0	0	0	5.85	0	1.3	9.11
20 C20BevTob	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 C21Textiles	1.95	3.43	0.57	0.48	0	0.46	0.1	0.05	0	0	0	0	0.14	0	0.19	0	0
22 C22WoodPaper	0.59	1.02	0.17	0.14	0	0.13	0.03	0.02	0	0	0	0.58	6.89	15.79	39.22	11.17	9.34
23 C23RubPlas	0.71	1.24	0.22	0.16	0	0.17	0.04	0.01	0	0	0	3.59	106.36	214.69	285.88	34.68	13.05
24 C24Construct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 C25TradeMarg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26 C26LodgCater	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 C27InlndTran	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28 C28OtherTran	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29 C29Commun	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 C30Credit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31 C31OtherSers	0	0	0	0	0	0	0	0	0	0	0	73.91	53.59	432.37	2469.13	28.78	55.12
32 C32PublServ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33 C33ONonMkt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34 C34Dwellings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	74.55	152.86	23.82	62.22	13.23	18.06	11.81	3.28	3.54	5.94	164	363.94	451.21	2086.96	10730.2	162.82	234.87

Appendix 3.2 continued

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	Total
1 C1Milk	0	17.62	0	0	0	0	0	0	0	0	0	0	0	3.09	0	0	0	27.54
2 C2Cattle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13.5
3 C3SheepWool	0	0	0	47.52	0	0	0	0	0	0	0	0	0	0	0	0	0	50.1
4 C4OtherLive	0	1.55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33.74
5 C5Cereals	0	9.41	13.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27.31
6 C6FruitVeg	0	2.27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.1
7 C7RootGreen	0	24.16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26.5
8 C8OtherCrops	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.82
9 C9Forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.54
10 C10Fishing	0	84.54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90.48
11 C11PetCoal	0.5	1.97	0.52	0.76	1.17	0.65	40.34	40.45	1.28	50.96	63.68	2.01	2.25	8.73	2.57	3.29	0	497.76
12 C12ElecGas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 C13NonMet	0.51	1.93	11.62	0	0.35	3.64	229.61	0	30.04	0	0	0	0	55.17	0.78	0.53	0	490.01
14 C14Chemicals	17.72	67.04	33.96	17.73	57.46	43.41	52.35	0.27	0.65	0	0	0	0	134.18	5.66	54.1	0	2061.73
15 C15Metal	14.39	62.36	61.09	9.4	108.5	114.14	1975.33	520.33	7.56	151.88	157.79	4.07	5.53	167.37	114.72	168.26	0	12073.69
16 C16MeatProds	0.41	1.55	0	1.15	0.25	0	0	1.16	0	0	0.76	0	0.32	0	0.32	3.07	0	9.34
17 C17MilkProds	3.36	12.5	6.1	0	0	0	0	2.49	0	0	3.74	0	0.67	2.39	0.62	2.28	0	107.61
18 C18AnimFeed	119.68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	205.73
19 C19OtherFood	0	125.83	21.28	0	0	0	0	0	0	0	0	0	0	0	0	7	0	170.37
20 C20BevTob	0	0	59.43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	59.43
21 C21Textiles	0.03	0.13	0	219.38	9.65	28.78	3.11	7.78	32.34	4.64	1.1	0.4	0	4.15	8.22	4.38	0	331.44
22 C22WoodPaper	4.14	15.69	24.41	1.48	415.9	7.94	262.79	39.83	7.75	4.79	3.1	7.83	30.97	75.35	10.19	27.17	0	1024.41
23 C23RubPlas	8.13	30.97	13.79	14.18	15.9	263.91	108.22	111.64	3.35	3.21	1.64	1.64	2.25	28.81	9.33	34.1	0	1311.89
24 C24Construct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 C25TradeMarg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26 C26LodgCater	0	0	0	0	0	0	0	0	0	0	5.27	0	0	0	0	0	0	5.27
27 C27InlndTran	0	0	0	0	0	0	0	0	0	9.26	0	0	0	0	0	0	0	9.26
28 C28OtherTran	0	0	0	0	0	0	0	77.2	19.83	30.43	730.92	0	0	0	0	0	0	858.38
29 C29Commun	0	0	0	0	0	0	0	18.73	10.26	0	0	38.41	20.95	23.71	19.22	0	0	131.28
30 C30Credit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31 C31OtherSers	8.43	939.78	88.25	22.31	317.14	27.89	218.62	764.16	205.12	51.03	133.74	42.61	559.02	457.11	128.35	91.38	0	7167.81
32 C32PublServ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	44.51	0	0	44.51
33 C33ONonMkt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34 C34Dwellings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	177.31	1399.28	334.43	333.9	926.32	490.37	2890.37	1584.05	318.2	306.19	1101.76	96.98	621.97	960.05	344.48	395.55	0	26844.55

Appendix 3.3: 1998 Domestic Intermediate Flows, Purchasers Prices

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1 C1Milk	4.14	6.18	0.94	8.3	0	0	0	0	0	0	0	0	0	0	0	0	1079.1
2 C2Cattle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1006.13	0
3 C3SheepWool	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	162.52	0
4 C4OtherLive	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0	0.07	324.04	0
5 C5Cereals	0	0	0	0	10.07	0	0	0	0	0	0	0	0	0	0	0	0
6 C6FruitVeg	0	0	0	0	0	0	0	0	0	0	0.07	0.06	0.08	0	0.78	0	0
7 C7RootGreen	0	0	0	0	0	0	1.84	0	0	0	0	0.01	0.01	0	0.13	0	0
8 C8OtherCrops	0	0	0	3.18	0	0	0	0.47	0	0	0	0	0	1.78	0	0	0
9 C9Forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 C10Fishing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 C11PetCoal	29.6	37.68	4.68	4.26	3.09	4.62	2.18	0.58	3.09	3.69	115.12	119.86	26.91	47.2	9.4	14.07	2.08
12 C12ElecGas	19.3	27.4	3.62	3.34	1.83	3.67	1.65	0.45	0	0	1.43	293.63	46.63	107.81	99.71	33.21	22.47
13 C13NonMet	2.27	3.74	0.63	0.52	0	0.5	0.12	0.06	0	0	1.14	54.34	160.86	25.05	14.31	0.23	4.57
14 C14Chemicals	39.46	100	14.76	4.2	10.92	10.88	9.96	1.64	0	0	0.57	16.19	21.48	212.17	22.82	0	2.82
15 C15Metal	0.52	0.82	0.14	0.11	0.01	0.11	0.02	0.01	0.32	0.42	1.87	35.99	20.47	10.4	171.95	4.53	6.52
16 C16MeatProds	0.94	1.46	0.23	2.18	0	0	0	0	0	0	0.02	0.19	0.19	0.58	1.31	262.31	0.31
17 C17MilkProds	14.46	22.53	3.5	33.2	0	0	0	0	0	0	0.03	0.22	0.21	0.71	1.58	0.34	312.3
18 C18AnimFeed	77.01	120.96	18.95	181.45	0	0	0	0	0	0	0	0	0	0	0	0	0
19 C19OtherFood	0	0	0	0	0	0	0	0	0	0	0.01	0.14	0.45	4.35	1.04	6.02	46.01
20 C20BevTob	0	0	0	0	2.79	0	0	0	0	0	0	0	0	2.29	0	0	0
21 C21Textiles	0.23	0.25	0.06	0.03	0	0.04	0.02	0.03	0	0.15	0	0	0.48	0.19	0.52	0	0
22 C22WoodPaper	1.76	2.88	0.5	0.4	0	0.39	0.1	0.06	0	0	0.19	1.64	19.72	45.51	107.83	35.75	30.83
23 C23RubPlas	1.09	1.72	0.29	0.23	0	0.22	0.06	0.03	0	0	0.21	4.72	14.58	42.34	134.37	21.24	21.61
24 C24Construct	32.83	52.14	7.75	8.75	1.8	0	1.7	0.82	0	0	0.88	329.3	25.64	100.78	82.87	8.04	13.92
25 C25TradeMarg	62	118.45	19.55	36.12	9.45	20.12	7.55	3.67	4.29	6.16	0.35	239.55	85.69	556.2	906.92	80.2	107.78
26 C26LodgCater	0	0	0	0	0	0	0	0	0	0	0.2	3.79	1.99	17.69	26.22	1.52	3.02
27 C27InlndTran	1.54	2.82	0.13	0.08	0.17	0.24	0.27	0.09	1.32	2.58	0.77	3.05	54.27	99.77	226.4	32.99	6.1
28 C28OtherTran	0.36	0.7	0.02	0.01	0.04	0.05	0.06	0.01	0	0.53	0.91	3.64	62.52	112.8	182.27	34.08	6.27
29 C29Commun	7.95	14.72	0.67	0.38	0.88	1.24	1.35	0.46	0.07	0.15	0.52	25.52	14.04	59.57	191.94	8.05	5.59
30 C30Credit	84.86	114.27	19.46	11.45	9.21	12.94	7.91	2.94	1.46	1.68	1.99	46.37	71.83	2104.74	881.61	33.21	46.82
31 C31OtherSers	19	35.31	1.6	0.88	2.1	2.95	3.24	1.16	8.59	6.45	6.39	50.03	34.96	290.56	1520.6	19.44	37.43
32 C32PublServ	0	0	0	0	0	0	0	0	0	0	0.15	3.12	1.6	14.64	21.63	1.26	2.5
33 C33ONonMkt	2.83	5.33	0.23	0.12	0.32	0.43	0.48	0.18	0	0	0.14	3.24	1.64	15.12	22.37	1.3	2.59
34 C34Dwellings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	402.13	669.39	97.72	299.17	52.68	58.4	38.52	12.66	19.13	21.81	132.95	1234.62	666.3	3872.25	4628.7	2090.49	1760.62

Appendix 3.3 continued

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	Total
1 C1Milk	0	35.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1133.9
2 C2Cattle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1006.13
3 C3SheepWool	0	0	0	2.98	0	0	0	0	0	0	0	0	0	0	0	0	0	165.5
4 C4OtherLive	0	2.55	0	0	0.01	0	0.07	0.72	0.13	0.15	0.64	0.17	0.34	2.08	0.34	1.32	0	332.64
5 C5Cereals	26.64	14.97	37.47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	89.14
6 C6FruitVeg	0	3.05	0.07	0	0.16	0.18	0.85	8.93	1.86	1.61	8.08	2.27	4.26	26.15	4.32	16.3	0	79.07
7 C7RootGreen	0	31.11	0.01	0	0.02	0.02	0.18	1.62	0.31	0.31	1.46	0.43	0.77	4.72	0.79	2.96	0	46.7
8 C8OtherCrops	11.86	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.3
9 C9Forestry	0	0	0	0	37.59	0	0	0	0	0	0	0	0	0	0	0	0	37.59
10 C10Fishing	0	11.83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11.83
11 C11PetCoal	1.51	4.87	1.71	2	3.98	2.26	95.21	78.7	8.01	27.57	187.9	33.49	53.87	98.06	43.59	37.21	0	1108.03
12 C12ElecGas	6.85	22.19	17.17	10.24	29.17	21.94	63.14	169.71	71.09	11.59	23.84	39.82	31.13	214.88	68.16	49.32	0	1516.43
13 C13NonMet	3.26	10.55	29.66	0.38	3.97	9.78	869.19	0.28	40.91	1.05	0	0	14.78	40.11	11.89	6.79	0	1310.95
14 C14Chemicals	3.11	10.12	7.49	4.48	34.17	21.29	74.5	3.64	12.28	1.45	5.43	0.02	0	245.57	10.92	54.61	0	956.95
15 C15Metal	0	3.58	7.75	2.44	46.15	7.93	98.38	46.91	4.31	48.8	42.02	0.67	14.18	8.2	13.59	11.58	0	610.71
16 C16MeatProds	6.23	20.41	0.6	16.44	3.41	0.16	0.37	12.85	0.81	2.07	11.6	3.03	5.11	26.57	7.48	51.72	0	438.61
17 C17MilkProds	25.45	82.47	45.69	0.12	0.48	0.19	0.46	13.95	0.95	2.43	31.63	3.66	5.72	21.4	6.51	20.25	0	650.48
18 C18AnimFeed	129.42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	527.79
19 C19OtherFood	0	42.76	45.85	0.39	0.32	0.12	0.32	9.61	0.62	1.82	27.58	2.77	5.03	22.54	16.27	39.02	0	273.04
20 C20BevTob	0.35	1	76.77	0	0	0	0	123.99	1.04	9.97	31.43	9.01	35.89	52.97	10.81	28.41	0	386.71
21 C21Textiles	0.12	0.38	0	29.11	6.68	4.88	2.96	7.44	4.16	0.48	4.43	2.27	0.24	5.37	15.08	3.56	0	89.14
22 C22WoodPaper	11.55	37.57	23.5	4.09	253.99	24	219.71	82.94	22.43	13.68	9.71	31.7	113.62	277.79	47.95	140.62	0	1562.41
23 C23RubPlas	4.93	16	20.85	6	18.81	36.56	64.34	61.41	4.74	5.26	2.82	3.94	5.91	35.82	18.46	33.93	0	582.46
24 C24Construct	2.96	21.77	0.94	4.13	66.55	7.02	0	322.4	187.13	89.86	106.74	586.41	77.69	412.04	487.02	68.93	3258	6366.68
25 C25TradeMarg	28.06	206.19	58.56	54.31	496.68	40.84	801.57	373.26	55.41	129.74	17.78	29.7	64.41	210.04	52.03	18.25	0	4900.86
26 C26LodgCater	1.41	10.31	5.24	1.06	15.92	1.37	2.77	35.42	2.81	7.06	56.93	10.35	38.41	53.43	13.95	17.56	0	328.47
27 C27InlndTran	5.89	43.17	15.87	9.19	127.55	15.09	67.63	366.32	2.68	51.58	54.92	7.11	3.98	20.92	11.12	7.39	0	1243.04
28 C28OtherTran	6.6	48.45	18.68	8.41	144.3	17.59	0	42.6	5.08	12.97	216.82	0	1.26	0.44	13.1	0.01	0	940.63
29 C29Commun	1.55	11.43	5.28	5.78	88.71	8.49	29.78	132.11	68.77	23.54	32.88	271.7	160.73	166.19	135.84	59	0	1534.91
30 C30Credit	7.52	213.06	116.4	23.5	413.42	36.54	235.68	712.75	153.24	56.03	48.75	76.01	520.93	528.68	165.62	28.72	0	6789.58
31 C31OtherSers	6.9	553.76	60.46	16.36	212.99	25.3	127.96	452.61	117.78	38.04	79.82	30.18	375.66	342.22	83.45	873.35	0	5437.51
32 C32PublServ	0	10.51	4.31	0.86	13.04	1.14	0	166.02	79.84	19.96	43.01	18.89	102.91	227.93	3.96	63.57	0	800.86
33 C33ONonMkt	0	10.9	4.47	0.88	13.5	1.17	1.73	1.39	0	0.3	0.13	0.12	22.56	137.95	14.4	61.86	0	327.72
34 C34Dwellings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	292.19	1480.22	604.77	203.15	2031.58	283.84	2756.81	3227.59	846.39	557.33	1046.33	1163.72	1659.4	3182.08	1256.68	1696.26	3258	41603.76

Appendix 3.4: 1998 Imported Intermediate Flows, Purchasers Price

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1 C1Milk	7.34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.76
2 C2Cattle	0	11.94	0	0	0	0	0	0	0	0	0	0	0	0	0	2.95	0
3 C3SheepWool	0	0	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0.66	0
4 C4OtherLive	0	0	0	10.68	0	0	0	0	0	0	0	0	0	0	0	21.8	0
5 C5Cereals	0	0	0	0	4.08	0	0	0	0	0	0	0	0	0	0	0	0
6 C6FruitVeg	0	0	0	0	0	5.06	0	0	0	0	0	0	0	0	0	0	0
7 C7RootGreen	0	0	0	0	0	0	2.46	0	0	0	0	0	0	0	0	0	0
8 C8OtherCrops	0	0	0	0	0	0	0	1.32	0	0	0	0	0	3.57	0	0	0
9 C9Forestry	0	0	0	0	0	0	0	0	3.81	0	0	0	0	0	0	0	0
10 C10Fishing	0	0	0	0	0	0	0	0	0	6.28	0	0	0	0	0	0	0
11 C11PetCoal	12.93	16.47	2.05	1.87	1.36	2.02	0.95	0.26	0	0	162.65	46.39	28.33	33.17	2.52	4.15	1
12 C12ElecGas	0	0	0	0	0	0	0	0	0.15	0.18	0	0	0	0	0	0	0
13 C13NonMet	0.22	0.35	0.05	0.04	0.04	0.04	0.01	0.02	0.03	0.04	0	10.88	114.9	13.07	18.51	0	2.99
14 C14Chemicals	32.76	83.05	12.26	3.48	9.07	9.03	8.27	1.37	1.75	2.1	0	66.09	58.25	1278.46	36.5	0	9.2
15 C15Metal	12.9	20.5	3.38	2.77	0.35	2.7	0.77	0.44	0	0	4.06	190.02	100.97	111.7	8040.75	58.97	73.01
16 C16MeatProds	0.06	0.1	0.01	0.15	0	0	0	0	0	0	0	0	0	0	0	0	0
17 C17MilkProds	2.01	3.13	0.49	4.63	0.04	0.04	0.02	0	0.05	0.07	0	0	0	0	0	0	63.47
18 C18AnimFeed	16.64	26.13	4.09	39.18	0	0	0	0	0	0	0	0	0	0	0	0	0
19 C19OtherFood	0	0	0	0	0	0	0	0	0	0	0	0	0	5.91	0	1.31	9.21
20 C20BevTob	2.46	2.63	0.29	0.25	0	0.26	0.14	0.03	0.25	0.29	0	0	0	0	0	0	0
21 C21Textiles	2.58	4.12	0.65	0.55	0.08	0.53	0.13	0.05	0.1	0	0	0	0.15	0	0.2	0	0
22 C22WoodPaper	0.66	1.09	0.18	0.14	0.03	0.13	0.03	0.02	0.04	0.04	0	0.61	7.11	15.99	39.62	11.27	9.46
23 C23RubPlas	0.84	1.38	0.23	0.17	0.04	0.19	0.05	0.01	0.06	0.07	0	3.85	112.9	219.98	291.53	35.32	13.36
24 C24Construct	0	0	0	0	0	0.06	0	0	0.06	0.07	0	0	0	0	0	0	0
25 C25TradeMarg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26 C26LodgCater	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 C27InlndTran	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28 C28OtherTran	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29 C29Commun	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 C30Credit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31 C31OtherSers	0	0	0	0	0	0	0	0	0	0	0	74.75	54.11	434.02	2476.67	28.87	55.32
32 C32PublServ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33 C33ONonMkt	0	0	0	0	0	0	0	0	0.02	0.01	0	0	0	0	0	0	0
34 C34Dwellings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	91.39	170.9	25.79	63.91	15.08	20.05	12.83	3.52	6.31	9.16	166.71	392.58	476.71	2115.87	10906.3	165.33	237.78

Appendix 3.4: Continued

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	Total
1 C1Milk	0	18	0	0	0	0	0	0	0	0	0	0	0	3.48	0	0	0	29.57
2 C2Cattle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14.9
3 C3SheepWool	0	0	0	48.11	0	0	0	0	0	0	0	0	0	0	0	0	0	50.87
4 C4OtherLive	0	1.58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34.06
5 C5Cereals	0	9.61	14.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27.76
6 C6FruitVeg	0	2.32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.37
7 C7RootGreen	0	24.68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27.14
8 C8OtherCrops	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.9
9 C9Forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.81
10 C10Fishing	0	86.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	92.63
11 C11PetCoal	0.66	2.37	0.55	0.85	1.36	0.71	51.13	60.2	1.92	134.76	88.07	5.24	9.76	18.92	6.65	8.52	0	707.79
12 C12ElecGas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.33
13 C13NonMet	0.53	1.99	11.71	0	0.35	3.69	238.13	0	32.12	0	0	0	0	64.09	0.95	0.65	0	515.39
14 C14Chemicals	18.35	68.52	34.17	17.96	58.47	43.88	53.88	0.29	0.69	0	0	0	0	151.29	6.64	63.5	0	2129.3
15 C15Metal	15.48	65.26	61.9	9.65	112.53	116.74	2096.32	578.5	8.44	209.08	171.65	5.56	9.77	212.09	156.36	229.57	0	12682.17
16 C16MeatProds	0.41	1.56	0	1.15	0.25	0	0	1.18	0	0	0.76	0	0.35	0	0.34	3.17	0	9.52
17 C17MilkProds	3.38	12.55	6.1	0	0	0	0	2.53	0	0	3.79	0	0.72	2.45	0.65	2.36	0	108.48
18 C18AnimFeed	119.68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	205.73
19 C19OtherFood	0	128.57	21.42	0	0	0	0	0	0	0	0	0	0	0	0	8.19	0	174.61
20 C20BevTob	0	0	65.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72.48
21 C21Textiles	0.04	0.14	0	228.8	10.22	29.83	3.42	9.15	38.22	7.42	1.25	0.63	0	5.91	12.96	6.91	0	364.02
22 C22WoodPaper	4.29	16.06	24.58	1.5	423.65	8.03	270.9	42.06	8.2	5.71	3.23	9.29	42.86	85.48	12.05	32.15	0	1076.44
23 C23RubPlas	8.72	32.36	13.96	14.55	16.47	269.72	114.62	123.67	3.73	4.37	1.77	2.23	3.9	36.24	12.61	46.08	0	1385.03
24 C24Construct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
25 C25TradeMarg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26 C26LodgCater	0	0	0	0	0	0	0	0	0	0	5.38	0	0	0	0	0	0	5.38
27 C27InlndTran	0	0	0	0	0	0	0	0	0	9.82	0	0	0	0	0	0	0	9.82
28 C28OtherTran	0	0	0	0	0	0	0	78.03	20.05	31.51	736.99	0	0	0	0	0	0	866.57
29 C29Commun	0	0	0	0	0	0	0	19.2	10.54	0	0	41.61	24.55	25.16	20.81	0	0	141.87
30 C30Credit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31 C31OtherSers	8.52	946.31	88.42	22.4	318.86	27.98	220.62	776.9	208.64	53.91	135.49	44.96	622.6	475.32	135.3	96.35	0	7306.28
32 C32PublServ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46.22	0	0	46.22
33 C33ONonMkt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03
34 C34Dwellings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	180.08	1418.2	342.78	344.96	942.17	500.59	3049.01	1691.73	332.57	456.56	1148.39	109.53	714.52	1080.41	411.52	497.44	0	28100.65

Appendix 3.5: Total Cost Matrix

	1 Dairy	2 Cattle	3 Sheep	4 Other Live	5 Cereals	6 Fruit & Veg	7 Root & Green	8 Other Crops	9 Forestry	10 Fishing	11 PetCoal	12 ElecGas	13 NonMet	14 Chemicals	15 Metal	16 Meat Prods	17 Milk Prods
Int Dom	375.25	640.8	94.64	296.36	49.09	55.72	36.97	12.32	15.99	17.98	131.03	1184.66	647.11	3850.11	4608.5	2074.2	1744.89
Int Imp	74.55	152.86	23.82	62.22	13.23	18.06	11.81	3.28	3.54	5.94	164	363.94	451.21	2086.96	10730.23	162.82	234.87
Indirect Tax	43.72	46.63	5.05	4.5	5.44	4.66	2.57	0.58	5.91	7.05	4.64	78.6	44.69	51.05	196.26	18.8	18.63
Lab	26.03	35.46	10.94	33.12	6.43	3.69	9.61	2.01	25.37	17.86	12.94	345.71	441.4	593.89	2202.04	192.36	171.53
Cap	437.9	615.39	255.94	30.72	17.28	64.19	20.88	10.22	36.68	118.86	786.93	146.71	220.62	6447.5	1885.34	37.52	34.87
Land	242.36	209.6	26.63	28.91	82.53	11.78	6.82	1.94	101.58								
Subsidy	-77.91	-521.38	-264.11	-0.07	-99.79	-11.45	-0.21	0	-0.09	-0.02	-166.49	-0.12	-5.44	-86.44	-136.26	-25.62	-12.61
Error	44.46	1.47	15.56	-1.43	29.81	15.01	0.68	0.2	-79.85	0.02	1.11	0.03	0.11	2.33	2.53	1.55	0.02
Total	1166.37	1180.84	168.46	454.32	104.03	161.67	89.12	30.54	109.12	167.7	934.17	2119.54	1799.7	12945.39	19488.65	2461.63	2192.2

	18 Anim Feed	19 Other Food	20 BevTob	21 Textiles	22 Wood Paper	23 RubPlas	24 Const	25 Trade Marg	26 Lodg Cater	27 Inlnd Tran	28 Other Tran	29 Commun	30 Credit	31 Other Sers	32 PublServ	33 Non-Mkt	34 Dwellings	Total
IntDom	288.45	1466.12	595.19	200.8	2014.71	281.23	2677.6	3079.04	824.07	494.73	966.55	1075.63	1395.44	2916.89	1142.13	1530.02	3257.88	15835.62
IntImp	177.31	1399.28	334.43	333.9	926.32	490.37	2890.37	1584.05	318.2	306.19	1101.76	96.98	621.97	960.05	344.48	395.55	0	14563.34
Indirect Tax	6.51	33.02	17.93	13.41	32.71	12.83	237.85	256.23	36.69	212.97	126.41	100.64	356.51	385.55	181.59	268.13	0	538.78
Lab	38.14	293.37	201.89	222.49	637.23	309.88	2573.2	3391.83	996.51	482.03	918.61	494.64	2166.72	2481.35	2720.4	4416.51	0	4130.39
Cap	61.71	154.96	678	395.38	179.23	557.48	995.44	3146.41	713.59	495.84	406.54	685.09	3187.56	5408.64	163.06	299.1	0	11167.55
Land																		712.15
Subsidy	-118.28	-3.31	-0.6	-51.78	-5.01	-58.05	-0.74	-582.2	-4.54	-0.1	-19.71	0	-4.74	-62.47	0	0	0	-1408.01
Error	98.99	0	0.02	0.29	0.13	0.04	0.16	2.56	0.51	-3.73	-13.58	0.79	0.8	19.48	1.89	0.08	0	33.61
Total	552.83	3343.44	1826.86	1114.49	3785.33	1593.76	9373.88	10877.92	2885.04	1987.93	3486.58	2453.76	7724.25	12109.49	4553.55	6909.39	3257.88	45573.45

Appendix 3.6: 1998 Domestic Commodity Demand Flow and Import Demand

	Intermediate	Invest't	Household	Export	Govern't	Stocks	Marg's	Total	Imports
1 C1Milk	1119.35	0	17.67	0	0	0	0	1137.02	27.54
2 C2Cattle	997.3	0	0	125.84	0	5.23	0	1128.37	13.5
3 C3SheepWool	164.04	0	0	10.81	0	-6.3	0	168.55	50.1
4 C4OtherLive	329.09	0	32.01	85.06	0	8.13	0	454.29	33.74
5 C5Cereals	87.31	0	0	16.74	0	0	0	104.05	27.31
6 C6FruitVeg	70.63	0	19.32	72.47	0	0	0	162.42	352.47
7 C7RootGreen	44.46	0	42.36	2.31	0	0	0	89.13	26.5
8 C8OtherCrops	16.83	0	12.47	1.3	0	0	0	30.59	4.82
9 C9Forestry	36.96	0	7.46	65.02	0	0	0	109.44	3.54
10 C10Fishing	11.58	0	4.97	151.15	0	0	0	167.69	90.48
11 C11PetCoal	739.49	0	101.11	68.59	0	25.24	0	934.43	802.06
12 C12ElecGas	1430.78	0	607.1	0	0	81.58	0	2119.46	0
13 C13NonMet	1252.98	14.84	44	487.28	0	0.65	0	1799.75	528.5
14 C14Chemicals	897.92	0.05	204.6	11738.62	0	104.15	0	12945.33	2375.66
15 C15Metal	557.76	158.92	29.3	18655.95	0	86.73	0	19488.67	17657.93
16 C16MeatProds	434.74	0	764.24	1259.17	0	3.54	0	2461.69	134.22
17 C17MilkProds	646	0	560.53	1094.03	0	-108.3	0	2192.26	183.16
18 C18AnimFeed	527.79	0	0	26.98	0	-1.94	0	552.83	205.73
19 C19OtherFood	257.01	0	596.48	2477.29	0	12.64	0	3343.42	1060.48
20 C20BevTob	194.18	0	917.45	691.5	0	23.77	0	1826.9	360.16
21 C21Textiles	74.98	14.37	266.94	747.49	0	10.83	0	1114.62	1544.24
22 C22WoodPaper	1439.2	13.79	439.95	1896.91	0	-4.69	0	3785.17	1493.16
23 C23RubPlas	537.33	29.59	110.44	915.36	0	1.22	0	1593.94	1628.96
24 C24Construct	6303.89	3069.9	0	0	0	0	0	9373.79	0
25 C25TradeMarg	4867.39	0	131.2	168.77	0	0	5710.28	10877.64	0
26 C26LodgCater	314.83	0	1404.58	1165.55	0	0	0	2884.96	77.31
27 C27InlndTran	1225.54	0	609.31	153.05	0	0	0	1987.9	54.96
28 C28OtherTran	935.43	0	143.73	2116	0	0	290.85	3486.02	989.42
29 C29Commun	1454.11	0	558.7	440.96	0	0	0	2453.77	216.99
30 C30Credit	6668.79	0	964.77	90.75	0	0	0	7724.32	0
31 C31OtherSers	5307.46	52.08	5117.72	1632.31	0	0	0	12109.58	9198.61
32 C32PublServ	779.2	28.65	49.73	225.92	3470.23	0	0	4553.73	44.51
33 C33ONonMkt	317.77	0	1898.56	185.31	4507.75	0	0	6909.39	0
34 C34Dwellings	0	0	3257.88	0	0	0	0	3257.88	0
Total	40042.09	3382.2	18914.59	46768.5	7977.98	242.49	6001.14	123329	39186.08

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