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by
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A Computable General Equilibrium Model of the Irish Economy: Technical Appendix

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Section 1. Introduction

This working paper provides a technical introduction to a computable general equilibrium (CGE) model of the Irish economy, developed at the UCD Economics Department. The paper is intended as a technical reference point for readers of forthcoming working papers which will apply the model to various policy issues. Section 2 presents the model's theoretical structure. Section 3 outlines how the model was calibrated to 1985 data. Section 4 gives the parameters (elasticities) that are used in the model and explains how these values were chosen.

Section 2. A general equilibrium model of the Irish economy

There are four components of a neoclassical general equilibrium model.[1] Production sectors are characterized by a production function; to each sector there corresponds an activity level, which is endogenously determined by the model. Commodities each have a price, which is determined by the model. Consumers are characterized by endowments and a utility function; their income and utility are endogenous. Finally, a model may also incorporate side constraints (e.g. a minimum real wage), to which there correspond 'rationing variables' which move so as to ensure that the [illegible]

[illegible]

adopt this standard framework.[2] Production and utility functions are specified; the package then calculates cost, factor demand and commodity demand functions for all sectors and commodities. Equilibrium is defined by a set of prices, activity levels and incomes such that (i) no sector earns a positive profit; (ii) supply minus demand for each commodity is nonnegative; (iii) income from factor endowments is fully distributed.[3] In addition, in an environment with taxes, all tax income must accrue to some agent (in this case, the government).

2.1. An overview of the model

Apart from its labour and capital market assumptions, the model is a standard neoclassical one, assuming perfect competition and constant returns to scale. 11 domestic producer goods are produced by sectors using other domestic and imported producer goods, as well as labour and capital, as inputs. Producer goods and imports are transformed into 11 consumer goods, which are then used to produce an aggregate consumption good. Producer goods can also be exported, or used to produce other aggregate goods (private and public investment, and government consumption).

The single consumer in the model is endowed with labour and capital, and receives transfers from the government and abroad. Consumption and savings trade off in the production

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[2] Although by introducing side constraints appropriately a variety of non-standard features can be introduced into the model.

[3] See Rutherford (1988, 1994).

petrol, durables, transport equipment, other goods, other services, and foreign holidays. Each is produced by an artificial sector also indexed by m. Finally, there are 4 aggregate goods in the model, indexed by n: a public and a private investment good, a government consumption good, and a private consumption aggregate.

There are four primary factors of production: labour, capital, high-tech capital and agricultural capital. Agricultural capital is only used in the agricultural sector, and is in fixed supply: land is considered to form a part of this stock. High-tech capital is only used in the high-tech sector, and is supplied to the economy in a perfectly elastic fashion, at an exogenous (post-tax) rate of return. Capital is perfectly mobile between the other 9 production sectors, and is in fixed supply. Finally, labour is mobile across all 11 sectors.

2.3. Balance for individual commodities

2.3.1. Producer goods

Let Q_i be the output of producer good i. Aij is the input of good i into sector j, C_{im} is the input of good i into consumption good m, and B_{in} is the input of good i into aggregate good n. E_i represents exports of good i. For each i, balance requires that

$$Q_i = \Sigma_j A_{ij} + \Sigma_m C_{im} + \Sigma_n B_{in} + E_i \qquad (1)$$

2.3.2. Imported goods

Let M_k represent imports of good k. A_{kj} represents inputs of good k into sector j, C_{km} inputs of good k into consumption good m, and B_{kn} inputs of good k into aggregate good n. For each k, balance requires that

$$M_k = \Sigma_j A_{kj} + \Sigma_m C_{km} + \Sigma_n B_{kn} \qquad (2)$$

2.3.3. Consumer goods

The output of each consumer good is entirely used in the production of the aggregate consumption good.

2.3.4. Aggregate goods

The entire output of the aggregate consumption good is used in the production of the first utility good, U1. The entire output of government investment and consumption are consumed by the government.

Balance for the private investment good is trickier, since this aggregate good is used to represent all private savings and investment flows in the economy. Savings represent a demand for the investment good, while borrowing represents a supply of the good.

Let I be the output of the investment good, S_P be private savings, G_b government borrowing, and K_I net capital inflows (the negative of the current account). Balance requires that

$$I + G_b = S_P + K_I \qquad (3)$$

2.3.5. Factors of production

The entire endowment of agricultural capital is used by the agricultural sector. All high-tech capital is used in the high-tech sector. The balance for non-agricultural, non-high-tech capital is however somewhat complicated, since capital is used to model all flows of interest as well as profits in the economy. Let K_j be the capital used in sector j, H_K the household's endowment of capital, G_K the government's endowment of capital, G_I interest payments on the national debt, and F_K net interest and profits paid to foreigners. Balance requires that

$$G_K + H_K + F_K = \Sigma_j K_j + G_I \qquad (4)$$

2.3.6. Foreign exchange

An artificial commodity, foreign exchange, is introduced to handle foreign transactions. Let F_i be the foreign exchange earned from exports from sector i, F_k be foreign exchange used to import good k, F_G be net foreign transfers to the government, F_H net foreign transfers to households, and TS the trade surplus. Balance requires that

$$\Sigma_i F_i + F_G + F_H = \Sigma_k F_k + (TS + F_G + F_H) \qquad (5)$$

where the term in parentheses represents the foreign consumer's demand for foreign exchange.

2.4. Production

In each sector, we assume a nested two-level production structure (see Figure 1). At the upper level, aggregate producer goods (i.e. intermediate goods) combine with a value-added aggregate. At the lower level, capital and labour produce value-added via a CES production function, and imported and domestic producer goods combine to produce aggregate producer goods via CES production functions. There are 10 intermediate goods, associated with each of the production sectors apart from export services. For reasons explained below the entire output of this sector is exported.[4]

Taxes are levied on inputs of capital and labour, as well as on inputs of intermediate goods. Within a sector, all intermediate input taxes are the same. All input taxes vary by sector.

Firms in all sectors minimize costs, which generates factor demand and cost functions. It is a standard problem to generate these functions in the Leontief and CES cases. In the Leontief case, where production is given by

$$Q = \min_i[\{X_i/a_i\}] \qquad (6)$$

the demand for factor i equals

$$X_i = a_i Q \qquad (7)$$

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4 Production functions in the three manufacturing sectors are specified differently, for reasons given in section 4.1.2.

and the cost function is given by

$$c(\{w_i\}, Q) = \Sigma_i w_i a_i Q \qquad (8)$$

where w_i represents the cost to the firm of input i, inclusive of input taxes.[5]

In the CES case, where production is given by

$$Q = [\Sigma_i a_i X_i^{\tau}]^{1/\tau} \qquad (9)$$

where $\tau = (\sigma-1)/\sigma$, and σ is the elasticity of substitution, factor demands are given by

$$X_i(\{w_j\}, Q) = Q[(a_i/w_i)\{\Sigma_j(a_j^{\sigma}w_j^{1-\sigma})\}^{1/1-\sigma}]^{\sigma} \qquad (10)$$

and the cost function is

$$c(\{w_i\}, Q) = Q[\Sigma_i(w_i/a_i)^{1-\sigma}]^{1/1-\sigma} \qquad (11)$$

The 'top level' production function is Leontief. Therefore equation (7) generates the demands for the value added aggregate and for the aggregate producer goods in each sector.[6] In this case the w_i's refer to the cost of the value added aggregate and intermediate inputs.

The 'bottom level' production functions are CES.

5 For the sake of notational simplicity, we here drop subscripts referring to sectors; with the understanding that there are separate production functions for each sector.

6 Except in the cases of utilities and building, where the top level production function is CES; in these cases factor demands are generated by (10). See section 4.1.3.

Equation (10) generates the demands for labour and capital, in the case where Q represents the value-added aggregate; and it generates the demands for domestic and imported producer goods, in the case where Q represents aggregate producer goods. In the former case, σ represents the elasticity of substitution between capital and labour within a sector; in the latter case, σ represents the 'Armington' elasticity of substitution between domestic and imported producer goods. Since the cost of input i, w_i, is inclusive of input taxes, these taxes influence firms' choice of techniques.

The model assumes perfect competition and constant returns to scale. Thus, for each sector, price equals cost (where the cost includes taxes levied on inputs). The cost function for each sector is represented by equation (8). However, the w_i's in equation (8) are equal to the average cost of producing the input in question (value-added aggregate or intermediate input). These average cost functions are given by equation (11).

2.5. Consumption

Consumers are endowed with labour, capital and agricultural capital. They also receive transfers (of foreign exchange) from abroad, and transfers (of an artificial "transfer" commodity) from the central government. Some of the government transfers are related to the level of unemployment. Consumers have a 4-level nested utility function, represented here by a series of pseudo-production functions (see Figure 2). At the top level, consumption substitutes with savings (modelled as purchases of an aggregate investment good). At the next level, consumption goods substitute in the production of the consumption aggregate. At the next level, aggregate producer goods substitute in the production of consumer goods and the investment good. At the lowest level, domestic and imported producer goods substitute in the production of aggregate producer goods.

Proceeding from the bottom up: consumers consume 11 goods: food, drink, tobacco, clothes and footwear, fuel, petrol, durables, transport equipment, other goods, other services, and foreign tourism services. The last good is imported. Fictional sectors produce the other 10 consumption goods, by combining domestic and imported producer goods. Again, these sectors are characterised by nested production functions. At the top level, aggregate producer goods produce consumption goods via Leontief production functions. At the lower level, aggregate producer goods are produced by CES production functions, with domestic and imported producer goods as inputs. Again, the elasticity of substitution in the lower level functions is the 'Armington' elasticity.

(Similar fictional sectors are used to produce, in precisely the same way, an aggregate investment good, as well as a government investment good, and a government consumption good.[7] It is the aggregate investment good which here

[7] Inputs into the production of the investment good are uniformly subsidised, reflecting capital subsidies. Inputs into the production of government investment are uniformly taxed, as are inputs into the production of government consumption.

concerns us.)

The 11 consumption goods are then combined to produce an aggregate consumption good, via a CES production function. Consumption taxes are modelled as taxes on the inputs of consumption goods in this sector. Next, a pseudo-sector uses a CES production function to produce the 'first utility good', with the consumption and investment goods as inputs. Inputs of the investment good here represent household savings; the elasticity of substitution in this sector represents the consumers willingness to trade off present for future consumption.[8] Finally, a further pseudo-sector transforms the entire output of this 'first utility good' into a 'second utility good', taxing inputs of the first good at the marginal income tax rate: this is how income taxation is introduced into the model.[9] Consumers spend their entire income on this second utility good.

2.6. The government sector

The government receives all tax revenues. In addition it is endowed with capital (representing government trading profits) and the investment good (representing government borrowing). It is also endowed with foreign exchange, representing lump sum transfers from abroad. It makes

[8] The formulation here follows that of the single period submodel in Ballard, Fullerton, Shoven and Whalley (1985).

[9] Since in fact not all income is taxed at this marginal rate, the government has to transfer the excess taxation arising from this procedure back to the households. This is an admittedly crude way of incorporating a marginal income tax rate which differs from the average income tax rate.

transfers to consumers, and consumes capital (representing interest payments on the national debt). The government consumes two goods: the government investment and consumption aggregates.

In order to do "equal yield" tax analysis, government expenditures are kept constant. Government expenditures on aggregate goods are treated as negative endowments, which effectively fixes their quantities, as are government interest payments on the national debt. Transfers are modelled by endowing households with the transfer good; the government spends all net income on this transfer good. Auxiliary constraints keep the price of this transfer good equal to the price of the aggregate consumption good, fixing the amount of the transfers in real terms.[10]

To summarise, the government statement will be of the following form (E representing endowments, and D demands):

E: capital	(government trading profits)
E: foreign exchange	(foreign transfers)
E: investment good	(government borrowing)
E: -capital	(interest on national debt)
E: -government consumption	
E: -government investment	
E: -transfers	(related to unemployment)
D: transfers	(not related to unemployment)

2.7. Trade

Pseudo-production functions are used to model trade flows. Export 'sectors' convert domestic producer goods into

[10] This statement is not entirely accurate: as will be seen, some transfers are allowed to vary (proportionally) with the rate of unemployment. This implies that when doing tax reform analysis we are keeping constant (in real terms) all non-transfer expenditures, all real transfers not related to unemployment, and the real unemployment-related transfer per unemployed person.

foreign exchange. Import 'sectors' convert foreign exchange into the import good. In the benchmark equilibrium, Ireland ran a trade surplus. A foreign consumer is introduced, and endowed with enough foreign exchange to allow her to finance this deficit. This (together with the assumption that 'foreign exchange' is the numeraire good) amounts to assuming that the nominal trade surplus is exogenous. This is of course unsatisfactory; but it is no more convincing (and more complicated) to assume, for example, that trade is always balanced, or that the real value of the surplus is exogenous. As is well known, an intertemporal model would be required to model the current account rigorously; in the context of a static model, some ad hoc assumption is required.

Ireland is assumed to be 'small' in the markets for foreign producer goods; thus their prices are exogenous. This is modelled by allowing imports of these goods to exchange for foreign exchange at a fixed ratio. Let I_i stand for imports of good i, and let F_i denote the amount of foreign exchange used as an input into the relevant import sector:

<u>Sector</u>	<u>Output</u>		<u>Input</u>
Imports of good i	I_i	=	F_i/p_{if}

where p_{if} is the world price of foreign good i. In the benchmark equilibrium all these prices are unity.

The price-cost equations for these sectors tie down the exogenous prices of these goods; it remains to determine the level of imports of the goods.

Ireland is assumed to be 'big' in world markets for its producer goods: the more of a good Ireland exports, the lower will be its price. Thus, the production functions converting exports into foreign exchange will exhibit decreasing rather than constant returns to scale. This is done by modelling the export sectors in a Cobb-Douglas fashion:

$$F_i = A_i E_i^{\alpha} Z_i^{1-\alpha} \qquad (12)$$

where A_i is a constant and Z_i is a fictitious factor of production (one for each export sector).[11] This factor is in fixed supply, which is what generates the decreasing returns to scale:

$$Z_i = \bar{Z}_i \qquad (13)$$

By 'minimizing costs' in this sector, a foreign demand function for the Irish producer good is generated, which exhibits a constant elasticity of demand:

$$E_i = C_i p_i^{\beta i} \qquad (14)$$

where C_i is a constant, βi is the elasticity of demand and p_i is the price of the good.[12]

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[11] Outputs from 5 sectors are exported: agriculture, traditional manufacturing, food processing, high-tech manufacturing, and exported services.

[12] Ownership of the fictitious fixed factors generates income which corresponds to nothing in the real world; so a fictitious consumer is introduced, endowed with the fixed factors, who spends all his income on foreign exchange.

2.8. Employment, unemployment and migration

The labour market in our model differs from most conventional CGE models in two key respects. First, we allow for a semi-rigid real wage which is sufficiently high in the benchmark to generate the benchmark unemployment rate. Since the latter (in 1985) was 18.2% it seems implausible to assume that the economy is at the NAIRU. Unemployment is taken to be classical in this model. The real wage is semi-rigid in the sense that it responds negatively to the level of unemployment. The second key difference is that we allow for migration of labour into and out of the economy. We take our estimates of the key parameters from the literature as explained in section 4.3.

The wage equation is of the form:

$$\log(W/P) = \alpha - a.(U - U_B) \qquad (15)$$

where "a" is the semi-elasticity of the real wage w.r.t. the rate of unemployment, and U and U_B are the unemployment rate and the benchmark unemployment rate respectively. For convenience we write the model such that in the benchmark the real wage is unity ($\alpha = 0$). In the CGE model the real wage is the nominal wage divided by the price of the second utility good which is essentially the true-cost-of-living index. (The price of this good incorporates income taxes as well as taxes on consumption.)

Labour supply is equal to the labour force plus net migration, which is a function of the unemployment rate and the levels of real wages and unemployment benefits. Note that we exclude conventional labour supply responses by the existing, indigenous, labour force. The labour supply equation is

$$L^S = LF + MIG = ((W/P).(1-U) + (B/P).U)^{\theta} \qquad \textbf{(16)}$$

where L^S is the labour supply, LF is the labour force in the benchmark, MIG is net migration, and B is unemployment benefit. W, P and U are as defined before. θ is the relevant elasticity. Note that this differs from conventional migration equations in that the level of the labour force, rather than the change in the labour force (i.e. the rate of migration), depends on the level of wages, unemployment, etc.

2.9. Equilibrium

Equilibrium is defined by the following conditions: for every sector, price equals cost; for every commodity, demand equals supply; the consumer's income equals the value of endowments; and all taxes are fully distributed. If there are n sectors, m commodities, and p consumers, this implies n + m + p equations (and, owing to Walras' Law, n + m + p - 1 independent equations), to solve for n + m + p unknowns (n activity levels, m prices and p consumers' incomes). Sectors here include sectors which transform goods into foreign exchange or vice versa, sectors which transform producer goods into consumer goods, and the sectors producing the various consumption, investment and utility aggregates.

Section 3. Calibrating the model

The model was calibrated to 1985, the last year for which detailed input-output tables were available to us. A social accounting matrix was constructed detailing all intersectoral and inter-agent commodity, factor input, transfer and tax flows for that year. This involved reconciling input-output data with the national income accounts, the balance of payments, and the government accounts.

The three main sources of data were the input-output tables for 1985 (IO 1985), National Income and Expenditure 1989 (NIE 1989), and Curtis and FitzGerald (1993) (CF).[13] Curtis and FitzGerald kindly made available to us spreadsheet files containing a more detailed breakdown of the 1985 IO tables, and on occasion it was necessary to turn to these rather than the published version of the tables to get the data we wanted. Table 1 briefly outlines the data sources for the social accounting matrix. The rows of the matrix represent commodities while the columns represent the sources and uses of those commodities (sectors and agents).

3.1. Sectoral aggregation

There are 41 industry sectors in the 1985 input-output table, complying with the NACE-CLIO (R44) classification of the Statistical Office of the European Communities. These sectors are set out in Appendix 1 of this paper. The aggregation of these sectors used here is that of CF (see

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13 The consumer goods disaggregation is entirely due to Curtis and FitzGerald.

Table 2).

In addition, the model incorporates an eleventh sector, the exported services (TS) Sector (A11). Several service sectors at our level of aggregation exported a small amount of output. If these sectors were to be treated as non-traded in the model, it was empirically necessary to hive off their exported output (and associated inputs) into an 11th sector.

Output in the sector was calculated as the sum of the exports from utilities, distribution, transport and communication, other marketed services and non-marketed services. Inputs into the sector were calculated as follows. For each of the five sectors above, other than transport and communications, indexed by j, let a_j be the percentage of exports in total output. If the input of commodity (or factor) i into sector j is denoted by X_{ij}, then the input of commodity i into the ES-sector was calculated as $\Sigma_j a_j X_{ij}$.

In the case of transport and communications, we returned to the NACE-CLIO code and considered inputs into each of the subsectors separately, otherwise following exactly the procedure outlined above. The transport and communications sector was treated differently due to the large export content of some of its subsectors and the small export content of others.[14]

Having calculated total TS-sector inputs and output, the inputs and outputs of the five non-traded sectors mentioned

[14] For example, the maritime/air transport sector (S63) exported £331.3 m. of its £465.65 m. total output (or 71.1%) while communication services (S67) exported £17.16 m. of its £632.27 m. output (or 2.7%).

had to be correspondingly reduced. The result was a new, 11-sector input output table. Tables 3 and 4 present the basic input-output data for these 11 sectors.

Section 3.2. Final demand

There are four components of final demand: government current expenditure, investment, exports and personal consumption. IO gives the breakdown between these categories of expenditure. CF further disaggregate personal consumption into eleven consumption goods: food, drink, tobacco, clothes and footwear, fuel, petrol, durables, transport equipment, other goods, other services and tourism imports.

Tables 5 and 6 give the end uses of domestic and imported goods respectively.[15] Tables 7 and 8 break down the flows of domestic and imported goods used for personal consumption, into the consumption good categories listed above.

Section 3.3. Tax rates

All taxes are ad valorem by construction. The taxes are:

[15] For two sectors-- agriculture and utilities-- total investment (including changes in stocks) was given as negative in IO. The figures involved were fairly small: £2 m. in the case of utilities, £12.87 m. in the case of agriculture. The model cannot handle negative investment, and so the ad hoc procedure was adopted of letting investment be zero for both sectors, and reducing exports by the amounts given, thus maintaining overall goods market balance.

Of course, reducing exports by this amount affects the trade balances for the two goods; to maintain trade balances at their initial levels, imports of the two goods were also correspondingly reduced.

Production taxes

1. Employers' PRSI: treated as a tax on labour inputs
2. Corporate taxes: treated as a tax on capital inputs
3. Taxes/subsidies on intermediate inputs: uniform on all inputs in a given sector

Intermediate input taxes: aggregate goods

Levied uniformly on all inputs of producer goods into the production of government consumption, government investment and private investment. Differ by aggregate good.

Export taxes/subsidies

By sector.

Consumption taxes

Household consumer taxes levied on inputs of consumption goods into the production of the consumption aggregate. Differ by consumer good.

Income taxes

Levied on input of the consumption/savings aggregate into the production of household utility. Average tax is 1985 marginal rate (60%); lump sum transfers to household compensate for excessive taxation of intra-marginal income.

3.3.1. Production Taxes

Labour Taxes

The labour tax rate is the employers' PRSI contribution as a percentage of wages and salaries bill in each sector.[16] For example the labour tax rate for the agriculture sector was calculated as the employers' PRSI contribution of £14.68 m.

[16] Net of PRSI, of course.

divided by £112.2 m., being the wages and salaries paid by the agriculture sector.[17] Table 9 gives details.

Capital/Corporate Taxes

NIE gives corporate tax revenue received by the government as £217.52 m. To this figure fees under the Petroleum and Minerals Development Act (£8.001 m.) are added, giving a corporate tax level of £225.521 m. Because of the discrimination between manufacturing (the traditional, high-tech and food processing sectors, which faced a 10% tax rate) and non-manufacturing sectors (utilities, distribution, buildings, transport and communications, other marketed services and non marketed services, which faced a 50% rate) there are two tax rates calculated. These tax rates are calculated by assuming that the non-manufacturing rate is five times the manufacturing rate, ('t'), and adjusting 't' so as to produce the actual tax yield:

$$tK_m/(1+t) + 5tK_n/(1+5t) = £225.521 \text{ m.} \qquad (17)$$

where K_m = manufacturing profits, and K_n = non-manufacturing profits. It is assumed that the agricultural sector does not pay corporate tax, since the majority of agricultural profits consists of income accruing to the self-employed. There are a limited number of agricultural firms, such as stud farms,

[17] It should be noted that the agricultural sector has a large self-employed work force and that the wages and salaries for self-employed people are included in profits, rather than in the wages and salaries figure. Our calculation thus overstates the labour tax rate in agriculture.

which would pay corporate tax but as these figure are (a) not available and (b) probably very small they are ignored here.

The corporate tax rates that were calculated are: 0.014852 for manufacturing sectors and 0.074262 for non-manufacturing sectors.

Note that this ratio reflects only the difference in legal tax rates and not differences in effective tax rates which might arise from differences in tax allowances across sectors or assets. The methods used to deal with this problem are well known[18] but it was not possible to implement them in the current model.

Input Taxes

Input taxes are calculated as the sum of indirect taxes, less subsidies, divided by total output. This calculation is carried out for each of the eleven sectors, as well as for private and public investment, and government consumption. Table 9 gives details.

3.3.2. Export Taxes

IO gives indirect taxes and subsidies for both merchandise and invisible exports, and within the merchandise category, for agricultural and manufactured exports. IO and CF break down exports from each sector into their invisible, agricultural, and industrial components. (See Table 10.) It is assumed that export taxes (or subsidies) vary across these three types of exports, but are otherwise constant across

[18] See King and Fullerton (1984).

sectors. To calculate the average export tax rate for sector i, we proceed as follows. Let E_{ij} represent exports from sector i of category j (where j = invisible, agricultural, or industrial). Let T_j be total export taxes on exports of category j. The average tax on exports of category j, t_j, is then given by

$$t_j = T_j/\Sigma_i E_{ij} \qquad (18)$$

For example, the export tax on invisible exports is (77.91/1078.92) = 7.2%. The export tax for sector i, τ_i, is then given by

$$\tau_i = \Sigma_j t_j E_{ij}/\Sigma_j E_{ij} \qquad (19)$$

3.3.3. Consumption taxes

The consumption tax rate is calculated for each of the consumer goods, based on data given in CF (see Table 11).[19]

Section 3.4. Reconciliation with the national accounts

Section 3.4.1. Household income and expenditure

Households are endowed with labour and capital, and receive transfers from the government and from abroad. They pay taxes on their labour and capital income, consume consumer goods, and save the remainder. Households are here taken to be the entire Irish private sector; so undistributed company profits are part of household income.

[19] The tax on foreign holidays is taken to be zero.

All labour is owned by households. The labour endowment of the economy is listed as £9504.60 m. (IO, p. 5). Table 12 of NIE lists total labour income as £9518.0 m.; however, of this, £13.4 m. is labour income received abroad. This will be treated as a foreign transfer; the residual accords with the IO figure.

Of the total labour payments of £9504.6 m., £642.8 m. are employers' PRSI contributions (IO, p. 29). This money obviously does not accrue to households; households are thus endowed with £8861.8 m. (=9504.6-642.8) in labour income.

Table 2 of NIE lists the following sources of 'capital' income accruing to households:

Income of independent traders, etc.	£2218.4 m.
Profits/rents/interest accruing to non-profit sector	£965.1 m.
Undistributed company profits	£657.1 m.

This implies a total household capital income of £3840.6 m. However, corporate taxes amounted to £225.5 m. (NIE, p. 21).[20] This money does not accrue as income to the private sector either (it is here treated as representing a tax on the use of capital by firms). Capital income received by households thus amounted to £3615.1 m.

In addition, households receive transfers of 3129.3 + 13.4 = £3142.7 m. Where do these transfers come from?

NIE, Table 30a, lists transfers from abroad of £1319.3 m.

[20] Corporation taxes plus fees under the Petroleum and Minerals Development Acts.

and transfers made to foreigners of £345.5 m., implying that the Irish economy received net transfers from abroad of £973.8 m. To this the £13.4 m. in wages received overseas is added, yielding a total net transfer from abroad of £987.2 m.

NIE Table 21 lists total government transfers of £3002.9. m. Tables 19 and 20 reveal that of this total, £45.0 m. consisted of transfer payments to the rest of the world (ROW), with the residual, £2957.9 m., accruing to households. Households are therefore taken to receive £2957.9 m. in transfer payments from the government. Subtracting this total from £3142.7 m., we find that transfers to households from ROW amounted to £184.8 m. (including the £13.4 m. figure referred to earlier). Finally, subtracting £184.8 m. from £987.2 m. implies that the government receives transfers of £802.4 m. Note that this figure includes EC subsidies (net of EC taxes) which are treated as government expenditure here, but not in NIE.

The model distinguishes between government transfers to households that vary with the level of unemployment, and those that do not. The following transfers are taken to vary with the level of unemployment: unemployment assistance, redundancy payments, unemployment benefit, retirement pensions, pay-related benefit, the social employment scheme, the enterprise allowance scheme, and Fás allowances. Disability benefit and invalidity pensions are a grey area: we assume that half of these transfers in 1985 were by nature linked to unemployment. From Table 24 in NIE, we arrive at a total for these transfers of £990.2 m. This implies that a residual of £1967.7 m.

represented transfers not linked with unemployment.

To summarise, households receive labour income of £8861.8 m., capital income of £3615.1 m., unemployment-related transfers from the government of £990.2 m., other transfers from the government of £1967.7 m. and transfers from the ROW of £184.8 m. This implies a total household income of £15619.6 m. The total given in NIE Table 12 is £16487.9 m. However, this includes the corporate taxes of £225.5 m., and the employers' PRSI contributions of £642.8 m. Subtracting these taxes from the total given in NIE, we arrive again at £15619.6 m.

NIE Table 22 gives details of taxation. The table lists taxes on income and wealth of £3557.5 m., and taxes on capital of £30.5 m. Taxes on capital are here aggregated with taxes on income and wealth, yielding a tax total of £3588 m. However, of this £3588 m., £64.5 m. consists of motor vehicle duties paid by households. These are here treated as taxes on expenditure. They are therefore subtracted from £3588 m., yielding a total for taxes on income and wealth of £3523.5 m. Furthermore, this figure includes the corporate taxes of £225.5 m.; and the total for social insurance includes the employers' contributions to PRSI of £642.8 m. Subtracting these figures, we arrive at a total for taxes on household income and wealth of £2655.2 m.

Taxes on expenditure equal 3032.5 + 237.2 (taxes on expenditure plus EC taxes) = £3269.7 m. To this, £2.5 m. has to be added (see IO p. vii) to yield a total of £3272.2 m., which accords with the entry in IO (p. 5). To this total,

however, the motor vehicle duties of £64.5 m. referred to earlier must be added, yielding a total expenditure tax of £3336.7 m.

Household income is £15619.6 m. Taxes on income and wealth equal £2655.2 m. Consumption expenditure by households (including sales taxes) is given as £10493.1 m. in IO (p. 5). This is equal to the entry in NIE Table 7 (£10490.6 m.) plus £2.5 m. To this figure, the extra £64.5 m. in motor vehicle duties must be added, yielding a total consumption expenditure of £10557.6 m. Subtracting taxes on income and wealth, and consumption, from household income, we arrive at a figure for household saving of £2406.8 m.

NIE Table 11 gives personal saving at £2008.2 m., and corporate saving at £431.6 m., implying a total saving of £2439.8 m. However, this figure includes the £30.5 m. in capital taxes, which we have here included with taxation rather than saving. Subtracting 30.5 from 2439.8 yields £2409.3 m. Moreover, the NIE figures do not take into account the extra £2.5 m. in expenditure taxes included in the IO figures. This £2.5 m. should be added to the NIE consumption figures, and hence subtracted from the NIE savings figures, yielding a new total of £2406.8 m., which is the figure we have already arrived at.

Section 3.4.2. The Government sector

The government levies taxes on income and expenditure. It receives transfers from abroad, and is endowed with capital. It purchases current goods and services, as well as the investment good; it subsidises expenditure, as well as private sector purchases of the investment good; it pays interest on the national debt; it pays transfers to households; and it borrows the excess of expenditure over revenue.

We have already covered some items of government income. Total tax receipts on household income and wealth amounted to £2655.2 m. Total expenditure taxes amounted to £3336.7 m. Corporate taxes were £225.5 m., and employers' PRSI contributions were £642.8 m. Total tax receipts therefore equalled £6860.2 m. The government received net transfers from abroad of £802.4 m. Government capital income was £551.1 m. (NIE, Table 10).

Government transfers to households amounted to £2957.9 m. (see above). Government current expenditures on goods and services amounted to £3301.0 m. (IO p. 5). This accords with the figure given in Table 10 of NIE. Table 21 lists current expenditures of £3590.9 m., and miscellaneous current receipts of £419.7 m. A note on p. 54 states that the figure in Table 10 equals 3590.9 - 419.7, plus estimated public authorities' depreciation (excluding the depreciation of local authority dwellings). One may therefore infer that this depreciation amounted to £129.8 m.

Government gross physical capital formation amounted to £711.0 m. (NIE, Table 21). In addition, capital grants to the private sector amounted to 155.1 + 95.8 = £250.9 m. (ibid.). Moreover, EC capital grants amounted to £50.4 m. (NIE Table 11). Total capital subsidies therefore amounted to £301.3 m.

Expenditure subsidies amounted to £1452.7 m. (IO, p. 5). This equals the sum of Irish government subsidies (£588.5 m.) and EC subsidies (£864.2 m.) given in NIE Table 23. Interest payments on the national debt totalled £1824.7 m. (NIE Table 21).

Total expenditures therefore equalled £10548.6 m. Total income equalled £8213.7 m. The government therefore borrowed £2334.9 m.

Given the way in which Tables 10 and 21 in the NIE are presented (they are presented in incompatible formats), it is difficult to reconcile this figure with the data in Table 21. It is however possible to reconcile the figure with the figure for net public <u>current</u> saving in Table 10 (-£1406.1 m.).

This figure does not take into account taxes on capital (£30.5 m.). If these are included with taxes on income, as we have done, then the figure should be reduced by £30.5 m., yielding £1375.6 m. Second, the NIE figures do not take into account the extra consumption tax receipts of £2.5 m.; these should also be subtracted from the figure to give £1373.1 m. Third, we are here including 2 types of expenditure classified in the NIE as being 'capital' in nature: government purchases of the investment good (£711.0 m.) and government capital subsidies (£301.3 m.). These expenditures should be added to the figure, giving £2385.4 m. Finally, £50.4 m. of the capital subsidies were as we saw EC subsidies; this figure was not included in the government receipts in Table 10. 50.4 should therefore be subtracted from 2385.4, yielding a final result of £2335 m., only £0.1 m. greater than our figure for government borrowing.

Section 3.4.3. The savings-investment balance

Household saving is £2406.8 m. Net capital inflows (the negative of the current account balance) amounted to £650.1 m. (NIE, Table 30a). In addition, additions to the pool of available savings have to be made to take account of stock appreciation (£99.4 m.; NIE Table 11) and depreciation (£1723.8 m.; IO, p. 5). Government borrowing amounted to £2334.9 m.. The net amount available for investment expenditure was thus £2545.2 m.

Gross fixed capital formation (including changes in stocks of £168.9 m.) amounted to £3557.6 m. (IO, p. 5). This is also the amount given in NIE, Table 11. However, this includes capital expenditures by the government (£711 m.), as well as government capital subsidies (£301.3 m.). Subtracting these from the total yields a figure of £2545.3 m. This differs from the pool of available savings by £0.1 m., since in NIE (Table 11), the value of depreciation is given as £1723.9 m., not £1723.8 m. as in IO.

The stock appreciation adjustment, as well as the value of depreciation, are both elements of gross income not allocated to any consumer. An artificial consumer could be introduced, endowed with capital to the extent of £1823.4 m., the sum of these two amounts. In an earlier version of the model this is what was done; in this iteration of the model, however, the representative consumer is endowed with this extra capital, and her consumption of the investment good is

correspondingly increased.

Section 3.4.4. The foreign consumer

The foreign consumer is endowed with capital. It makes transfers to the Irish government and Irish households, and makes available savings to the Irish economy. Its residual income is spent on the surplus foreign exchange earnings generated in the model; i.e. the balance of trade surplus.

Irish residents earned £793.8 m. on investments abroad in 1985; foreigners earned £2772.9 m. on investments in Ireland. There was thus a net deficit on trading and investment income of £1979.1 m. (NIE, Table 30a). The foreigner is thus endowed with capital of £1979.1 m. Net transfers to Ireland from abroad amounted to £987.2 m. £184.8 m. of these went to households, and £802.4 m. went to the government. In addition, the foreign agent made available £650.1 m. in savings to the Irish economy in 1985. Finally, total exports in 1985 came to £10822.9 m. (IO, p. 5), and total imports to £10481.1 m. The trade surplus was thus £341.8 m.

Section 4. Benchmark elasticities and other parameters

Section 4.1. Elasticities of Substitution

In most cases we relied on a literature search to provide estimates of production function substitution elasticities. In the cases of building, utilities and non-market services we estimated CES production functions to calculate substitution elasticities as there were none readily available. In cases where we lacked evidence on the elasticity of substitution between value added and materials, we assumed that the elasticity was zero. Table 12 gives an overview of the elasticities we chose and the sources used.

Section 4.1.1. Agriculture

McKillop and Glass (1991) (MG) use a two-output multiple-input cost function to analyse empirically (1961-1985) the production structure of Irish agriculture. The two outputs are "livestock and livestock products" and "crops", while the four inputs are capital, feedstuffs and seed, fertilizers, and labour. MG use a translog cost function which assumes Hicks-neutral technical change; using the iterative Zellner procedure they give estimates of the elasticities of substitution between capital and labour for a number of years including 1985 (0.59), the mean value being 0.41. We used an average figure of 0.5.

Section 4.1.2. Manufacturing

A literature search for elasticities of substitution for the individual manufacturing sectors found none that were suitable. Moreover, an attempt to calculate elasticities using the same structural specification as with building and utilities (see section 4.1.3) proved unsuccessful.

We therefore used the elasticities, for manufacturing as a whole, calculated by Hannan (1993). The estimation procedure used is similar to that of MG: a three input translog cost function was used, the inputs being capital, labour and materials, and the Allen partial elasticities of

substitution calculated.[21] The share equations were estimated using an iterative Zellner estimator.[22] The Allen partial elasticity of substitution between capital and labour was estimated as 0.968577; that between capital and materials was 0.904403; and that between labour and materials was -0.015156.

We therefore adopted an alternative nesting system for the manufacturing sectors (see Figure 3): labour and materials were assumed to be used in fixed proportions, with the resulting bundle of inputs substituting with capital (the elasticity being 0.936). In the context of section 2.4., this implies that equation **(10)** generates the demands for capital and the labour/materials bundle, while at the lower level of the production function equation **(7)** generates the demands for labour and aggregate producer goods.

Section 4.1.3. Building and utilities

For building and utilities nested CES production functions were estimated. At the lower level, net output (Z) is a function of labour (L) and capital (K) (equation **20**), while at the upper level gross output (Y) is a function of net output and materials (M) (equation **21**):

$$Z = [\alpha L^{-\theta} + (1-\alpha)K^{-\theta}]^{(-1/\theta)} \qquad \textbf{(20)}$$

$$Y = [\delta Z^{-\rho} + (1-\delta)M^{-\rho}]^{(-1/\rho)} \qquad \textbf{(21)}$$

21 The data used was provided by the CSO and the data range is from 1960 to 1989. The cost of capital estimates are those of Frain (1990).

22 The share equation for materials was dropped.

The marginal product of labour (partial derivative of gross output with respect to labour) is calculated (equation **22**) and set equal to the wage (W). We then log the equation in order to linearise it (equation **23**):

$$\delta Y/\delta L = Y^{(1+\rho)} Z^{(\theta-\rho)} L^{-(\theta+1)} \delta\alpha \qquad (22)$$

$$\ln L = a_0 + a_1 \ln Y + a_2 \ln Z + a_3 \ln W \qquad (23)$$

where a_0 is a constant, $a_1 = (1+\rho)/(1+\theta)$, $a_2 = (\theta-\rho)/(1+\theta)$, $a_3 = -1/(1+\theta)$.

The elasticity of substitution between labour and capital is given by the negative of the coefficient on the log wage:

$$\sigma_{KL} = 1/(1+\theta) \qquad (24)$$

while the elasticity of substitution between net output and materials is given by

$$\sigma_{ZM} = 1/(1+\rho) \qquad (25)$$

These elasticities can also be estimated in the context of a regression taking the log wage as the dependent variable:

$$\ln W = b_0 + b_1 \ln Y + b_2 \ln Z + b_3 \ln L \qquad (26)$$

where $b_1 = 1+\rho$, $b_2 = (\theta-\rho)$, $b_3 = -(1+\theta)$. This specification has the advantage that the restriction to be placed on the coefficients takes a simple, linear form:

$$b_1 + b_2 + b_3 = 0 \qquad (27)$$

The ESRI/Department of Finance Databank (28th May 1993) was used in the estimation. Gross output, net output, the wage bill, and numbers employed over the period 1970 to 1990 (Buildings) and 1961 to 1990 (Utilities) are the series used. Estimates including a lagged dependent variable and a time trend were considered and the best estimates are outlined below for the individual sectors.

<u>Buildings</u>

Separate estimates for the buildings sector were calculated using employment and wages as dependent variables. In both cases a lag and a time trend was added. The time trend is added to allow for bias in technical progress between factors. The most robust results emerged when labour was the dependent variable with both a lag and time trend included in the model.

The elasticity of substitution between capital and labour is 0.5689913, while the elasticity of substitution between value added and materials is 1.4461948. (See Table 13).

<u>Utilities</u>

When employment is endogenous and a lag and time trend are included, the coefficient on the wage bill term turns out to be positive, invalidating the regression. An average estimate was calculated based on two regressions: (i) employment regressed on gross and net output and the wage rate, and (ii) the wage rate regressed on gross and net output and employment (see Table 14).

The elasticity of substitution between labour and capital for (i) is 0.1007011 and for (ii) is 0.28738. An average estimate, 0.1940434, is used. Similarly an average elasticity of substitution between value added and materials was calculated as 0.2662776.

4.1.4. Non-market services

Data was taken from the ESRI/Department of Finance Databank. The available data (1961-1990) consisted of value added, the wage bill, and total numbers employed. It was thus only possible to estimate a production function using two inputs (K and L) to produce value added:

$$V = (\delta L^{-\rho} + (1-\delta)K^{-\rho})^{-(1/\rho)} \qquad (28)$$

Converting this to a linear demand system implies:

$$\ln l = a_0 + a_1 \ln V + a_2 \ln W \qquad (29)$$

where W is the wage, as before, and where $a_1 = -1/(1-\rho)$, $a_2 = \rho/(1+\rho)$.

Two regressions were estimated, where (i) labour and (ii) the wage rate were the dependent variable; a lagged dependent variable was included in the regression. Results are given in Table 15.

The elasticity of substitution between labour and capital

was calculated as 0.1226729 under (i), and 0.1645285 under (ii). The average (0.1436007) is used.

4.1.5. Marketed services

Bradley, FitzGerald and Kearney (1991) (BFK) note the lack of empirical research on marketed services and build a model for the marketed services subsectors. Due to data constraints they could only model the supply side within a value-added framework using two factors, capital and labour. BFK use a translog cost function, with the underlying assumption that output is market determined; using Shephard's Lemma the factor demand equations are calculated assuming cost minimisation.

BFK also include a capacity utilisation variable, defined as actual output divided by trend output. This adds a dynamic element to the model, allowing short-run changes in utilisation rates to influence the share of value-added which accrues to capital. The authors use the ESRI/Department of Finance data bank and the data range is from 1970 to 1987 unless otherwise stated.

Distribution

A value of 0.86 is calculated for the elasticity of substitution between capital and labour. A CES production function yielded a higher but quite similar value of 0.94. We used an average value of 0.9.

Other marketed services

Data was only available from 1974 to 1987 for this sector. The elasticity of substitution between labour and capital was calculated as 1.2. Using a CES production function the estimate dropped slightly, to 1.07. We took an average value of 1.135.

Transport and Communication

BFK had difficulties in modelling this sector as it is dominated by a large number of state owned firms, operating in a market that is clearly not freely competitive. The translog production function produced poor results for the sector. The authors then used the Morrison version of the Generalised Leontief model, treating capital stock as a quasi-fixed factor, and estimated the system using the iterative Zellner procedure. They do not give a numerical estimate for the elasticity of substitution between capital and labour but state that all of the relevant determining coefficients are significant and that the estimated substitution possibilities were low. We assumed a value of 0.3.

4.1.6. Exported services

Since this sector is an artificial construct, we are obliged to impose an elasticity of substitution arbitrarily on the model: we chose 0.59, the average for utilities, distribution, other market services and non-market services.

Section 4.2. Trade-related elasticities

4.2.1. Armington elasticities

Armington elasticities measure the substitution between domestic and imported goods. In our model there are five import-competing sectors: agriculture, traditional manufacturing, food processing, high-tech, and utilities. Armington elasticities for these sectors are calculated as a weighted average of those used by Keuschnigg and Kohler (1993) (KK). KK review available Armington elasticities for 31 sectors, using the following sources: Harrison et al. (1991), Shiells, Deardoff and Stern (1986), Deardoff and Stern (1986), Lächler (1985) and Harris (1986). They choose either the most representative value, or else take an unweighted average of different estimates given by the various sources. The values used in our model are given in Table 16.

4.2.2. Export demand elasticities

It was not possible to estimate export demand elasticities for individual commodities. Our estimate of the world's price elasticity of demand for Irish exports is taken from Browne (1982). Browne uses a log-linear model of demand and supply, incorporating a simple partial adjustment specification.

The equation which Browne estimates is

$$\ln X^d_t = a_0 + a_1 \ln(PX/PW)_t + a_2 YW_t \qquad (30)$$

where X^d is the demand for Irish exports, PX/PW is the price of Irish exports relative to the price of competing goods on world markets, and YW is world income. The parameter of interest is a_1; this is estimated as -16.1, implying that Irish exporters have virtually no market power.

4.3. Labour market parameters

4.3.1. The wage equation

To parametrise the wage equation (equation **(15)** in section 2.8 above) we use estimates taken from the ESRI Hermes model [Bradley et al. (1989), Barry and Bradley (1991)]. While their modelling framework does not correspond exactly to ours, we attempted to model wage-setting in a manner as similar as possible to Hermes, partly to facilitate the comparison of results. Hermes specifies a wage equation of the form

$$\ln(W/P) = a_1+a_2\ln(TW)+a_3(U+U_{-1})/2+a_4\ln(LP)+(1-a_4)\ln(W/P) \quad \textbf{(31)}$$

where W is the wage rate in industry, P is the output deflator, U is the unemployment rate, LP is labour productivity, and TW is a tax wedge variable (being a function of firms' real labour costs divided by the real wage received by suppliers of labour).

In this model the long run semi-elasticity of the real wage with respect to the unemployment rate is a_3/a_4. Using the Hermes point estimates gives a value of -0.035.

4.3.2. Labour supply

In our model the labour force is a (constant elasticity) function of the expected real wage, where this is an unemployment-weighted average of wages and unemployment benefits. Our estimate of the relevant elasticity (θ) is based on Keil and Newell (1992). They estimate an equation of the form

$$\text{Migration/Population} = \theta.\Delta(W_I-W_{UK}) + X \quad \textbf{(32)}$$

where X includes terms in the level of wages and unemployment, Δ represents a proportionate change, and I and UK stand for Ireland and the United Kingdom respectively. We interpret the estimate of $-\theta$ as a measure of the long run elasticity of population/labour force w.r.t. the expected wage.[23] Keil and Newell find a value for this of 0.11, with a t-ratio of 3.9.

[23] We emphasize that this is our interpretation, which may not be shared by the authors of the paper cited.

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Table 1. Outline of data sources for CGE model

	P-Goods	C-Goods	Agg-Goods	Export Sectors	Import Sectors	Agents
P-Goods	A1	C&F	A1	A1	-	-
Imports	A4	C&F	A4	-	A4	-
Factors	A1	-	-	-	-	A1,NIE
Tax-F	A1, B2	-	-	-	-	A1,NIE
Tax-In	A1	-	A1	-	-	A1,NIE
Tax-Cons	-	C&F	-	-	-	C&F, NIE
Tax-Y	-	-	NIE	-	-	NIE
C-Goods	-	-	C&F	-	-	
Agg-Goods	-	-	NIE	-	-	A1,NIE

Notes:

P-Goods: producer goods
C-Goods: consumer goods
Agg-Goods: aggregate goods
Factors: factors of production
Tax-F: taxes on factors of production
Tax-In: taxes on intermediate inputs
Tax-Cons: taxes on consumer goods
Tax-Y: income tax
A1: Table A1 of the 1985 Input-Output Tables
A4: Table A4 of the 1985 Input-Output Tables
B2: Table B2 of the 1985 Input-Output Tables
NIE: National Income and Expenditure 1989
C&F: Curtis and FitzGerald (1993)

Unless otherwise stated sources for the following tables are given above.

Table 2. NACE-CLIO sectoral aggregation

No.	Description	Code	NACE-CLIO CODE
A1	Agriculture	AG	S01
A2	Traditional manufacturing	TR	S03,S05,S13,S15,S19,S21,S27 S29,S37,S39,S41,S43,S45,S47, S49,S51
A3	Food-processing	FP	S31,S33,S35
A4	High-tech manufacturing	HT	S17,S23,S25
A5	Utilities	U	S07,S09,S11
A6	Building	B	S53
A7	Distribution	DI	S55,S57,S59
A8	Transport & communications	TC	S61,S63,S65,S67
A9	Other marketed services	OMS	S69,S71,S73,S79
A10	Non-marketed services	NMS	S81,S89,S93

Table 3. Domestic inter-industry flows

To: From:	AG	TR	FP	HT	U	B	DI	TC	ONS	NMS	TS
AG	610.69	47.55	2262.25	1.06	0	0	0.33	0.06	0.59	1.82	0.26
TR	19.43	377.89	84.18	74.77	63.51	453.26	97.44	67.71	71.48	129.39	52.38
FP	399.83	81.5	591.59	1.77	0	0	5.9	1.17	8.28	24.77	4.74
HT	212.41	36.69	9.24	102.99	2.29	43	24.53	0.68	36.68	30.21	8.46
U	49.15	162.09	93.85	84.11	253.48	44.01	98.99	23.07	45.44	65.65	48.61
B	44.78	11.61	8.75	7.43	0.76	0	117.84	116.53	116.37	54.67	40.47
DI	211.69	251	371.71	125.61	7.81	298.6	87.63	80.1	156.85	138.07	44.56
TC	20.01	73.28	46.33	46.56	8.48	77.57	171.15	47.35	153.63	129.88	55.32
ONS	45.96	93.51	46.01	96.7	21.5	28.96	517.13	110.83	1226.98	207.02	206.52
NMS	0.44	64.97	22.56	127.21	1.07	60.81	10.35	0.02	174	19.05	8.64
TS	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1614.39	1200.09	3536.47	668.21	358.9	1006.21	1131.29	447.52	1990.3	800.53	469.96

Notes:

TS: traded services
All figures in millions of Irish pounds. The same is true of subsequent tables.

Table 4. Foreign and other inputs into domestic production

	AG	TR	FP	HT	U	BU	DI	TC	ONS	NMS	TS	Total
AG-F	12.34	47.37	168.12	4.51	0	0	0	0	0	0	0	232.34
TR-F	17.19	1236.43	112.44	415.49	7.94	227.03	69.21	2.72	34	40.29	22.72	2185.46
FP-F	74.48	13.38	248.12	17.97	0	0	0	0	0	0	0	353.95
HT-F	93.5	138.96	63.21	1532.25	15.16	36.33	1.72	0.98	28.54	43.47	3.26	1957.38
U-F	46.97	67.63	57.04	36.92	311.09	69.46	21.41	27.89	17.64	25.01	41.62	722.68
INV	5.96	70.63	53.24	47.68	0.63	6.34	42.98	88.42	115.39	4.24	155.51	591.02
LAB	112.2	1286.71	447.58	498.85	156.38	760.5	948.52	364.39	1139.72	2720.29	426.66	8861.8
CAP	0	462.948	237.92	0	407.07	147.8	704.23	255.01	721.02	169.75	242.68	3348.428
CAPHT	0	0	0	1244.09	0	0	0	0	0	0	0	1244.09
CAPAG	1551.51	0	0	0	0	0	0	0	0	0	0	1551.51
TI	-133	134.49	134.23	67.53	31.17	53.8	47.76	42.81	-81.86	42.47	17.67	357.07
TL	14.68	124.4	43.66	50.27	12.52	65.29	86.03	27.37	91.3	93.88	33.4	642.8
TK	0	6.87	3.53	18.48	30.22	10.98	52.3	18.93	53.54	12.61	18.02	225.48

Notes:

-F: imported input (e.g. AG-F: imported agricultural goods)
INV-F: invisible imports
LAB: labour costs
CAP: capital inputs -all sectors except AG and HT
CAP-AG: agricultural capital
CAPHT: high-tech capital
TI: tax on intermediate inputs
TL: labour tax
TK: capital tax

Table 5. Domestic goods: end uses

	TII	Personal	Exports	GOV	INV	Total Output
AG	2924.61	130.04	355.57	0.00	0	3410.22
TR	1491.44	847.19	2318.438	0.00	132.84	4789.908
FP	1119.55	1321.18	2618.39	0.00	46.44	5105.56
HT	507.18	92.49	3942.52	0.00	60.06	4602.25
U	968.45	362.63	0	0.00	0	1331.08
B	519.21	0.00	0	149.35	1715.18	2383.74
DI	1773.63	1128.33	0	0.00	203.49	3105.45
TC	829.56	432.99	0	0.00	13.49	1276.04
OMS	2601.12	1467.73	0	40.74	0	4109.59
NMS	489.12	422.28	0	3041.14	0	3952.54
TS	0	0.00	1431.5	0.00	0	1431.5

Notes:

TII: total inter-industry flows
Personal: personal consumption
GOV: government consumption
INV: investment

Table 6. Imported goods: end uses

	Personal	INV	Total imports
AG-F	104.50	73.98	410.82
TR-F	259.07	691.76	4136.29
FP-F	301.20	14.25	669.4
HT-F	246.44	293.5	2497.32
U-F	200.11	26.8	949.59
INV-F	0	13.68	604.7
TOUR-F	401.7	0	401.7

Notes:

TOUR-F: foreign holidays

Table 7. Consumption of domestic goods

	FO	DR	TB	CF	FU	PL	DU	TE	OG	OS	TOTAL
AG	130.04	0	0	0	0	0	0	0	0	0	130.04
TR	0	320.96	84.17	127.09	0	0	25.63	4.95	284.39	0	847.19
FP	1321.18	0	0	0	0	0	0	0	0	0	1321.18
NT	0	0	0	0	0	0	39.7	0	52.79	0	92.49
U	0	0	0	0	319.3	43.33	0	0	0	0	362.63
B	0	0	0	0	0	0	0	0	0	0	0
DI	254	170	46	163	9	104	53	45	195	89.33	1128.33
TC	0	0	0	0	0	0	0	0	0	432.99	432.99
OMS	0	0	0	0	0	0	0	0	0	1467.73	1467.73
NMS	0	0	0	0	0	0	0	0	0	422.28	422.28

Notes:

FO:FOOD
DR:DRINK
TB:TOBACCO
CF:CLOTHING AND FOOTWEAR
FU:FUEL
PL:PETROL
DU:DURABLES
TE:TRANSPORT EQUIPMENT
OG:OTHER GOODS
OS:OTHER SERVICES

Table 8. Consumption of imported goods

	FO	DR	TB	CF	FU	PL	DU	TE	OG	OS	TOTAL
AG-F	104.5	0	0	0	0	0	0	0	0	0	104.5
TR-F	0	57.45	20.91	476.3	74.15	0	34.59	129.19	466.48	0	1259.07
FP-F	301.2	0	0	0	0	0	0	0	0	0	301.2
NT-F	0	0	0	0	0	0	136.72	0	109.72	0	246.44
U-F	0	0	0	0	0	200.11	0	0	0	0	200.11

Table 9. Labour and intermediate input taxes

(a) Producer goods

	AG	TR	FP	HT	U	B	DI	TC	CNS	MNS	TS
L TAX	14.68	124.4	43.66	50.27	12.52	65.29	86.03	27.37	91.3	93.88	33.4
WAGES	112.2	1286.71	447.58	498.85	156.38	760.5	948.52	364.39	1139.72	2720.29	426.66
% L TAX	13.1	9.7	9.8	10.1	8.0	8.6	9.1	7.5	8.0	3.5	7.8
I TAX	-133	134.49	134.23	67.53	31.17	53.8	47.76	42.81	-81.86	42.47	17.67
INPUTS	1864.83	2774.49	4238.64	2723.03	693.72	1345.37	1266.61	567.53	2185.87	913.54	693.07
% I TAX	-7.1	4.8	3.2	2.5	4.5	4.0	3.8	7.5	-3.7	4.6	2.5

(b) Aggregate goods

	OUTPUT	INPUTS	I TAX	% I TAX
PI	2545.3	2628.85	-83.55	-3.2
GI	711	656.62	54.38	8.3
GC	3301.03	3231.23	69.8	2.2

Notes:

L TAX: employers' PRSI
WAGES: wage bill minus employers' PRSI
% L TAX: L TAX/WAGES

I TAX: tax on purchases of intermediate inputs
INPUTS: domestic and imported intermediate inputs
% I TAX: I TAX/INPUTS

PI: private investment
GI: government investment
GC: government consumption

Table 10. Export taxes

	INVEX	MANEX	AGEX	ALL EX	E TAX	% E TAX
AG	0.93	0	354.64	355.57	-94.112	-26.5
TR	70.1	2248.34	0	2318.44	-29.603	-1.3
FP	39.74	691.15	1887.5	2618.39	-509.03	-19.4
HT	0.82	3941.7	0	3942.52	-60.714	-1.5
TS	967.33	368.16	96	1431.49	38.6818	2.7
ALL EX	1078.92	7249.35	2338.14			
E TAX	77.91	111.77	620.92			
% E TAX	7.2	1.5	26.6			

Notes:

INVEX: invisible exports
MANEX: manufacturing exports
AGEX: agricultural exports
ALL EX: total exports
E TAX: export taxes
% E TAX: E TAX/ALL EX

Source:
Curtis and FitzGerald's disaggregation of IO95.

Table 12. Production elasticities of substitution: overview

Sector	Source	Elast-KL	Elast-VM
AG	MG	0.5	0
U	DHO	0.194	0.266
B	DHO	0.569	1.446
DI	BFK	0.9	0
TC	BFK	0.3	0
OMS	BFK	1.135	0
NMS	DHO	0.1436	0

Sector	Source	Elast-KLM	Elast- LM
Manufacturing TR,HT,FP	Hannan (1993)	0.936	0

Notes:

MG: McKillop and Glass (1991)
Est.: Estimated in this paper
BFK: Bradley, FitzGerald and Kearney (1991)

Elast-KL: elasticity of substitution between capital and labour
Elast-VM: elasticity of substitution between value added and materials
Elast-KLM: elasticity of substitution between capital and labour/materials
Elast-LM: elasticity of substitution between labour and materials

Table 13. Calculating the elasticity of substitution: building

Dependent variable: L	Coefficient	Std. Error
a_0 (constant)	-3.503905	1.059636*
a_1 (gross output)	0.1970134	0.1202003
a_2 (net output)	0.6039421	0.1967556*
a_3 (wage rate)	-0.2849197	0.1063404*
a_4 ($labour_{-1}$)	0.4992547	0.1728217*
a_5 (time)	0.0278782	0.01546336

Note: * implies that the t-test is significant at the 95% level. All variiables in natural logarithms except time.

Source: see text

Table 14. Calculating the elasticity of substitution: utilities

Dependent variable: L	Coefficient	Std. Error
a_0 (constant)	-0.3305474	0.817911
a_1 (gross ouput)	0.4421035	0.1322209*
a_2 (net output)	0.0145973	0.0274596
a_3 (wage rate)	-0.1007011	0.364193*
Dependent variable: wage rate		
a_0 (constant)	-12.84661	1.840883*
a_1 (gross output)	3.281078	0.5100624*
a_2 (net output)	0.198569	0.1407831
a_3 (labour)	-3.479646	0.3884997*

Note: * implies that the t-test is significant at the 95% level. All variables in natural logarithms except time.

Source: see text

Table 15. Calculating the elasticity of substitution: non-market services

Dependent variable: L	Coefficient	Std. Error
a_0 (constant)	-3.759258	0.3419146*
a_1 (value added)	0.9434181	0.0983426*
a_2 (wage rate)	-0.0816293	0.009092*
a_3 (labour$_{-1}$)	0.3345776	0.0974401*
Dependent variable: wage rate		
a_0 (constant)	13.77404	2.684794*
a_1 (value added)	3.161866	0.7620733*
a_2 (labour)	-1.973308	0.6359017*
a_3 (wage rate $_{-1}$)	0.6753346	0.0500879*

Note: * implies that the t-test is significant at the 95% level. All variables in natural logarithms except time.

Source: see text

Table 16. Armington elasticities

Sector	Elasticity
Agriculture	1.413
Traditional	1.539
Food Processing	0.797
High-Tech	1.205
Utilities	1.046

Source: Keuschnigg and Kohler (1993)

Appendix 1: Sector Classification (41 sectors) and Aggregation (10 sectors).

NCC	DESCRIPTION	No.	Code
S01	Agric/Forestry/Fishing	A1	AG
S03	Coal/Lignite/Briquettes	A2	TR
S05	Products of Coking	A2	TR
S07	Petrol Prod /Natural Gas	A5	U
S09	Electricity/Gas/Water	A5	U
S11	Radioactive Material & Ores	A5	U
S13	Metals and Ores	A2	TR
S15	Non Metallic Min Products	A2	TR
S17	Chemical Products	A4	HT
S19	Metal Prod (excl. mach.)	A2	TR
S21	Agric./Industrial Machinery	A2	TR
S23	Office Machines	A3	FP
S25	Electrical Goods	A4	HT
S27	Motor Vehicles	A2	TR
S29	Other Transport Equipment	A2	TR
S31	Meat/Meat Products	A3	FP
S33	Milk & Dairy Products	A3	FP
S35	Other Food Products	A3	FP
S37	Beverages	A2	TR
S39	Tobacco Products	A2	TR
S41	Textiles/Clothing	A2	TR
S43	Leather/Footwear	A2	TR
S45	Wooden Products/Furniture	A2	TR
S47	Paper/Printing Products	A2	TR
S49	Rubber/Plastic Products	A2	TR
S51	Other Manuf Products	A2	TR
S53	Building & Construction	A6	B
S55	Repair/Recovery Services	A7	DI
S57	Wholesale/Retail Trade	A7	DI

S59	Lodging/Catering Services	A7	DI
S61	Inland Transport	A8	TC
S63	Maritime/Air Transport	A8	TC
S65	Auxiliary Transport	A8	TC
S67	Communication Services	A8	TC
S69	Credit and Insurance	A9	OMS
S71	Business Services	A9	OMS
S73	Renting of Immovable Goods	A9	OMS
S79	Other Marketing Services	A9	OMS
S81	General Public Services	A10	NMS
S89	Non Market Health Services	A10	NMS
S93	Other Non Market Services	A10	NMS

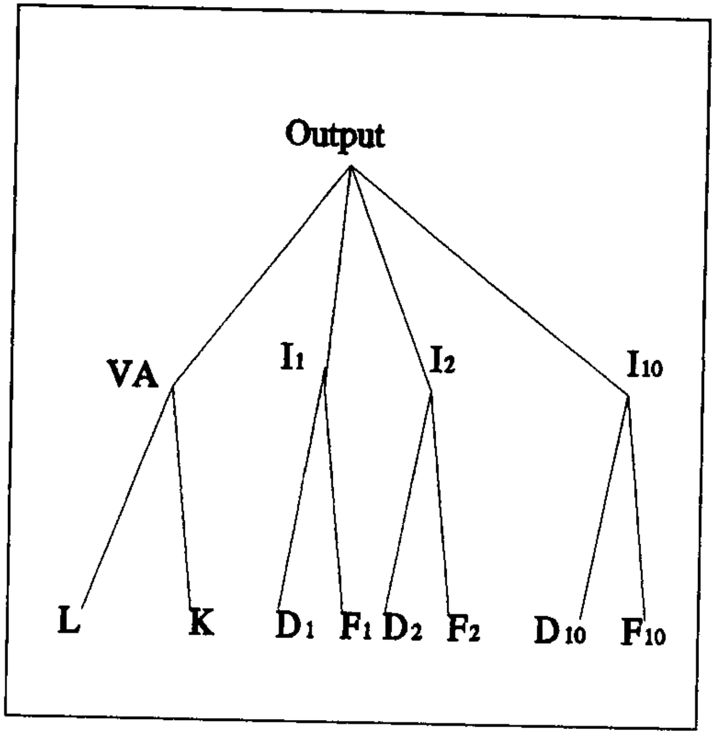

Figure 1. Production

VA: value added
L: labour
K: capital
I_i: intermediate goods (aggregate producer goods)
D_i: domestic producer goods
F_i: imported producer goods

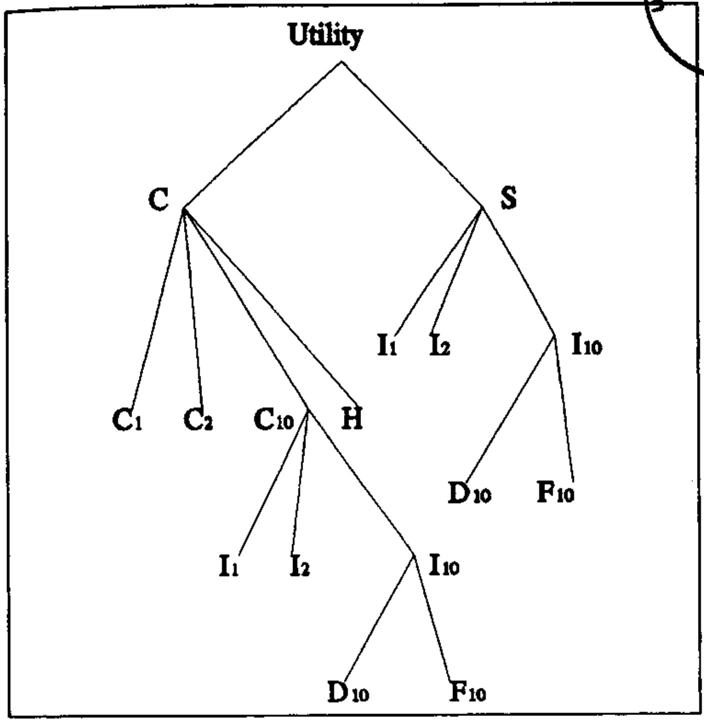

Figure 2. Consumption

C: aggregate consumption good
S: savings (aggregate investment good)
I_i: intermediate goods (aggregate producer goods)
D_i: domestic producer goods
F_i: imported producer goods
H: foreign holidays

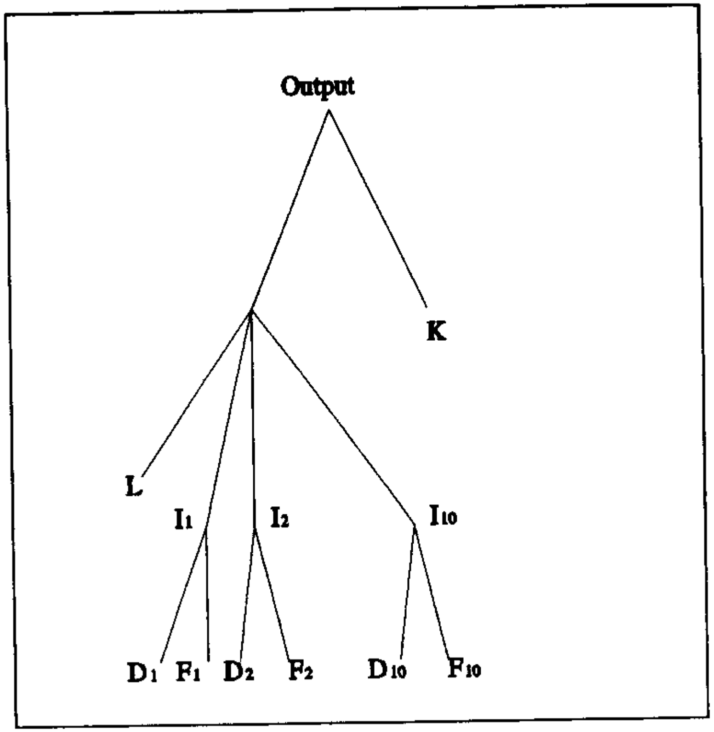

Figure 3. Production: manufacturing

L: labour
K: capital
I_i: intermediate goods (aggregate producer goods)
D_i: domestic producer goods
F_i: imported producer goods