# A General Equilibrium Modeling Facility

# for Costa Rica


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This report documents a general equilibrium modeling facility built at the OECD Development Centre for its own research and that of collaborating ministries in Costa Rica. The opinions expressed below are those of the authors and should not be attributed to the OECD or the Costa Rican government.

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# 1. Introduction

This report provides complete documentation for the 1991 Costa Rican SAM and the CGE model developed collaboratively by the OECD Development Centre and MIDEPLAN. Together, this integrated economywide database and model represent new capacity for policy analysis in Costa Rica. While SAMs and other economic models have been built for this country in the past, none are so up-to-date, detailed, and based on state-of-the-art methodology as the research products described below. In the hands of trained investigators, this modeling facility can provide analytical support for a wide variety of economic policy work, including trade, public finance, industry policy, and agricultural policy.

The next chapter gives a complete description of how the new SAM for Costa Rica was estimated, including citation to all data sources and detailed discussion of estimation techniques. This SAM represents a valuable research to in its own right, with detailed information on financial flows and economic structure which can be extensively analyzed by a variety of means. For the present project, this table has been paired with a calibrated general equilibrium (CGE) model, which today represents the preferred research tool for economywide policy analysis. The CGE methodology is described in detail in Chapter 3 below, with ample references for readers with a deeper interest in the literature on this subject.

The Costa Rican CGE model is implemented with the GAMS programming language, a high-level algebraic modeling language compatible with all Intel/PC computers and a variety of workstations and larger machines. Although the GAMS language is fully documented, a brief introduction to its use with CGE modeling is given in Chapter 4. Together, the three chapters provide complete documentation of the Costa Rican modeling facility and the introduction needed for nonspecialist, computer-literate economists to begin using this research tool.

## 2. The 1991 Social Accounting Matrix for Costa Rica

This chapter describes the construction of the 1991 SAM for Costa Rica. It is organized as follows: section 2.1 explains the estimation of the aggregate Macro SAM, section 2.2 deals with the building of a detailed Input-Output matrix and section 2.3 describes the factor and households accounts disaggregations as well as the final procedure for the SAM balancing.[1]

### *2.1 The 1991 Macro Sam For Costa Rica*

This section details the procedures and data sources used in building the 1991 Macro SAM for Costa Rica. It follows its accounts classification scheme.

#### 2.1.1 Activities

The values for the expenditures and receipts of this account are derived from the National Accounts and the Production Accounts both produced by the Central Bank of Costa Rica.[2] Tables 1 and 2 shown below reproduce the original data.

**Table 2.1: Gross Domestic Product (Million Colones)**

| | |
|---|---|
| PrivateDomesticCons | 410226 |
| GovernExpend | 111876 |
| VarStock | 35395 |
| GrossInvestiment | 136098 |
| Export | 265690 |
| Import | 269438 |
| GDP | 689848 |
| Labor VA | 327436 |
| Capital VA | 254673 |
| Depreciation | 18400 |
| IndirectTax(Tariff) | 99591 |
| Subsidies | 10252 |
| GDP | 689848 |

From Table 1 were obtained the values for Private Consumption - cell 1,4, Government Expenditure - cell 1,5, Gross Investment - cell 1,7, Variation of Stocks - cell 1,8, Subsidies -

[1] An appendix below presents the various classification schemes that were employed.
[2]See Banco Central de Costa Rica (1993a,b) Cuadro 27 and various tables.

cell 1,10, Export - cell 1,12; and, considering the expenditures, Capital and Labor payments - cells 2,1 and 3,1, Depreciation - cell 7,1, and Import - cell 12,1.

**Table 2.2: Production Accounts (Million Colones)**

| | GrossProd | IntermDem | VA | VAfromNA | %Diff VA | IntermDem* | GrossProd* |
|---|---|---|---|---|---|---|---|
| | [1] | [2] | [3] | [4] | [5] | [6] | [7] |
| | | | [1]-[2] | | ([3]/[4]-1) | [1]-[4] | [4]+[6] |
| Agriculture | 173049 | 53608 | 119442 | 119442 | 0.00 | 53608 | 173049 |
| ManufactMin | 403430 | 265961 | 137469 | 137469 | 0.00 | 265961 | 403430 |
| ElectWater | 28965 | 4887 | 24078 | 24078 | 0.00 | 4887 | 28965 |
| Construction | 49309 | 29760 | 19549 | 19549 | 0.00 | 29760 | 49309 |
| ComRestHotel | 220760 | 81301 | 139459 | 139459 | 0.00 | 81301 | 220760 |
| TranspServ | 73867 | 37983 | 35884 | 35884 | 0.00 | 37983 | 73867 |
| FinancServ | 68463 | 15008 | 53455 | 53655 | -0.37 | 14808 | 68463 |
| RealEstate | 43337 | 3819 | 39519 | 22870 | 72.80 | 2210* | 25080 |
| Government | 116746 | 22090 | 94656 | 92818 | 1.98 | 23928 | 116746 |
| OthPersSev | 93585 | 48936 | 44649 | 44623 | 0.06 | 48963 | 93585 |
| Total | 1271513 | 563353 | 708160 | 689848 | 2.65 | 563408 | 1253256 |

Table 2 summarizes the estimation of total Intermediate Demand - cell 1,1. The first three columns show raw data from Production Accounts, column 4 reproduces the Value Added data from the National Account[3], column 5 is self-explanatory and the last two columns are the estimates for Intermediate Demand and Gross Production obtained using the National Account Value Added column. It should be noticed that for the Real Estate sector the Intermediate Demand has been calculated by multiplying the original Intermediates value (in column 2) by the ratio of the VAs of columns 3 and 4. This methodology allowed to maintain full consistency with the values from the National Accounts.

The value for Indirect Taxes in table 1 has been disaggregated into three components: Export Taxes, Import Tariffs and Indirect Taxes. The first two were added and the result is shown in cell 11,1 the last is in cell 9,1. The data used for this disaggregation come from Central Bank of Costa Rica data[4].

[2]See Banco Central de Costa Rica (1993a) Cuadro 21.

[4]These data were derived from unpublished documents. Note that the import values in table 2 do not include tariffs whereas exports do contain taxes.

### 2.1.2 Rest Of The World (Row)

All the values registered in this account are derived from the following table.[5]

**Table 2.3: International Transactions (Million Colones)**

| | | | |
|---|---|---|---|
| Export | 265690 | Import | 269438 |
| Goods | 181990 | Goods | 207289 |
| InsurancesFreight | 1258 | InsurancesFreight | 21416 |
| PortServices | 5959 | PortServices | 6056 |
| PassengerTrspCost | 48095 | PassengerTrspCost | 20244 |
| Other | 28388 | Other | 14432 |
| VA from ROW | 15153 | VA to ROW | 34359 |
| IntDividOth (in) | 11990 | IntDividyOth (out) | 33175 |
| WageSalar (in) | 3162 | WageSalar (out) | 1184 |
| *Transfer (in)* | 13162 | *Transfer (out)* | 403 |
| Trf Governt (in) | 6789 | Trf Governt (out) | 305 |
| Trf OthSect (in) | 6374 | Trf OthSect (out) | 98 |
| | | ROW Savings | -10196 |
| Total | 294005 | Total | 294005 |

Note that the only difference, between table 3 and the Macro SAM, is represented by introducing the ROW Savings as a positive value, therefore a different total value is obtained.

### 2.1.3 Government

Table 4 below illustrates the data used in balancing the Government account.

**Table 2.4: Government Current Account (Million Colones)**

| | | | | | |
|---|---|---|---|---|---|
| 1 | Property Income | 14691 | 1 | Final Consumption | 111876 |
| 2 | Indirect Taxes | 99591 | 2 | InterestsDebt | 33449 |
| 3 | Direct Taxes | 14545 | 3 | IntDomDebt | 28584 |
| 4 | DirTaxes on Corptn | 11809 | 4 | IntExtDebt | 4865 |
| 5 | Oth DirTaxes | 2736 | 5 | Subsidies | 10252 |
| 6 | SanctionsFinesOth | 7230 | 6 | SocialSecurityPayments | 11363 |
| 7 | SocialSecurity | 54447 | 7 | Donations | 386 |
| 8 | Transfers | 7645 | 8 | SocialSecurityContribn | 1220 |
| 9 | Trf from Resid | 857 | 9 | Transfers | 16229 |
| 10 | Trf from ROW | 6789 | 10 | Trf to Resid | 15924 |
| | | | 11 | Trf to ROW | 305 |
| | | | 12 | Savings | 13375 |
| | HH -> Gov [3+6+7+9] | 77079 | | Gov->HH [2+6+7+8+10] | 62342 |
| | PublCrp->Gov | 10304 | | | |
| | Tot | 198151 | | Tot | 198151 |

[5]Table 4 reproduces Cuadros 33a,b from Banco Central de Costa Rica (1993a).

The top part of the table reproduces the Government current account as it is presented in the National Account[6]. The bottom part contains sums that are allocated to the SAM relevant cells and the value of the transfers of the Public Corporations to the central Government. This value (10304) is obtained from data published by the Treasury.[7] The difference between the total Property Income and this latter value (i.e. 4388) has been allocated to cell 5,7.

The other values in the Government row are the Tariff collection and the Indirect taxes which correspond exactly to the values paid by the Activities.

### 2.1.4 Capital Account

The balance of this account is derived from the following table.[8]

**Table 2.5: Investment Financing (Million Colones)**

| | |
|---|---|
| Tot Financing | 171493 |
| Depreciation | 18400 |
| NetTotDomSavings | 142898 |
| GovernSavings | 13375 |
| PublCorpSavings | 9457 |
| NetPrivateDomSavings | 120067 |
| ROWSavings | 10196 |

The important variation introduced in the SAM consists in the *Property Income* (the residual value 4388 calculated above) that the Capital Account receive from Capital (cell 7,2) and pays back to the Government (cell 5,7, see above).

### 2.1.5 Public Corporations

A Public Corporations account was created to maintain the distinction between these Institutions' Value Added and Savings and the Government's ones. Public Corporations receive money from the factors of production according to table 6 shown below.

[6]See Banco Central de Costa Rica (1993a) Cuadro 41.
[7]See Contraloria General de la Republica (1993) Cuadros 66, 72, 78.
[8]See Banco Central de Costa Rica (1993a) Cuadro 29.

**Table 2.6: Public Sector Value Added**

| Sector | Tot VA | VA Lab | VA Cap |
|---|---|---|---|
| Tot VA SectPubl | 184022 | | |
| Agriculture | 254 | 65 | 189 |
| ManufactMin | 3667 | 941 | 2726 |
| ElectWater | 23593 | 9738 | 13855 |
| Construction | 5332 | 4864 | 468 |
| ComRestHotel | 7432 | 1907 | 5524 |
| TranspServ | 17734 | 10740 | 6994 |
| FinancServ | 30470 | 15045 | 15425 |
| OthPersSev | na | | |
| Tot PublCorptn | 88481 | | |
| Government | 92818 | | |
| ConstrGovern | 2723 | | |
| *Treasury data* | | | |
| NoFinPublCorptn | 58011 | 14888 | 43123 |
| FinancPublCorpnt | 30470 | 15045 | 15425 |
| *National Accounts data* | | | |
| Construction | | 16399 | 1576 |
| TranspServ | | 18781 | 12230 |
| ElectWater | | 6314 | 13855 |
| Tot PublCorptn | 88481 | 43300 | 45181 |

The values of the first column come from the National Accounts estimations.[9] The disaggregation of total Value Added into its components is derived from shares calculated from various data. For the financial sector the Treasury data[10] were used, for the remaining sectors the shares were calculated directly from the National Accounts or again from the Treasury source.

### 2.1.6 Households

Two entries in this account need some clarification, namely the factor incomes. These are equal to the residual values of the Capital and Labor Value Added. For example the value in cell 4,3 (Labor Income to Households) was calculated as the Labor VA (cell 3,1) plus Labor payments from the ROW minus Labor payments to Public Corporations and ROW.

[9]See Banco Central de Costa Rica (1993a) Cuadro 40.
[10]See Contraloria General de la Republica (1993) Cuadro 118. The values for Labor payments are presented here, those for the Capital VA are calculated as residuals.

All the remaining accounts (INVENTORY, INDIRECT TAX, SUBSIDIES and TARIFF) are self-explanatory.

## Table 2.7: Costa Rica Macro SAM 1991 (Million Colones)

| | | 1 | 2 | 3 | 45 | 67 | 8 | 9 | 10 | 11 | 12 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ACT | CAP | LAB | HH | GOV | PBLCRP | CAP ACC | INVENT | INDTAX | SUBSID | TARIFF | ROW | Receipt |
| 1 | ACTIVITIES | 563408 | | | 410226 | 111876 | | 136098 | 35395 | | 10252 | | 265690 | 1532946 |
| 2 | CAPITAL | 254673 | | | | | | | | | | | 11990 | 266663 |
| 3 | LABOR | 327436 | | | | | | | | | | | 3162 | 330598 |
| 4 | HOUSEHOLDS | | 183920 | 286114 | | 62342 | 68720 | | | | | | 6374 | 607470 |
| 5 | GOVERNMENT | | | | 77079 | | 10304 | 4388 | | 51660 | | 47932 | 6789 | 198151 |
| 6 | PUBLCORP | | 45181 | 43300 | | | | | | | | | | 88481 |
| 7 | CAP ACC | 18400 | 4388 | | 120067 | 13375 | 9457 | | | | | | 10196 | 175881 |
| 8 | INVENTORY | | | | | | | 35395 | | | | | | 35395 |
| 9 | IND TAX | 51660 | | | | | | | | | | | | 68027 |
| 10 | SUBSID | | | | | 10252 | | | | | | | | 10252 |
| 11 | TARIFF | 47932 | | | | | | | | | | | | 31565 |
| 12 | ROW | 269438 | 33175 | 1184 | 98 | 305 | | | | | | | | 304200 |
| | Expenditure | 1532946 | 266663 | 330598 | 607470 | 198150 | 88481 | 175881 | 35395 | 68027 | 10252 | 31565 | 304200 | |

## 2.2 *The 1991 Input-Output Table For Costa Rica*

This section provides a description of the methodology and data sources used in building the 1991 Input-Output Table for Costa Rica. This 1991 table presents the same sectors of the 1980 table estimated in 1985 by a team of researchers of the University of Costa Rica[11].

It is organized as follows: the first subsection details the estimation of the Import and Export flows, the second describes the procedure followed in calculating the Value Added and the Gross Production, the third and the fourth illustrate how the Final Private Consumption and Investment (by origin) were obtained and the last subsection explains how the Intermediate supply, Variation of Stocks were estimated and how the Interindustry Intermediates table was calculated.

### 2.2.1 International Trade

In Costa Rica, International Trade statistics are collected and elaborated by the Central Statistical Bureau and then transmitted to the Central Bank which uses them to produce its National Accounts official estimates. The raw data employed to obtain our estimates were supplied directly by the Statistical Bureau on electronic media. These data include a basic description of the product traded, its correspondences to a *use* and a *sector of origin* classification schemes, country of origin or destination, physical quantities and values (in current colones and US dollars) CIF for Imports and FOB for Exports, and tariff collections.

These raw *single product - single country* data were aggregated into a *4 digit sector - 6 macro region* scheme.

The 4 digit sector classification corresponds to the International Standard Industrial Classification[12].

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[11] See Universidad de Costa Rica Instituto de Investigaciones en Ciencias Economicas (1985).
[12] Clasificacion Industrial Internacional Uniforme (CIIU).

The 6 regions[13] are:

| | | |
|---|---|---|
| 1 | Central America | CENTRO, |
| 2 | South America and the Caribbeans | SAC, |
| 3 | Other Pacific | OP, |
| 4 | Canada, USA, Mexico | NAFTA, |
| 5 | Europe | EUROPE |
| 6 | Rest of the world | ROW. |

It should be noticed that the Costa Rican Law on International Trade distinguishes two categories of products and countries, the “traditional” and the “non-traditional” ones. The main agricultural exportables (such as Coffee and Bananas) and the Central American countries belong to the first category. The main purpose of this partition is to define a criterion for eligibility to export subsidies: only non-traditional exports to non-traditional markets can be subsidized. The export subsidy is normally embodied into a tradeable right for an indirect tax reimbursement (CAT Certificado de Abono Tributario) proportional to the value of the exported goods[14].

In order to disaggregate the total value of export subsidies was then necessary to have for each region (excluding Central America) two vectors of exports both classified with the *4 digit sector* scheme: one containing only *traditional* products (not eligible for subsidies) and the other with the *non-traditional* ones.

The final step was to create a correspondence between this *4 digit sector* scheme and the Input-output sectoring scheme. This required to use the original disaggregated data for agricultural goods (instead of the single sector 1110[15]) and to match them to the *agriculture* sectors of the IO table. For the remaining IO table sectors was necessary to further aggregate the 4 digit classification according to the following table.

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[13] For a complete listing of the countries included in each of the six regions see appendix. [file COUNTRY.TXT]

[14] For an extended and clear analysis of the recent Costa Rican trade policy see E Franco and C Soyo (1992).

[15] See Appendix.

**Table 2.8: IO sectors - ISIC 4 digit correspondence**

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ProducAgropecuria | 1110 | | | | | | | | | | | |
| 9 | SilviculturaPesca | 1210 | 1220 | 1301 | 1302 | | | | | | | | |
| 11 | ProdCarneLeche | 3111 | 3112 | | | | | | | | | | |
| 12 | EnlatadoDePescado | 3114 | | | | | | | | | | | |
| 13 | AceitesComestib | 3115 | | | | | | | | | | | |
| 14 | ProcesDeCafe | 3116 | | | | | | | | | | | |
| 15 | MolineriaGranos | 3121 | 3122 | | | | | | | | | | |
| 16 | Panaderia | 3117 | | | | | | | | | | | |
| 17 | Azucar | 3118 | | | | | | | | | | | |
| 18 | OtrosProdManuf | 3113 | 3119 | 3121 | | | | | | | | | |
| 19 | Bebidas | 3131 | 3132 | 3133 | 3134 | | | | | | | | |
| 20 | ProdDeTabaco | 3140 | | | | | | | | | | | |
| 21 | TextilesRopa | 3211 | 3212 | 3213 | 3214 | 3215 | 3219 | 3220 | | | | | |
| 22 | CuerosZapatos | 3231 | 3232 | 3233 | 3240 | | | | | | | | |
| 23 | MaderaMuebles | 3311 | 3312 | 3319 | 3320 | | | | | | | | |
| 24 | PapelImprenta | 3411 | 3412 | 3419 | 3420 | | | | | | | | |
| 25 | Quimicos | 3511 | 3512 | 3513 | 3521 | 3522 | 3523 | 3529 | | | | | |
| 26 | RefineriasPetroleo | 3530 | 3540 | | | | | | | | | | |
| 27 | Llantas | 3551 | | | | | | | | | | | |
| 28 | CauchoPlasticos | 3559 | 3560 | | | | | | | | | | |
| 29 | VidrioCeramica | 3610 | 3620 | | | | | | | | | | |
| 30 | MaterialesConstr | 2100 | 2200 | 2301 | 2302 | 2901 | 2902 | 2903 | 2909 | 3691 | 3692 | 3699 | |
| 31 | MetalesBasicos | 3710 | 3720 | 3811 | 3812 | 3813 | 3819 | 3821 | 3822 | 3823 | 3824 | 3825 | 3829 |
| 32 | BienesElectricos | 3831 | 3832 | 3833 | 3839 | | | | | | | | |
| 33 | EqpDeTransporte | 3841 | 3842 | 3843 | 3844 | 3845 | 3849 | | | | | | |
| 34 | OtrasManufacturas | 3851 | 3852 | 3853 | 3901 | 3902 | 3903 | 3909 | | | | | |
| 37 | Comercio | 6100 | | | | | | | | | | | |
| 40 | Electricidad | 4101 | | | | | | | | | | | |

The first two columns represent the IO table sectoring scheme and the remaining columns detail the corresponding ISIC sectors.

For trade in services and tariff statistics see subsection 2.2.2 below.

### 2.2.2 Value Added and Gross Production

The 1991 IO table for Costa Rica presents 7 components for Value Added: Labor, Capital, Depreciation, Indirect Taxes, Export Taxes, Import Taxes and Subsidies. International trade taxes are included in the Value Added to follow Costa Rican conventions.

This section aims to clarify the procedures employed to consistently estimate these 7 components. Differences in the available data did not allow to employ the same estimation method for all the sectors. This requires, in turn, to describe separately the estimation for *agriculture, manufacturing* and *service* sectors.

Three main sources of data[16] were available for the *agriculture* sectors: the *first* is an aggregated production account for agriculture as a whole, that is consistent with the control total given in the National Accounts and it is presented in table 2.9 below.

**Table 2.9: Agriculture - Production account (million current colones)**

| | |
|---|---|
| Gross Production | 173049 |
| Value Added | 119442 |
| Indirect Tax | 7791 |
| Subsidies | 3841 |
| Labor V A | 50266 |
| Capital VA | 63393 |
| Depreciation | 1832 |

The *second* source of data consists in value added and gross production figures for single crop (and the forestry-fishing sector). It should be noticed that their sum was consistent with the total values from source one. The *third* is composed of production accounts, with detailed information on value added components and intermediates consumption. The basic procedure has been to calculate from the production accounts the shares of the value added components (initially only Capital, Labor, Depreciation and Indirect taxes) and of the Intermediates Demand and then to multiply these by the Gross Production figures of the second source. This method provided the needed results once an exact correspondence between the production account sectors and the IO sectors had been created. So for the *Granos Basicos* and *Otros Prod Agric* sectors, for which this correspondence did not hold, it was necessary to calculate appropriate averages[17]. Besides detailed production accounts were not available for the *Cacao, Algodon, Ganaderia* and *Silvicultura-Pesca* sectors. This problem was overcome by using Mexican data and implicitly assuming that Costa Rica had the same production technology. The combination of these data allowed to obtain preliminary estimates for Gross Production, Value Added and Intermediates Demand values.

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[16]These data are contained in various Central Bank's documents that were made available from the sections dealing with the National Accounts.

[17]For *Granos Basicos* the shares were weighted averages calculated from the production accounts of Maize, Rice and Beans, where the weights were gross production values. *Otros Prod Agric*'s shares were obtained from the values of Palm Trees, Onions, Plantains and Yuca

These were not completely satisfactory because they did not take into account further information concerning international trade taxes and export subsidies. As already noticed above, export subsidies were disaggregated using per cent shares of non-traditional exports to non-traditional markets. Import taxes collections were estimated using the trade data of the Statistical Bureau and export taxes collections were estimated from data of the Central Bank. These latter estimates were not fully consistent with the values presented in the National Accounts so that normalization of these values was necessary. The control totals for Indirect Taxes, Import and Export taxes (for all the sectors) are presented in table 2.10 which is derived from Central Bank unpublished documentation.

Once the values of Labor and Capital value added, Indirect Taxes, Import and Export Taxes, Depreciation and Subsidies were preliminary estimated with the above described methods, the full consistency with the totals of table 2.9, was obtained applying a RAS procedure.

**Table 2.10: Indirect Taxes (million current colones)**

| Sector | Imp Tax | Exp Tax | IndirectTax | Total |
|---|---|---|---|---|
| Agricultura | 5 | 5644 | 2142 | 7791 |
| Industria | 13956 | | 11881 | 25837 |
| ElectrAgua | | | 415 | 415 |
| Constrccion | | | 987 | 987 |
| Comercio | 27459 | 311 | 27665 | 55434 |
| Transportes | 79 | | 3014 | 3093 |
| EstablFin | | | 1541 | 1541 |
| BienesImmuebles | | | 1280 | 1280 |
| Servicios | 480 | | 2734 | 3213 |
| Gobierno | | | 274 | 274 |
| Total | 41978 | 5955 | 51933 | 99866 |

The basic data for the *manufacturing* sectors are provided by the aggregate production account of table 2.11 below.

**Table 2.11: Manufacturing sectors - Production account (million current colones)**

| | |
|---|---|
| Gross Production | 403430 |
| Adjust. Tax | 15009 |
| Value Added | 137469 |
| Indirect Tax | 25837 |
| Subsidies | 5622 |
| LabourVA | 43889 |
| Capital VA | 69170 |
| Depreciation | 4195 |

The second main source of data is represented by the detailed production accounts prepared by the Industrial section of the Central Bank of Costa Rica. These Bank's estimates are calculated by applying *costs structures* (basically percentage shares for value added components and intermediates consumption) to current sectorial gross production values. The costs structures were obtained from a survey made in 1985. To these data was necessary to add Import and Export taxes, export subsidies and to distribute to the various sectors the value 15009 which represents a tax adjustment[18] (see table 2.11).

All these data are collected at the *4 digit* sectoral level, so that the aggregation described in table 1 was repeated here. To obtain full consistency with the controls of table 2.11 a RAS procedure was applied to the manufacturing sectors.

The procedure used for the *service* sectors' value added and gross production estimations was based on the data shown in table 5. This was obtained combining the data from the National Accounts (that in the case of services present the same detail of the IO table) and table 2.10.

**Table 2.12: Service sectors - Production Accounts (million current colones)**

| | Constuc | ComRH | TrspCom | BFinSeg | BImm | OtrSer | EleAgua | Gobierno |
|---|---|---|---|---|---|---|---|---|
| Gross Production | 49309 | 220760 | 73867 | 68463 | 25080 | 93585 | 28965 | 116746 |
| Value Added | 19549 | 139459 | 35884 | 53655 | 22870 | 44623 | 24078 | 92818 |
| Indirect Tax | 987 | 27665 | 2515 | 1470 | 1280 | 2734 | 985 | 0 |
| ExportTaxes | 0 | 311 | 0 | 0 | 0 | 0 | 0 | 0 |
| ImportTaxes | 0 | 27459 | 79 | 0 | 0 | 480 | 0 | 0 |
| Labor V A | 16399 | 53875 | 18781 | 22925 | 0 | 22170 | 6314 | 92818 |
| Capital VA | 1576 | 28732 | 12230 | 28707 | 17754 | 18465 | 13855 | 0 |
| Depreciation | 587 | 1418 | 2279 | 553 | 3836 | 774 | 2924 | 0 |

### 2.2.3 Final private Consumption

The Central Statistical Bureau conducted a Households survey on Incomes and Expenditure for the years 1987-1988, which had, among others, the objectives of measuring

[18]This Tax value is the sum of a consumption and a sale tax. The sectoral distribution of these taxes was estimated from unpublished data of the Central Bank.

the households' expenditures structure and of complementing the available data for the estimation of final private consumption of the National Accounts[19].

This survey represented the main source of data for the estimation of the final private consumption vector of our IO table. In fact a preliminary structure of expenditures per cent shares corresponding to the IO table sectors was obtained from the most disaggregated list of products provided by the Statistical Bureau. This structure calculated for the year 1987-88 was used also for the 1991 base year of the IO table since no relevant variations in relative prices of most consumers goods were recorded between the 2 periods[20].

The information provided by this survey was then combined with the National Accounts estimates of table 2.13 shown below. Table 2.13 was used to *correct* the preliminary structure of expenditure shares estimated from the survey so that the expenditures for services were equal to those of the National Accounts[21]. A definitive structure of expenditures shares was recalculated and multiplied by the control total of table 2.13 to obtain the final IO table vector of private consumption.

**Table 2.13: Private Final Consumption**[22]

| | Million Col | % |
|---|---|---|
| Bienes Orig Import | 61447 | 15 |
| Bienes Orig Agric | 47523 | 12 |
| Bienes Orig Industr | 145081 | 35 |
| Electricidad | 18715 | 5 |
| Serv Transp | 32591 | 8 |
| Serv Alquiler | 18261 | 4 |
| Serv Financeros | 10399 | 3 |
| Serv Hotel | 3058 | 1 |
| Serv Rest | 11559 | 3 |
| Otros Serv | 61594 | 15 |
| Total | 410226 | 100 |

[19]See Direccion General De Estadistica Y Censos (1992), page 1 points C and F.
[20]The price check was made using Statistical Bureau's data.
[21]In fact the services shares calculated from the survey were considered too low and therefore the National Accounts ones were considered more reliable.
[22]This table exactly reproduces Cuadro 34 of Banco Central De Costa Rica (1993).

### 2.2.4 Investment (by origin)

The total values of Investment for the 1991 year are illustrated in the following table, which is derived from the National Accounts.

**Table 2.14: Total Investment (million current colones)**

| | |
|---|---|
| MaquinariaYEqp | 80381 |
| NuevasConstr | 55718 |
| Tot FormBrCapFijo | 136098 |

Costa Rica both imports and domestically produces Capital goods (*Maquinaria y Equipo*), therefore to calculate the Investment vector of the IO table was necessary to consider both the imports and the domestic capital goods production data.

As long as imports are concerned the relevant data are obtained by extracting capital goods from the total imports[23]. Import tariffs and commercial margins were added to these data so that they were evaluated at purchasers' price. The resulting values were allocated to the relevant IO table sectors according to the correspondence shown in table 2.8. The same procedure was followed for domestic production of capital goods. The final sum of these 2 categories of data, foreign and domestic, was just 3 per cent larger than the total value 80381 of table 2.14, so that a simple renormalization was enough to correct the difference.

Lastly, the value of new construction (*Nuevas Constr*) was entirely allocated to the *Construccion* sector of the IO table.

### 2.2.5 Intermediates Supply. Variation of Stocks. Intermediates Table

The total available resources for the 42 IO table sectors were implicitly obtained once Value Added, Gross production and Import figures were estimated as described above. These resources can be used for, Private Consumption, Government Expenditure, Exports, Investment, Variation of Stocks and Intermediates Supply. The first part of this section

[23]This is done by considering the *use* classification of the traded goods, in particular were extracted those products included in the categories *Capital goods for agriculture, Capital goods for manufacturing* and *transport equipments* (categories 7,8 and 9 of the CUODE classification, see appendix)

presents the basic assumptions employed to estimate Variation of Stocks and Intermediates Supply.

The sum of these two variables is calculated as the difference of total resources and the other elements of final demand (Private Consumption, Government Expenditure, Exports, Investment). The ideal situation would be to have some updated estimate (by sector) of either of them and to calculate the remaining one as a residual. Unfortunately no reliable official estimates were available, so that the only available solution was to assume that the "intermediate-ness' of the economy for the year 1991 was not dramatically changed from 1980. This means that the intermediates supply vector was calculated multiplying the sectorial ratios of Intermediates to Total Resources for the 1980 year by the 1991 Total Resources. The implicit assumption here is that the ratio of resources devoted to intermediate use by sector in 1980 has not varied. However, the sum of the values of the resulting intermediates vector did not correspond to the control total for 1991, so that a normalization was performed to obtain consistency. The variation of stocks vector was then calculated as a residual.

Once the row vector of total intermediates demand and the column vector of total intermediates supply were estimated the inter- industries flows were calculated by applying a RAS procedure to the 1980 intermediates table using as controls those two mentioned vectors. Since the 1980 table presented a column of zeros for the intermediates demand of the government sector some other initial values had to be found to distribute the total (non zero) sum of intermediates demand for this sector. These were provided from Central Bank unpublished data.

### *2.3 Final Sam Estimations*

The main focus of this section is the description of the factor and households account disaggregation procedure. This is analized in subsections 2.3.1 and 2.3.2. The last section provides an explanation of the final balancing of the SAM.

### 2.3.1 Value Added Disaggregation

This subsection is divided in two parts dealing with the labour and the capital value added disaggregations respectively.

#### *2.3.1.1 Labor Value Added*

The 1991 Costa Rican SAM includes the following 16 types of labor:

1 Urban Salaried Professionals and Managers
2 Urban Salaried White Collar workers, Commerce men and Salesmen
3 Urban Salaried Industrial Workers
4 Urban Salaried Unskilled Workers
5 Urban Indipendent Professionals and Managers
6 Urban Indipendent White Collar workers, Commerce men and Salesmen
7 Urban Indipendent Industrial Workers
8 Urban Indipendent Unskilled Workers
9 Rural Salaried Professionals and Managers
10 Rural Salaried White Collar workers, Commerce men and Salesmen
11 Rural Salaried Industrial Workers
12 Rural Salaried Unskilled Workers
13 Rural Indipendent Professionals and Managers
14 Rural Indipendent White Collar workers, Commerce men and Salesmen
15 Rural Indipendent Industrial Workers
16 Rural Indipendent Unskilled Workers.

They are differentiated by location, employment status and skill. The *Salaried* category includes people employed in the public and private sectors and those working at home for another member of the household, the *Indipendent* one includes people running their business without employing permanently any worker and those who hire permanently other workers.[24] The skill categories are obtained by aggregating the 11 occupational levels considered in the population census. This follows the same scheme adopted by F. Tattenbach in his 1980 SAM[25] and the following correspondence table is taken from his work.

---

[24]In the Costa Rican classifications the Salaried workers include: Empleado del Estado, Empleado Empresa Privada, Servicio Domestico, Tabajador Familiar; the Indipendents: Trabajador por Cuenta Propia, Patron o Socio Activo. Complete definitions are given in Direccion General de Estadistica y Censos (1986).
[25]See F Tattenbach (1990).

| Skill Categories | Census Categories |
|---|---|
| Professionals and Managers | 0 , 1 |
| White Collar Workers, Commerce men and Salesmen | 2 , 3 |
| Industrial Workers | 5 , 6 , 7 , 8 |
| Agricultural, Domestic and Unknown Workers (unskilled Workers) | 4 , 9 , 10 |

The census codes correspond to the following definitions[26]:

| | |
|---|---|
| 0 | Professionals and Technicians |
| 1 | Directors, Managers and General Administrators |
| 2 | Administrative Employees of Government and Private Sector |
| 3 | Commerce Men and Sales Personnel |
| 4 | Farmers, who do not hire labor or do so in small quantity, agricultural workers |
| 5 | Drivers or Operators of Transportation means |
| 6 | Artisan or Workers of the Textile, apparel, construction type of production or other mechanical or electricity related types of activities |
| 7 | Artisans or workers of the paper and printing, chemical, mining, metal, food and beverages, ceramics,leather, tobacco and other industrial type of production |
| 8 | Workers of the loading-and -storage related activities |
| 9 | Personal services or related types of occupations |
| 10 | Not well specified types of occupations |

In order to disaggregate the Labour Value Added vector of the IO table two components are needed: employment figures and the average wages corresponding to the 16 labor types and to the 42 productive sectors.

The main source of employment data was the yearly survey on Households[27]. Unfortunately, since not all the 4 variables (location, employment status, skill and sector) were simultaneously available in the survey data, the following estimation method was applied. The employment distributions by sector and skill and that by sector and status were available for the rural and urban areas; that by skill and status was available without sectoral disaggregation. Therefore it was decided to use a RAS estimation procedure where the initial values were given by the global skill-status table and the controls were derived from the sector-skill and the sector-status tables. This method allowed to obtain employment figures for 9 sectors: agriculture, mining, manufactures, public utilities, construction, commerce, transportation and communication, financial services, other services. The further disaggregation necessary to obtain the full detail of the IO table was realized using Social

[26] For a more complete definition of these categories see Direccion General de Estadistica y Censos (1986).
[27] See Direccion General de Estadistica y Census (1992). Note that the results of the survey used here are not currently published but they were kindly made available by that Direccion General.

Security data[28]. These include detailed sectoral information on insured employers and employees[29] and allowed to derive the final employment structure in the following way. The first step was to build a correspondence between the 170 sectors considered in the Social Security survey and the 42 of the IO table, then per cent share distributions were calculated from the employer and the employee figures and used to disaggregate the *Patron* and the Salaried estimates obtained from the previous RAS result. The other component of the Indipendent category, ie *Trabajadores por Cuenta Propia,* was disaggregated using the per cent share distribution calculated from the sum of the employer and employee figures.The final estimates for the Indipendent category was obtained from the sum of the *Patron* and the *Trabajadores por Cuenta Propia* figures[30].

The estimation method employed for the average wages basically follows the same steps. Once again from the yearly survey on Households was possible to obtain total wage income distributions for the rural and urban areas by sector and skill and that by sector and status. A new RAS procedure was performed with the sector-skill and the sector-status values as controls and with initial values represented by the employment figures. The usual 9 macro sectors were obtained and further disaggregated using Social Security data. The sectoral per cent share distribution for the Salaried category are directly calculated using the Social security average wages and the employment values, the analogous distribution for the Indipendent category is calculated from the difference of the IO Labor Value Added and the Salaried total wage vectors.

Once the total wages figures for the 42 IO sectors and the 3 relevant variables (location, employment status and skill) are calculated from the average wages and employment estimates, the IO table vector of Labor Value Added can be disaggregated into the 16 components listed above.

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[28]See Caja Costarricense de Seguro Social (1992).

[29]Note that the Social Security Insurance system covers more than 80% of the total formal employment in Costa Rica. In its statistics the employees category roughly corresponds to the salaried group defined above and the employers correspond tothe *Patrones*.

[30]The Social Security statistics do not consider the location variable, so that for the disaggregation of the initial 9 sectors the same per cent share distribution was used for the Rural and Urban areas.

*2.3.1.2 Capital Value Added*

The Capital Value Added in the 1991 SAM has been disaggregated in the following four components:

1 Domestic Corporate Private Capital
2 Domestic Corporate Public Capital
3 Foreign Corporate Capital
4 Domestic Small Business Private Capital.

The estimation of the Corporate and the Small Business components represented the first stage of this disaggregation. A precise measure of the contribution of the Corporate sector to the Capital value added was not available so that an indirect estimate was calculated from data on the distribution of employment by dimension of the firm[31]. The following table presents, in the Small Business column, the shares of employers who hire less than 5 employees whereas the Corporate column collects the shares of the larger economic units.

**Table 2.15: Percent Shares of Small Business and Corporate Employers**

| | Small Business | Corporate |
|---|---|---|
| Agriculture | 71 | 29 |
| Manufacturing and Mining | 48 | 52 |
| Electricity,Gas, Water | 47 | 53 |
| Construction | 54 | 46 |
| Commerce | 66 | 34 |
| Transport, Communication | 74 | 26 |
| Financial Services | 72 | 28 |
| Other Services | 81 | 19 |

A first aggregate measure of the Corporate Capital was calculated applying these shares to the total Capital Value Added vector of the IO table. It should be noticed that these shares were applied to the Capital Value Added net of the Public Corporate component. This was estimated from the National Accounts and it is shown in the table below[32].

[31]These data are presented in the Social Security survey.
[32]Note the correspondence with table 6 of chapter I.

**Table 2.16: Value Added of the Public Sector**

| Sector | Tot VA | VA Lab | VA Cap |
|---|---|---|---|
| Agriculture | 254 | 65 | 189 |
| Manufacturing and Mining | 3667 | 941 | 2726 |
| Electricity,Gas, Water | 23593 | 9738 | 13855 |
| Construction | 5332 | 4864 | 468 |
| Commerce | 7432 | 1907 | 5524 |
| Transport, Communication | 17734 | 10740 | 6994 |
| Financial Services | 30470 | 15045 | 15425 |

Then the 8 macro sectors of table 2.15 were further disaggregated using the per cent share distribution of the total number of employers. This resulted in a vector of 42 elements corresponding to the IO table sectors. Finally a few values of this vector were corrected to take into account the sector specific capital intensity and/or concentration. The sector specific capital intensity was calculated in this way: first capital to value added per cent shares were calculated for all the sectors and the economy as a whole, then index numbers were measured as the ratio of the sectoral shares to the average share, so that an index number greater than 1 represented a sector with a higher-than-the-average capital intensity. The sectoral concentration was measured by the employment per cent share. Two basic assumptions guided the corrections. First, a larger number of corporations should be expected for those sectors with a higher-than-the-average capital intensity, so that the above mentioned index numbers were used as increment coefficients for the Corporate Capital Value Added shares. Second, for those sectors with an average dimension of 25 employees or less the per cent share of the *employees* distribution replaced that of the employers allowing a more precise indirect estimation of the *presence* of corporations. Consider for example the Coffee sector: the average farm employee dimension is equal to 8, the per cent share of employers calculated with respect to the agriculture sector as a whole is 26, that of the employees is 16. The medium-small average dimension of the sector and the impossibility of discriminating the 26% employers between true Corporate (for the agriculture sectors large farms are treated as corporations) and small business (small farm) employers suggested to use the share of employees instead of that of the employers. The rationale of this adjustment was given by the fact that for sectors with a medium-small average dimension, an employees share smaller than that of the employers excludes the presence of many large corporations. Basically, in this case, the use of the employers share leads to an overestimation of the Corporate contribution to the Capital Value Added.

These estimations resulted in a final vector of *private* (domestic and foreign) Corporate Capital value added covering all the 42 IO sectors. The *public* component of Corporate Capital, shown in table 2.16, was disaggregated using the per cent shares of the IO table Capital Value Added and then added to the private one. In this way it was possible to calculate the Small Business component residually as the difference of total Capital Value Added and its Corporate (private and public) portion.

The measurement of the domestic and foreign fractions of the Private Corporate Capital represented the last stage of the Capital Value Added disaggregation.

Table 2.17 below shows the distribution of the value of gross production by geographical origin of capital ownership[33]. The Costa Rican proportion of Corporate Capital is represented by the first column of this table whereas the last column collects the foreign shares.

**Table 2.17: Gross Production value per cent shares by Capital origin**

| | CostaRica | USA | Japan | UK | Spain | Switz | Mex | Other | TotFor |
|---|---|---|---|---|---|---|---|---|---|
| Tot Manufact | 59.25 | 23.51 | 1.46 | 2.76 | 0.63 | 1.83 | 3.27 | 7.29 | 40.75 |
| FoodBevTob | 63.64 | 17.97 | 0.00 | 7.24 | 0.66 | 0.00 | 7.28 | 3.21 | 36.36 |
| TextilLeather | 62.83 | 27.82 | 5.55 | 0.00 | 0.00 | 0.00 | 0.00 | 3.80 | 37.17 |
| WoodFurnish | 66.15 | 0.75 | 0.00 | 0.00 | 30.32 | 0.00 | 0.00 | 2.78 | 33.85 |
| PaperPrint | 52.94 | 47.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 47.06 |
| ChemicRubPlast | 63.21 | 31.88 | 0.00 | 0.66 | 0.00 | 2.00 | 0.00 | 2.25 | 36.79 |
| NoMetalMin | 37.67 | 0.00 | 0.00 | 0.00 | 0.00 | 18.61 | 0.00 | 43.72 | 62.33 |
| MetalProd | 51.79 | 26.38 | 5.57 | 0.00 | 0.00 | 0.22 | 5.44 | 10.60 | 48.21 |
| Other | 66.09 | 0.00 | 24.11 | 0.00 | 0.00 | 0.00 | 0.00 | 9.80 | 33.91 |

The 8 manufacturing sectors of table 2.17 were further disaggregated to obtain the full IO detail assuming the same per cent shares for the domestic and foreign components, namely the distribution of the private Corporate Capital calculated above. The assumption of zero foreign Capital in the Agriculture and Service sectors completed the estimation of the Capital Value Added disaggregation.

### 2.3.2 Private Consumption Disaggregation

In the 1991 Costa Rican SAM, the households account has been disaggregated into the following 10 categories:

1 Urban Professionals and Managers
2 Urban White Collar workers, Commerce men and Salesmen
3 Urban Industrial Workers
4 Urban Unskilled Workers
5 Urban Inactive Population
6 Rural Professionals and Managers
7 Rural White Collar workers, Commerce men and Salesmen
8 Rural Industrial Workers
9 Rural Unskilled Workers
10 Rural Inactive Population

Two main sources of information were used in this choice: the 1980 SAM built by F. Tattenbach[34] and the 1987-88 survey on Households Incomes and Expenditures[35].

One of the major strengths of Tattenbach's work is its careful analysis of the Households disaggregation. In order to jusify his disaggregation, he defines two evaluation criteria: Homogeneity and Endogeneity. The first criterion aims to measure the intra-group income and consumption variation as opposed to the inter-group one. Thus, homogeneity is maximized when the SAM socioeconomic groups (SEGs) show for the consumption pattern and the income distribution the maximum degree of variation between them and the maximum degree of homogeneity within them. The second criterion refers to the underlying mapping scheme followed to distribute factorial income to SEGs. A careful disaggregation of factors, as well as households, and an accurate mapping model maximising the use of the available information on the human and phisycal wealth distribution among SEGs are crucial to improve the endogeneity of a SAM[36]. He argues that his final classification, based on the skill of the head of the household and on its spatial location, satisfies to the maximum possible extent these two criteria conditionally to the available information. The main data used to build this classification were derived from the Costa Rican 1984

[33]Table 3 reproduces table 15 in J.A.Bontempo (1992).
[34]See Franz Tattenbach (1990), see especially pages 12-16 and 27-32.
[35]See Direccion General de Estadistica y Census (1990).
[36]In Tattenbach's words: "Endogeneity, as a criterion of disaggregation, is maximized when the error of mapping labor and private capital income to SEGs is minimised. *Theoretically*, the mapping of factorial income to SEGs is determined by the wealth distribution among the SEGs. *Practically,* though, how well the mapping is done - that is how much endogeneity is achieved - depends on a wealth of information about household

Population Census and the household survey conducted by Tattenbach himself. Given the rigour Tattenbach employed in his estimations, the 1991 SAM reproduces his households classification modifying only its spatial location categories. Thus, the skill composition remains the same but, instead of having Central Valley and Non-Central Valley categories, the 1991 SAM presents the Urban and Rural ones. This was done to accomodate the new data supplied by the 1987-88 survey on Households Incomes and Expenditures and those of the 1992 yearly survey[37].

The disaggregation of the IO vector of final private consumption into the above described 10 categories proceeded as described in the remaining part of this section.

The first results consisted in the estimates of rural and urban shares from the 1987-88 Survey. Since it was not possible to obtain the 42 IO table sector classification directly from that survey a three stage procedure was applied. Firstly, the Urban and Rural consumption distributions were obtained for the following list of products[38]:

characteristics and fairly sophisticated models [...] which, in turn, [work well depending] on the choice of disaggregation - not only of the households but also of the factors.

[37]See note 26.

[38]See Table Ing 57 of Direccion General de Estadistica y Census (1992).

| | | | |
|---|---|---|---|
| 1 | Cereals and Derived Products | 20 | Wood Furniture |
| 2 | Meat | 21 | Home textiles |
| 3 | Fish | 22 | Electrical appliances |
| 4 | Eggs Milk Cheese | 23 | Glass Porcelaine Utensiles |
| 5 | Vegetal and Animal fat | 24 | Domestic Services |
| 6 | Vegetables | 25 | Pharmaceuitics |
| 7 | Fruits | 26 | Medical Expenses |
| 8 | Legumineuses | 27 | Transport Equipment |
| 9 | Roots Potatoes | 28 | Transport Equipment Repair |
| 10 | Sugar | 29 | Fuel |
| 11 | Coffee Tea Etc | 30 | Other Transport Expenses |
| 12 | Other Food | 31 | Transport Services |
| 13 | Beverages | 32 | Communication |
| 14 | Tobacco | 33 | Culture |
| 15 | Clothing | 34 | Schooling Expenses |
| 16 | Clothing Repir | 35 | Personal Services |
| 17 | Shoes | 36 | Jewellery |
| 18 | Shoes Repair | 37 | Other Goods and Services |
| 19 | Housing Rent Maintenance | | |

Secondly, the above product shares had been further disaggregated using the weights obtained from the most detailed product distribution available in the Consumption Survey[39]. So, for example the 5% and 8% shares of urban and rural consumption of *Cereals and Derived Products* have been disaggregated into the 51 components included in that category using the same weights. This allowed, in the third stage, to use the mapping function that was already constructed for the estimation of the vector of total private consumption of the IO table[40] and therefore to obtain the required 42 sector classification.

The urban and rural components had to be disaggregated according to the skill of the head of the household following Tattenbach's data. Before doing that it was necessary to transform his spatial classification concerned with the Central Valley and Non Central Valley areas into the one used here. This adjustment was based on the data of table 1 below. This shows the total income distribution shares of the rural and urban households, differentiated by head of the household skill, living in the two areas considered in Tattenbach's work[41]. It is worth noting that the richer central valley concentrates its income in the urban households at the highest skill levels, whereas the largest fraction of income of

[39]This distribution has been described in chapter II.
[40]See chapter II.
[41]See table Ing 14 and Ing 34 of Direccion General de Estadistica y Census (1992).

the non central valley is recorded in the unkilled rural households, which are also the most numerous.

**Table 2.18: Total Income distribution per cent shares**

| | ProMan | WhteComm | IndWks | UnskdWks |
|---|---|---|---|---|
| Central Valley Urban | 81 | 72 | 57 | 42 |
| Central Valley Rural | 19 | 28 | 43 | 58 |
| Central Valley | 100 | 100 | 100 | 100 |
| NoCentral Valley Urban | 54 | 47 | 33 | 15 |
| NoCentral Valley Rural | 46 | 53 | 67 | 85 |
| NoCentral Valley | 100 | 100 | 100 | 100 |

Tattenbach's SAM considers only 23 sectors which are shown in table 2.19 below. The last column of table 2.19 presents the corresponding sectors of the 1991 SAM.

**Table 2.19: Correspondence of the Commodities Sectors between 1980 and 1991 SAMs**

| | | |
|---|---|---|
| 1 | Banana Farming | 1 |
| 2 | Coffee Farming | 2 |
| 3 | Sugar Cane Farming | 3 |
| 4 | Rice Corn Beans Sorghum Farming | 5 |
| 5 | Cattle Dairy Poultry Swine Farming | 8 |
| 6 | Fishing Forestry | 9 |
| 7 | Other Farming | 4, 6, 7, 10 |
| 8 | Food Beverages Tobacco | 11 - 20 |
| 9 | Textiles Clothing Leather | 21 - 22 |
| 10 | Furniture Wood | 23 |
| 11 | Printing Paper Products | 24 |
| 12 | Chemical Oil Ref. Tires Plastics | 25 - 28 |
| 13 | Glass Ceramics Oth NonMetal Materials | 29 - 30 |
| 14 | Basic Metals Electrical Transport Equipment | 31 - 33 |
| 15 | Other Manufacturing | 34 |
| 16 | Electricity Telephone | 40 |
| 17 | Construction | 35 |
| 18 | Commerce | 37 |
| 19 | Transport Services | 38 |
| 20 | Financial Services | 36 |
| 21 | House Ownership | 41 |
| 22 | Other Services | 39 |
| 23 | Government Services | 42 |

The basic adjustment consisted in applying Table 2.18 Income shares to the values of final private consumption of the 23 sectors of Tattenbach's SAM, assuming, implicitly, proportional savings rates. In this way it was possible to calculate the per cent shares needed to disaggregate separately the *uban* and the *rural* consumption components into the relevant skills of the head of households. The same shares were employed for the 1991 SAM sectors not differentiated in the 1980 SAM.

The urban and rural inactive populations consumption distributions were estimated following the same procedure. They were treated separately in conformity of the data presented in the Survey on Households Income and Expenditures.

### 2.3.3 SAM Balancing

This section describes the estimation procedure necessary to complete the balancing of the 1991 Costa Rican SAM. This consists of three major stages: the first considers the introduction at the aggregate Macro SAM level of two new institutions, the Domestic Private Corporations and the Foreign Corporations, which together with the Public Corporation form the Corporate sector of the Costa Rican economy. The second stage focusses on the estimation of the mapping of the factorial incomes to households. The third stage analyses the disaggregation of the rest of the world account into six macro regions.

The introduction of the private corporation institutions is best described considering the two versions of the Costa Rican Macro SAM shown in the following page. Version 1 exactly reproduces the original macro SAM[42], version 2 presents the new institutions. The adjustments necessary in proceeding from one to the other concern the following accounts:

*-Households*: this account in version 1 includes the private corporate sector, therefore in version 2 the corresponding sector (account 4) is no longer receiving the same amount of income from Capital, but only the residual left after the payment made to the private corporation sectors (accounts 7 and 8). The estimation of these Capital payments to domestic and foreign companies is described above in the Capital Value Added disaggregation section.

[42]See Chapter I.

-*Capital Account, Government* and *Row*: the capital income reduction requires an analogous decrease in households savings and tax payments. In version 2 private corporations save and pay taxes the amount of which are estimated from the previous aggregate Households rates. It is also assumed that foreign companies savings are reinvested in Costa Rica. Finally Domestic Corporations pay back Costa Rican owners whereas Foreign companies send their profits to the ROW account.

The disaggregation of the tariff account in the export tax and import tax accounts is the last adjustment applied in version 2.[43]

The second stage considers the distribution of factorial income to the households. First consider the labor payments. These consist in the payments of the 16 types of labor to the 10 households. The equivalent classification scheme of households and labor facilitates the mapping which was based on Tattenbach's data. As an example of these consider Table 1 shown below. This presents the per cent shares calculated from the amounts received by the Central Valley Households from the salaried labor in Tattenbach' SAM. Two aspects are worth noting: first, this matrix shows important

[43]This adjustment was made according to data supplied by the Central Bank of Costa Rica. See chapter II.

## Table 2.20: Macro SAM Costa Rica 1991 (millions of current Colones)

*Version 1*

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ACT | CAP | LAB | HH | GOV | PBLCRP | CAP ACC | INVENT | INDTAX | SUBSID | TARIFF | ROW | receipt |
| 1 | ACTIVITIES | 563408 | | | 410226 | 111876 | | 136098 | 35395 | | 10252 | | 265690 | 1532946 |
| 2 | CAPITAL | 254673 | | | | | | | | | | | 11990 | 266663 |
| 3 | LABOUR | 327436 | | | | | | | | | | | 3162 | 330598 |
| 4 | HOUSEHOLDS | | 183920 | 286114 | | 62342 | 68720 | | | | | | 6374 | 607470 |
| 5 | GOVERNMENT | | | | 77079 | | 10304 | 4388 | | 51660 | | 47932 | 6789 | 198151 |
| 6 | PUBLCORP | | 45181 | 43300 | | | | | | | | | | 88481 |
| 7 | CAP ACC | 18400 | 4388 | | 120067 | 13375 | 9457 | | | | | | 10196 | 175881 |
| 8 | INVENTORY | | | | | | | 35395 | | | | | | 35395 |
| 9 | IND TAX | 51660 | | | | | | | | | | | | 51660 |
| 10 | SUBSID | | | | | 10252 | | | | | | | | 10252 |
| 11 | TARIFF | 47932 | | | | | | | | | | | | 47932 |
| 12 | ROW | 269438 | 33175 | 1184 | 98 | 305 | | | | | | | | 304200 |
| | Total Expend. | 1532946 | 266663 | 330598 | 607470 | 198150 | 88481 | 175881 | 35395 | 51660 | 10252 | 47932 | 304200 | |

## Table 2.21: Revised MacroSAM for Costa Rica, 1991 (millions of current Colones)

*Version 2*

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | Tot |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ACT | CAP | LAB | HH | GOV | PBLCrp | DPRIVCrp | FRGNCrp | CAP ACC | INVENT | INDTAX | M TAX | X TAX | SUBSID | ROW | Receipts |
| 1 | ACTIVITIES | 563408 | | | 410226 | 111876 | | | | 136098 | 35395 | | | | 10252 | 265690 | 1532946 |
| 2 | CAPITAL | 254673 | | | | | | | | | | | | | | 11990 | 266663 |
| 3 | LABOUR | 327436 | | | | | | | | | | | | | | 3162 | 330598 |
| 4 | HOUSEHOLDS | | 136977 | 286114 | | 62342 | 68720 | 30012 | | | | | | | | 6374 | 590539 |
| 5 | GOVERNMENT | | | | 70459 | | 10304 | 5639 | 981 | 4388 | | 51660 | 41977 | 5955 | | 6789 | 198151 |
| 6 | PUBLCORP | | 45181 | 43300 | | | | | | | | | | | | | 88481 |
| 7 | DPRIVCORP | | 44436 | | | | | | | | | | | | | | 44436 |
| 8 | FRGNCORP | | 7727 | | | | | | | | | | | | | | 7727 |
| 9 | CAP ACC | 18400 | 4388 | | 109756 | 13375 | 9457 | 8784 | 1527 | | | | | | | 10196 | 175881 |
| 10 | INVENTORY | | | | | | | | | 35395 | | | | | | | 35395 |
| 11 | IND TAX | 51660 | | | | | | | | | | | | | | | 51660 |
| 12 | M TAX | 41977 | | | | | | | | | | | | | | | 41977 |
| 13 | X TAX | 5955 | | | | | | | | | | | | | | | 5955 |
| 14 | SUBSID | | | | | 10252 | | | | | | | | | | | 10252 |
| 15 | ROW | 269438 | 27956 | 1184 | 98 | 305 | | | 5219 | | | | | | | | 304200 |
| | Total Expend | 1532946 | 266663 | 330598 | 590539 | 198150 | 88481 | 44436 | 7727 | 175881 | 35395 | 51660 | 41977 | 5955 | 10252 | 304200 | |

correlations in the off diagonal elements and, second, the elements of the main diagonal show the highest values as expected. Similar characteristics are shown in the Indipendent Labor and for the Non Central Valley Households matrices.

**Table 2.22: Central Valley Households Labor Income per cent shares**

| Households | Salaried Labor | | | |
|---|---|---|---|---|
| | ProfMan | WhteCom | Indwks | Unskld |
| Central Valley-ProfMan | 71 | 5 | 4 | 7 |
| Central Valley-WteCom | 7 | 62 | 5 | 9 |
| Central Valley-Indwks | 9 | 11 | 72 | 15 |
| Central Valley-Unskld | 14 | 21 | 20 | 69 |
| Total | 100 | 100 | 100 | 100 |

The main adjustment here was to transform the 1980 SAM spatial categories to conform to the rural-urban classification used for the 1991 SAM. This follows the same method and employs the same data described in the Consumption Disaggregation section. Two observations should be added. First, the labour value added of the public corporations was disaggregated by type of labor according to the per cent share of the total private labor payments. Second, the labor payments made to the ROW account concerned only the Professional and Managers skill level, assuming implicitly that this is the only sort of foreign labor category operating in Costa Rica, whereas the labor income from abroad goes to the Inactive population.

Not having a precise estimation of capital ownership distribution among households, the payments from this factor as well as those of the domestic private and public corporations (these include labor income too) were made according to the *total* income per cent shares calculated from Tattenbach's data. The main correction consisted in estimating the total capital income going to urban households as that produced mainly in urban activities, namely manufacturing and services, whereas that distributed to rural households originated from agricultural activities.

The urban and rural populations receive income from the Row account as migrants remittances and form the Government as transfers.

The per cent shares calculated from the difference between total income and final consumption were used to allocate to the 10 household groups total tax payments and savings.

The last stage details the estimation of the Row account disaggregation. The 6 region classification is described in section 2.1 as well as the disaggregation of Imports and Exports. Here it is explained how capital and labour transactions and Institution transfers were disaggregated. The main data used are summarized in table 2 shown below. Column 1 was derived from World Tables published by the World Bank and was used to disaggregate Costa Rican labor payments as well as institutional transfers paid to the rest of the world and the foreign savings. Column 2 is derived from the trade statistics and was employed to calculate capital and labor[44] receipts, and institutional transfers received from abroad. Column 3 was calculated from the data of table 3 of the capital value added disaggregation section and was used to obtain the Costa Rican capital payments. The remaining financial transactions that could not be disaggregated were collected into a special account, termed Foreign Financial Accounts.

**Table 2.23: Row GDP, Exports and Capital Payments per cent shares**

| | %GDP | % Exports | % CapPayments |
|---|---|---|---|
| CENTRO | 0.1 | 15.5 | 0.2 |
| NAFTA | 30.8 | 43.4 | 65.7 |
| ROW | 7.6 | 0.9 | 11.6 |
| SAC | 4.0 | 6.1 | 6.1 |
| OP | 22.7 | 2.5 | 3.6 |
| EUROP | 34.8 | 31.6 | 12.8 |
| World | 100.0 | 100.0 | 100.0 |

[44]Note that labor payments are assumed to be received only from the Centro, NAFTA and Sac regions.

# 3. An Introduction to Calibrated General Equilibrium Models

This chapter presents a simplified version of the Costa Rica model, a one-sector specification which captures most of the essential elements of a standard CGE specification. Each component of this basic model is amenable to a wide variety of alternative specifications, and indications of these are given in the discussion below. While emphasis is on the specification choices appropriate for a standard, neoclassical competitive model, the reader should bear in mind that this initial sufficient set of equations is adaptable to a wide variety of institutional, methodological, and empirical issues.

Table 3.1 presents the structural equations of the simplified model, followed by variable, parameter, and set definitions. Each of the equation groups will be discussed in sequence, but consider them first from an overall perspective. A calibrated general equilibrium model is a system of simultaneous equations which specify interactions between firms and households, usually mediated by commodity and factor markets. The role of government, capital markets, and the rest of the world are also specified, with varying degrees of detail and passivity (read exogeniety), to close the model and account for economywide resource allocation, production, and income determination. The role of commodity and factor markets is to mediate exchange, usually with a flexible system of prices, the most prominent endogenous variables in a typical CGE model. As in a real market economy, commodity and factor price changes induce changes in the level and composition of supply and demand, production and income, and the remaining endogenous variables in the system. In CGE models, an equation system like that in Table 3.1 is solved for prices which yield equilibrium in markets and satisfy the accounting identities governing economic behavior. If such a system is correctly specified, an equilibrium always exists and can be "calibrated" to a base year data set.[45] The calibrated equilibrium model is then used to simulate the effects of alternative policy or other exogenous scenarios on economic activity. When specified correctly, the model is internally consistent, since it fully captures the circular flow of income from firms to factors, from factors to households, and from households back to firms as final demand.

The distinguishing feature of a general equilibrium model, applied or theoretical, is its closed-form specification of all activity in the economy under consideration. The can be contrasted with partial equilibrium analysis, where linkages to other domestic markets and agents are deliberately excluded from consideration.[46] A large and growing body of evidence suggests, however, that indirect effects (e.g. up and down stream production linkages) arising from policy changes are not only substantial, but may in some cases even outweigh direct effects. This of course depends upon how one defines direct and indirect, but the usual distinction between partial and general equilbrium for single sector policy analysis is fairly simple. It is not difficult in this case to generate examples of up and down stream effects which exceed own sector direct effects. The effective rate of protection literature in fact arose as a partial response to this problem. Only a model which consistently specifies economywide interactions can fully assess the implications of economic policy.

Beyond a complete specification of domestic resource allocation, the CGE model leaves open the question of endogeniety for government and the rest of the world. An important indirect effect of trade policy may be the response it induces among trading partners, and an indirect effect of public policy is often realignment of other agency policies. Varying degrees of this kind of endogeniety have been used in CGE models, and these will be discussed in passing below. Obviously, there are decreasing returns to the quest for a universal model specification, and embellishments of this type are best developed on an as-needed basis.

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[45] The notion of calibration is elaborated below.

[46] Rousslang and Suomela (1985) provide a modern statement of this technique in the context of trade policy evaluation.

**Table 3.1: A Simplified Calibrated General Equilibrium Model**

***Domestic Demand***

$$\mathrm{Q}_{\mathrm{i}}^{\mathrm{h}} = \mathrm{LES}(\mathrm{PQ}_{\mathrm{i}}, \mathrm{Y}_{\mathrm{h}}) = \gamma_{\mathrm{i}}^{\mathrm{h}} + \frac{\eta_{\mathrm{i}}^{\mathrm{h}}}{\mathrm{PQ}_{\mathrm{i}}}\left(\mathrm{Y}_{\mathrm{h}} - \sum_{\mathrm{j}=1}^{\mathrm{n}} \mathrm{PQ}_{\mathrm{j}}\gamma_{\mathrm{i}}^{\mathrm{h}}\right) \qquad \text{(M.1)}$$

$$Q_i^G = s_i^G \overline{Q}^G \qquad \text{(M.2)}$$

$$Q_i^I = s_i^I \overline{Q}^I \qquad \text{(M.3)}$$

$$Q_i^V = \sum_{j=1}^{n} \iota_{ij} X_j \qquad \text{(M.4)}$$

***Demand Allocation Between Domestic and Imported Goods***

$$Q_i = CES\ (D_i, M_i, \overline{\lambda}_i), \quad Q_i = Q_i^C + Q_i^V, \qquad \text{(M.5)}$$

$$\frac{\mathrm{M}_{\mathrm{i}}}{\mathrm{D}_{\mathrm{i}}} = \left[\left(\frac{\mu_{\mathrm{i}}}{(1-\mu_{\mathrm{i}})}\right)\left(\frac{\mathrm{PQ}_{\mathrm{i}}}{\mathrm{PM}_{\mathrm{i}}}\right)\right]^{\overline{\lambda}_{\mathrm{i}}} \qquad \text{(M.6)}$$

***Production Technology and Factor Demands***

$$X_i = CES\ (F_i, \overline{\rho}_i), \quad F = L_1, \ldots, L_4, K_1, \ldots, K_4 \qquad \text{(M.7)}$$

$$\mathrm{F}_{\mathrm{i}} = \left(\frac{\mathrm{X}_{\mathrm{i}}}{\alpha_{\mathrm{Xi}}}\right)^{(1-\overline{\rho}_{\mathrm{i}})}\left[\beta_{\mathrm{Fi}}\frac{\mathrm{TC}_{\mathrm{i}}}{\mathrm{w}_{\mathrm{Fi}}}\right]^{\overline{\rho}_{\mathrm{ik}}}, \quad \mathrm{F} = \mathrm{L}, \mathrm{K} \qquad \text{(M.8)}$$

***Supply Allocation by Destination of Commodities and Services***

$$X_i = CET\ (S_i, E_i, \overline{\tau}_i) \qquad \text{(M.9)}$$

$$\frac{E_i}{S_i} = \left[ \left( \frac{\delta_i}{(1-\delta_i)} \right) \left( \frac{PS_i}{PE_i} \right) \right]^{-\bar{\tau}_i} \tag{M.10}$$

***Composite Domestic Prices***

$$PQ_i Q_i = PD_i D_i + PM_i M_i \tag{M.11}$$

***Foreign Prices***

$$PM_i = (1+t_{Mi}) PWM_i R \tag{M.12}$$

$$PE_i^k = (1+t_{Ei}^k) PWE_i R \tag{M.13}$$

***Domestic Market Equilibrium***

$$S_i = D_i \tag{M.14}$$

$$PS_i = PD_i \tag{M.15}$$

$$\sum_{i=1}^n F_i = \overline{F}_S \tag{M.16}$$

***Cost***

$$TC_i = \alpha_{Xi}^{-1} X_i \left[ \sum_F b_{Fi}^{\bar{\rho}_i} w_{Fi}^{1-\bar{\rho}_i} \right]^{\frac{1}{1-\bar{\rho}_i}} + \sum_{j=1}^n \iota_{ij} PQ_j X_i \tag{M.17}$$

***Pricing***

$$PX_i = AC_i \tag{M.18}$$

***Private and Public Income***

$$Y_F = w_F F_S + R\bar{r}_F \tag{M.19}$$

$$Y_h = \sum_F \theta_{hF} Y_F + \sum_g \theta_{hg} Y_g + \overline{T}_{hG} + R\overline{r}_h \tag{M.20}$$

$$Y_G = \sum_{i=1}^n t_i \, PX_i \, X_i \; + R\sum_{i=1}^n \left[ t_{Mi} PWM_i \, M_i \; - t_{Ei} PWE_i \, E_i \; \right] + Y_W \tag{M.21}$$

***Balance of Payments***

$$\sum_{i=1}^n \left[ PWE_i \, E_i - PWM_i \, M_i \right] = \overline{B} \tag{M.22}$$

***Numéraire***

$$\frac{\sum_{i=1}^n PD_i \, D_i}{\sum_{i=1}^n \overline{P}D_i \, \overline{D}_i} = 1 \tag{M.23}$$

## Variable and Parameter Definitions

***Variables***

| | |
|---|---|
| $AC_{ik}$ | Average cost of firm type k in sector i |
| B | Net foreign savings |
| $D_i$ | Total domestic demand for output in sector i |
| $E_i$ | Total exports in sector i |
| $E_{ik}$ | Exports of firm type k in sector i |
| $F_i$ | Total demand for factor F in sector i |
| $F_{ik}$ | Factor F  demand by firm type k in sector i |
| $FC_{ik}$ | Fixed cost of firm type k in sector i |
| $F_S$ | Economywide factor F supply |
| $M_i$ | Total imports in sector i |
| $N_{ik}$ | Number of firms of typs k in sector i |
| $P_{Di}$ | Domestic demand price for output in sector i |
| $P_{Ei}$ | Export demand price for output in sector i |
| $P_{Eik}$ | Export demand price for output of firm type k in sector i |
| $P_{Mi}$ | Import price in sector i |
| $P_{Qi}$ | Composite demand price in sector i |
| $P_{Si}$ | Domestic supply price in sector i |
| $P_{Sik}$ | Domestic supply price for firm type k in sector i |
| $PW_{Eik}$ | World export demand price for output of firm type k in sector i |
| $P_{Xi}$ | Output price in sector i |
| $P_{Xik}$ | Output price of firm type k in sector i |
| $PW_{Mi}$ | World import supply price in sector i |
| $Q_i$ | Composite (domestic and imported) domestic demand for output of sector i |
| $Q_i^C$ | Composite consumption demand for output of sector i |
| $Q^I$ | Aggregate real  investment demand |
| $Q^G$ | Aggregate real government demand |
| $Q_i^V$ | Composite intermediate demand for output of sector i |
| R | Exchange rate |
| $r_h$ | Remittance income accruing to household h |
| $r_F$ | Remittance income accruing to factor F |
| $S_i$ | Total domestic supply in sector i |
| $S_{ik}$ | Domestic supply of firm type k in sector i |
| $t_{Eik}$ | Export subsidy rate for output of firm type k in sector i |
| $t_{Mi}$ | Tariff rate in imports in sector i |
| $TC_{ik}$ | Total cost of firm type k in sector i |
| $t_{ik}$ | Sectoral producer or indirect tax rates |
| $T_{hG}$ | Government transfers to household h |
| $VC_{ik}$ | Variable cost per unit output |
| $w_F$ | Economywide average price of factor F |
| $w_{Fik}$ | Price of factor F paid by firm type k in sector i |
| $X_i$ | Total output in sector i |
| $X_{ik}$ | Output of firm type k in sector i |

| | |
|---|---|
| $X_i$ | Output of sector i |
| $Y$ | Aggregate domestic income |
| $Y_G$ | Government income |
| $Y_h$ | Household income |
| $Y_F$ | Household income |

***Parameters***

| | |
|---|---|
| $\delta_{ik}$ | Base share of exports in value of output of firm type k in sector i |
| $\rho_{ik}$ | Factor substitution elasticity of firm type k in sector i |
| $\theta_{hF}$ | Share of F-factor income going to household h |
| $\theta_{hg}$ | Share of g-household income transferred to household h |
| $\mu\alpha_i$ | Base share of imports in domestic demand for sector i |
| $\lambda_i$ | CES elasticity of substitution between imports and domestic goods |
| $\eta_i$ | Marginal budget share for consumption of good i |
| $\gamma_i$ | Subsistence consumption of good i |
| $\tau_{ik}$ | CET elasticity of transformation between domestic and export markets |
| $\beta_{Fik}$ | Factor F share in value-added of firm type k in sector i |
| $\alpha_{ij}$ | Intermediate demand share for good i by sector j |
| $\alpha_{Xi}$ | Calibrated intercept parameter for production |

***Subscripts***

| | |
|---|---|
| i | Sectors of production - Agriculture, Manufactures, Services |
| F | Factors of production - Up to Four Labor Types (see SAM) and Four Capital Types |
| h,g | Households - Up to Five Rural and Five Urban |

## Notes

Variables are denoted by English letters, structural parameters by Greek letters.

An overstrike denotes a base value in the case of a variable and an exogenously specified value in the case of a parameter.

More than one pricing rule is specified above, although they are mutually exclusive in the simulations.

### *3.1 Consumer Behavior*

The first equation of the simplified model is a typical specification of household behavior. To model consumption demand, a functional form should have at least sufficient flexibility to capture income effects and price-directed substitution between commodities. Many CGE models rely on the Cobb-Douglas or Constant Elasticity of Substitution (CES) functional forms for modeling both production technology and household consumption. In the latter context, however, these specification have the important limitation of assuming unitary income elasticities of demand for all products. Others feel this fails to account for the diversity of income effects on demand and the structural adjustment in the rest of the economy which ensue from policy changes or exogenous shocks. One popular demand specification which does not rely on unitary income elasticities is the Linear Expenditure System (LES), introduced by Stone (1954).

#### 3.1.1 The Linear Expenditure System

To better understand this demand system, consider commodities $x_i$ with prices $p_{i,}$, $i=1,...,n,$ and a single representative consumer with income *y*. The LES is derived with respect to the following maximization of a constrained Stone-Geary utility function:

$$\text{Max } \; U(x_1,\ldots,x_n) \; = \; \prod_{i=1}^{n}(x_i - \gamma_i)^{\alpha_i} \qquad \text{subject to} \quad \sum_{i=1}^{n} p_i x_i = y \tag{3.1}$$

where $0 < \alpha_i < 0$ and $\sum_i \alpha_i = 1.$ As Silberberg (1990) notes, the resulting Marshallian demand system is given by

$$x_i \; = \; \gamma_i + \left(\frac{\alpha_i}{p_i}\right)\left(y - \sum_{i=1}^{n} p_i \gamma_i\right) \qquad i = 1.,,,.n \tag{3.2}$$

To interpret the individual LES components, consider first the subsistence minimum consumption level for good i, $\gamma_i$. The total $\sum_i p_i \gamma_i$ represents a minimum overall expenditure for subsistence at current prices. The excess of total spending above this minimum (the second term in brackets above), is referred to as supernumerary income, and is allocated to commodities according to the marginal budget shares $\alpha_I$.

Carrying the derivation a step further, substitute the Marshallian demand functions into the direct utility function.[47] This yields the indirect utility function

$$v(p,y) \;=\; \prod\left(\frac{\alpha_i}{p_i}\right)\left(y-\sum_{i=1}^{n}p_i\gamma_i\right)^{\alpha_i} \tag{3.3}$$

which can be rewritten as

$$v(p,y) \;=\; \alpha\frac{\left(y-\sum_{i=1}^{n}p_i\gamma_i\right)}{\prod_{i=1}^{n}p_i{}^{\alpha_i}} \tag{3.4}$$

where $\alpha = \prod_i \alpha_i$ . This indirect utility function can be interpreted in terms of real expenditure, i.e. with supernumerary income (the numerator in expression 5.4) deflated by a consumption-weighted price index (the denominator).[48]

Inverting the indirect utility function yields the expenditure function

$$e(p,u) \;=\; (v/\alpha)\prod_{i=1}^{n}p_i{}^{\alpha_i}+\sum_{i}^{i=1}p_i\gamma_i \tag{3.5}$$

while the direct compensation function is given by

$$\mu(p^0;\, p^1, y^1) \;=\; e(p^0;\, v(p^1, y^1)) \tag{3.6}$$

The latter function measures the expenditure required a prices $p^0$ to maintain utility equal to that gained at reference prices $p^1$ and expenditure $y^1$. In explicit terms of the LES, this becomes

$$\mu(p^0;p^1,y^1) \;=\; \left(\frac{\left(y^1-\sum_{i=1}^{n}p^1{}_i\gamma_i\right)}{\prod_{i=1}^{n}p^1{}_i{}^{\alpha_i}}\right)\prod_{i=1}^{n}p^0{}_i{}^{\alpha_i}+\sum_{i}^{i=1}p^0{}_i\gamma_i \tag{3.7}$$

This indirect compensation function can be used to measure the equivalent variation (EV) welfare change between equilibrium outcomes ($p^0$,$y^0$) and ($p^1$,$y^1$), a welfare comparison commonly done in simulation modeling. In terms of the above derivations, this measure takes the form

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[47] See e.g. Deaton and Muellbauer (1980), p. 38 nad Varian (1984), p. 116.
[48] Deaton and Muellbauer (1980), p. 65.

$$EV = \mu(p^0; p^1, y^1) - y^0 \tag{3.8}$$

The EV measure measures the change in real income, in terms of base prices, which would bring level of utility attained in the new state, taking account of changes in purchasing power.

Implementation of an LES demand system utilizes a "Frisch parameter," which measures the expenditure elasticity of the marginal utility of expenditure.[49] This takes the form

$$\phi = -\frac{y}{\left(y - \sum_i p_i \gamma_i\right)} \tag{3.9}$$

As a practical matter, the marginal expenditure shares are calibrated with average budget shares as

$$\alpha_i = \eta_i \beta_i \tag{3.10}$$

where $\eta_i$ denotes the income elasticity of demand for commodity *i* and $\beta_i$ denotes the respective average budget share. The subsistence minima are related to the other parameters as

$$\gamma_i = x_i + \alpha_i \frac{y}{p_i \phi} \tag{3.11}$$

while the Engel aggregation condition requires that

$$\sum_{i=1}^{n} \beta_i \eta_i = 1 \tag{3.12}$$

Since the estimates of income elasticities $\eta_i$ are usually taken from econometric sources, this condition may not hold in a base dataset. Therefore, the income elasticities are usually adjusted so that the Engel aggregation condition holds. The following scaling procedure suffices:

$$\theta = \sum_{i=1}^{n} \eta_i \frac{p_i x_i}{y} \tag{3.13}$$

$$\eta_i \leftarrow \frac{\eta_i}{\theta} \tag{3.14}$$

[49] See e.g. Dervis, de Melo, and Robinson (1982), p.483.

### 3.1.2 The Linear Expenditure System with Endogenous Labor Supply

Many CGE models are based on an assumption that aggregate employment remains fixed between base scenarios and comparative static outcomes. Sometimes erroneously referred to as a full employment assumption, this specification of labor market closure omits an important component of labor market adjustment and is particularly unsatisfactory for capturing expansionary effects in economies with large underutilized labor reserves. A number of alternatives have been proposed to make aggregate labor supply endogenous, and among the most appealing are those which begin from microeconomic foundations of the labor-leisure choice. For example, Abbot and Ashenfelter (1976) made use of an LES system of the form

$$u \;=\; \alpha_0 \log(x_0 - \gamma_0) + \sum_{i=1}^{n} \alpha_i \log(x_i - \gamma_i) \tag{3.15}$$

where $x_0$ denotes an initial endowment of leisure. In their approach to this problem, de Melo and Tarr (1992) point out that this specification implies $\sum_i \gamma_i < 1$, which would violate Walras' Law in a CGE model. To remedy this, they propose a nested Stone-Geary utility function of the form

$$u(x_0, x_1, \ldots, x_n) = (x_0 - \gamma_0)^{\alpha_0} \left[ \prod_{i=1}^{n} (x_i - \gamma_i)^{\alpha_i} \right]^{\alpha} \tag{3.16}$$

where $\alpha_0 + \alpha = 1$. This utility function has the desirable LES properties and is weakly separable between commodities and leisure.[50]

Now define an aggregate commodity *x* by

$$(x - \gamma) \;=\; \prod_{i=1}^{n} (x_i - \gamma_i)^{\alpha_i} \tag{3.17}$$

where $\gamma$ denotes the the aggregate subsistence requirement as before. From this, the first-stage utility maximization problem is given by

$$\text{Max } \; U(x_0, x) \;=\; (x_0 - \gamma_0)^{\alpha_0} (x - \gamma)^{\alpha} \;\; \text{subject to} \quad wx_0 + px = Y \tag{3.18}$$

[50] Deaton and Muellbauer (1980), p. 127.

where $w$ denotes the wage, p is an aggregate price index, and $Y$ denotes income including implicit compensation for leisure. More specifically, consider a total endowment of time T, base amount of leisure $x_o$, and unearned income $y^*$. Then $Y=y^*+wT$ and labor supply is given by $L=T=x_0$.

The demand system resulting from this specification is given by

$$x_0 = \frac{\alpha_0}{w}\left(Y - w\gamma_0 - p\gamma\right) \tag{3.19}$$

$$x = \frac{\alpha}{w}\left(Y - w\gamma_0 - p\gamma\right) \tag{3.20}$$

and the labor supply function follows as

$$L = (T - \gamma_0) - \frac{\alpha_0}{w}\left[Y - w\gamma_0 - p\gamma\right] \tag{3.21}$$

Since total time $T = x_0+L$, we have $Y = y+wx_0$, where $y$ denotes total money income. From this observation, one can solve for the level of leisure by substitution, i.e.

$$x_0 = \gamma_0 + \frac{\alpha_0}{w}\left[\frac{y - p\gamma}{1-\alpha_0}\right] \tag{3.22}$$

and labor supply then follows in reduced-form as

$$L = (T - \gamma_0) - \frac{\alpha_0}{w}\left[\frac{y - p\gamma}{1-\alpha_0}\right] \tag{3.23}$$

The second-stage utility maximization, giving the allocation of consumption subject to labor supply, follows as in the previous section. Before implementing the indirect utility function, it should be observed that the definition of the aggregate commodity implies

$$p\gamma = \sum_{i=1}^{n} p_i\gamma_i \tag{3.24}$$

and thus

$$y - \sum_{i=1}^{n} p_i\gamma_i = y - p\gamma \tag{3.25}$$

Substituting the Marshallian demand system, (3.19-20) into the nested indirect utility function now yields

$$v(p,w,y) \;=\; \left[\frac{\alpha_0}{w}\left(\frac{y-p\gamma}{1-\alpha_0}\right)\right]^{\alpha_0}\left\{\prod_{i=1}^{n}\left[\frac{\alpha_i}{p_i}\left(y-\sum_{j=1}^{n}p_j\gamma_j\right)\right]^{\alpha_i}\right\}^{\alpha} \tag{3.26}$$

which is view of (3.25) can be rewritten as

$$v(p,w,y) \;=\; \left[\frac{\alpha_0}{w(1-\alpha_0)}\right]^{\alpha_0}\left[\frac{\alpha}{\prod_{i=1}^{n}p_i^{\alpha_i}}\right]^{(1-\alpha_0)}(y-p\gamma) \tag{3.27}$$

The expenditure function then follows by inversion of the indirect utility function, i.e.

$$e(p,w,u) \;=\; v\left[\frac{w(1-\alpha_0)}{\alpha_0}\right]^{\alpha_0}\left[\frac{\prod_{i=1}^{n}p_i^{\alpha_i}}{\alpha}\right]^{(1-\alpha_0)} + p\gamma \tag{3.28}$$

The indirect compensation function can now be obtained as

$$\mu(p^0,w^0;p^1,w^1,y^1) \;=\; \left(\frac{w^0}{w^1}\right)^{\alpha_0}\left(\frac{\prod_{i=1}^{n}p_i^{0\,\alpha_i}}{\prod_{i=1}^{n}p_i^{1\,\alpha_i}}\right)^{(1-\alpha_0)}(y^1-p^1\gamma)+p^0\gamma \tag{3.29}$$

It remains to discuss how $\alpha_0$ and the aggregates *x, γ,* and *p* are obtained during model calibration. Differentiating equation (3.23) with respect to income yields

$$\frac{\partial L}{\partial y} \;=\; -\frac{\alpha}{w(1-\alpha_0)} \tag{3.30}$$

which in turn yields the income elasticity of labor supply

$$\varepsilon \;=\; -\frac{a_0 y}{w(1-\alpha_0)L} \tag{3.31}$$

The parameter $\alpha_0$ can then be obtained as

$$\alpha_0 \;=\; -\frac{wL\varepsilon}{(y-wL\varepsilon)} \tag{3.32}$$

Given the definitions (3.17) and (3.24) of the demand aggregates and price index, respectively, and noting the budget constraint *px=y*, we have

$$p(x-\gamma) \;=\; y-\sum_{i=1}^{n} p_i\gamma_i \;=\; p\prod_{i=1}^{n}(x_i-\gamma_i)^{\alpha_i} \tag{3.33}$$

and thus

$$p \;=\; \frac{y-\sum_{i=1}^{n} p_i\gamma_i}{\prod_{i=1}^{n}(x_i-\gamma_i)^{\alpha_i}} \tag{3.34}$$

Finally, by observing that

$$\gamma \;=\; \frac{\sum_{i=1}^{n} p_i\gamma_i}{p} \;=\; \frac{\sum_{i=1}^{n} p_i\gamma_i\prod_{i=1}^{n}(x_i-\gamma_i)^{\alpha_i}}{y-\sum_{i=1}^{n} p_i\gamma_i} \tag{3.35}$$

we derive aggregate demand as

$$x \;=\; \prod_{i=1}^{n}(x_i-\gamma_i)^{\alpha_i}+\gamma \tag{3.36}$$

A number of alternative specifications of LES are available, each vigorously defended by its advocates, but they do not really disagree in ways which are substantive from a CGE perspective.[51] Investment and government spending are usually viewed as exogenous to the model.

### *3.2 Production Technology*

Producer behavior in the model is dictated by profit maximization subject to production technology and resource constraints. The most common technology specification is one of constant returns to scale, although increasing returns can also be specified as discussed below. In the simplified model, a constant elasticity of substitution (CES) production function is specified in expression (3.2), which includes as a special case the familiar Cobb-Douglas technology.[52] The

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[51] This argument is made by Lewbel (1989).
[52] See Chambers (1988) for theory and Dixon et al. (1982) for empirical methods.

elasticity of substitution between labor and capital, $\sigma_p$, is exogenous and estimated outside of the model. In cases where many types of labor and capital are specified, they are usually nested into the CES production function with their own CES aggregation.[53]

Intermediate inputs are aggregated with a standard leontief technology (3.3) and then enter the production function in a linearly homogeneous way, but they are not substitutable for productive factors. Extensions of this to admit substitution within intermediates and between them and factors have been attempted, but this does not appear to significantly affect policy assessments.[54] The simplified specification is for a single sector, so there is no role for up and down stream linkages. These important inter-industry effects will be fully captured in a given implementation of the model, which will be calibrated to a detailed social accounting matrix.

The equations of producer behavior are specified, one for each sector, and thus say nothing about the composition or behavior of firms within each industry. The default in CGE modeling is to assume each sector is populated by atomistic, perfectly competitive firms. This fiction is often less than innocuous, and imperfectly competitive behavior can play an important role in determining the outcomes of policies. This is the most active area in trade theory and policy, however, and a number of generalizations of the simplified specification are now available for experimentation with the prototype model.[55]

### *3.3 Factor Supply*

In the past, factor markets have been most often modeled with derived demand and relatively passive supply specifications. This case illustrates the important concept of closure, where the equations and endogenous variables of a given market component of the model must be exactly determined. Consider the labor market, where labor demand is derived from profit maximizing firm behavior and labor supply is passive in the sense that workers will accept employment at any wage. Fixing labor supply in itself does not fully determine the two variables, wage and employment, along the labor demand schedule, however. To "close" the labor market, one must either assume wages or employment are fixed. Thus a fixed wage may generate endogenous unemployment or a

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[53] See Keller (1980) on nested CES specifications.
[54] See related discussion in de Melo and Tarr (1989).
[55] More on this in section 5 below.

fixed (usually full) employment level an endogenous wage. This traditional method is open to obvious criticisms, and although it may be empirically innocuous for very small adjustments, it is highly implausible for large adjustments and in any case is unlikely to capture important realities about labor market adjustment. Shoven and Whalley, among others, have used a labor supply schedule derived from maximizing a utility function which treats income and leisure as substitutes.[56] Such a specification would trace labor supply to income, relative prices, and thus to consumption, as the LES notation in expression (3.4) indicates. Again, labor markets are currently a field of intense theoretical and applied research, and a number of alternative specifications can be tested in applications of the prototype model.[57]

The traditional CGE specification of capital markets is similar to that of labor, but generally more defensible (equation 3.5). Domestic capital ($K_D$) is usually assumed fixed for short run analysis, and variable according to exogenous mobility and accumulation assumptions in the long run. Long run closure of the capital market is usually obtained by assuming that the domestic rental rate is fixed and the supply of foreign capital ($K_M$) perfectly elastic. In light of the dramatic liberalization of international capital markets and their equally dramatic growth in recent years, it is doubtful that sector specific domestic trade policies can exert much influence on world interest rates.[58] Thus the simplified capital market specification, while not necessarily appropriate for central bank policy analysis, should be serviceable to assess trade policy. A few sensitivity experiments can test this assumption and give indications of a remedy if it is needed.

### *3.4 Factor Demand*

The factor demands in expression (3.6) correspond to their production function (3.2), in this case CES, and specify labor-capital shares which depend on the price of output and their own relative (factor) prices. Again this is a consequence of perfect competition and is open to generalization.

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[56] See Dervis, de Melo, and Robinson (1982) for the traditional approach, Shoven and Whalley (1984) and their tax literature for this alternative. The original idea is formalized in Abbot and Ashenfelter (1976).

[57] See e.g. Blanchard and Diamond (1989) and Katz and Summers (1989ab).

[58] See Frankel (1989) for discussion.

*3.5 Domestic Demand and Allocation of Tradeable Goods*

Next comes the part of the CGE specification which is of greatest direct relevance to the prototype model, the treatment of tradeable goods. Trade theorists generalized the classical model of comparative advantage to admit incomplete specialization and import competing domestic industries, but the everyday reality of intra-industry trade, simultaneous import and export in the same sector, still was not captured. A number of alternative paradigms are now available to explain this phenomenon, however, and the one used here is probably the most ubiquitous.[59] Simply stated, we view each sector as consisting in reality of three goods, where imports and exports in each industry category are imperfect substitutes for their domestic counterparts.

On the import side, we assume that foreign and domestic commodities are imperfect substitutes in domestic use and thus that the import composition of domestic demand is influenced by the ratio of domestic and import prices, as well as administrative quantity restrictions which may be in force.[60] For exports, we have assumed that domestic firms allocate their commodity output between domestic and foreign markets according to a transformation function which depends upon the ratio of domestic and foreign prices. Taken together, these two specifications allow for simultaneous export and import of goods in the same sector.

The Armington convention for treating imports is summarized in expression (3.7). A general specification of this postulates the existence of a composite sectoral domestic good, Q, which is an aggregation of imports and their domestic counterparts. The CES aggregation is especially convenient for this, and takes the general form (see expression 3.7)

$$Q = \alpha\left[\beta M^{(\sigma-1)/\sigma} + (1-\beta)D_D{}^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)} \quad (3.25)$$

where the structural parameters are a shift parameter $\alpha$, a share parameter $\beta$, and $\sigma$, the elasticity of substitution between imports and domestic goods in domestic use. Now the problem facing the domestic user is identical to that of a firm seeking to minimize the cost of producing a given level of output Q. This corresponds to the first order condition, written implicitly in expression (3.8) above,

[59] de Melo and Robinson (1989) provide a detailed discussion of the method.

$$\frac{M}{D_D} = \left[\frac{\beta}{1-\beta}\frac{P_D}{P_M}\right]^{\sigma} \qquad (3.26)$$

or the familiar equivalence between relative prices and marginal rates of substitution. Parameter estimates for the elasticity $\sigma$ are obtained outside the model, and those for $\alpha$ and $\beta$ by calibration. This is a general procedure for fitting the model specification to the observed data for the economy. In this case calibration entails solving (3.25) and (3.26) for $\alpha$ and $\beta$ with $\sigma$ and the base year values for $D_D$, M, $P_D$, and $P_M$. In the present example, the calibrated values are given, assuming unitary domestic and import base year prices, by

$$\beta = \frac{\left[\frac{M}{D_D}\right]^{1/\sigma}}{1 + \left[\frac{M}{D_D}\right]^{1/\sigma}} \qquad (3.27)$$

and $\alpha$ is obtained by substitution into (3.25). Thus, the structural parameters of the CGE consist of "elasticity" type parameters, measuring the responsiveness of the model equations around an equilribrium, and calibrated share and intercept parameters which "fit" the equations to the observed static equilibrium.

In the simplified treatment of imports, no distinction is made between those for intermediate and final use. Thus we assume the Armington elasticities are equal for both uses, and the evidence from studies which distinguish $\sigma$ values for intermediate and final use does not contradict this.[61] The implications of the Armington specification for evaluating protection are discussed in section 4 below.

The specification of export behavior is formally analogous to that of imports, in that the same family of flexible functional forms is used. The characters and underlying behavior are different,

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[60] The original reference on this approach to imports is Armington (1969) and it is discussed in Dervis, de Melo, and Robinson (1982), and Brown (1988).

[61] de Melo and Tarr (1989) provide the most recent example, with an exhaustive specification of Armington intermediates.

however. In what follows, exports will be discussed as through their levels were supply determined, and indeed the simplified model assumes world prices are fixed. The specifications of both import and export behavior are consistent with terms-of-trade changes, if these are explicitly specified in the model as in expressions (3.20) and 3.21). In any case, for a given sector of the economy, exports can be viewed as perfect substitutes for domestically consumed goods of domestic origin. As with imports, however, this view leads to methodological difficulties, in the form of market specialization and "corner solutions" which are incompatible with the observed reality of intra-industry trade. A more realistic view is one of products differentiated by destination, so that imports and domestic production for domestic use and export can all coexist together as is commonplace. The implied market segmentation for domestic output is modeled by the transformation function in expression (3.9). In the simplified model, this is a constant elasticity of transformation (CET) function of the form[62]

$$X = \gamma\left[\delta E^{(\tau+1)/\tau} + (1-\delta)D_S^{(\tau+1)/\tau}\right]^{\tau/(\tau+1)} \quad (3.28)$$

where the elasticity parameter $\tau$ measures the ease with which domestic production can be shifted between the domestic and export markets. The corresponding first-order conditions arise for the domestic producer, maximizing profits between the two markets, subject to their respective prices, i.e. expression (3.10) is derived explicitly as

$$\frac{E}{D_S} = \left[\frac{\delta}{1-\delta}\frac{P_E}{P_D}\right]^{\tau} \quad (3.29)$$

Expression (3.29) means that exporters desire the ratio of domestic and export shipments which equalizes their marginal revenues, in response to relative (endogenous or exogenous) prices in the

[62] This usage was first proposed by Powell and Gruen (1968), and is discussed in Caddy (1976) and de Melo and Robinson (1989).

two markets and according to some transformation elasticity between them.[63] Estimates of $\tau$ for each sector are again obtained outside the model and $\gamma$ and $\delta$ are calibrated in the base year by solving (3.28) and (3.29) for them with $\tau$ and base year values of X, D, $D_S$, and E.

### *3.6 Domestic Prices*

There are three sets of domestic prices in the simplified CGE model, producer prices $P_X$, purchaser prices of domestically produced goods $P_D$, purchaser prices of composite domestic demand $P_Q$. The latter is inclusive of an indirect tax $t_D$ on domestic production. The indirect tax rates will generally be disaggregated across all sectors, and these constitute an important sources of domestic distortions in the base data of most input-output accounts. Another component of the difference between producer and pruchaser prices is trade and transport margins. These are also present in the prototype database and prototype model, but are omitted from the simplified model in the interest of brevity.

### *3.7 Domestic Market Equilibrium*

Expressions (3.14)-(3.16) correspond to the basic equilibrium conditions for supply and demand in all markets. As was observed above, the convexity properties of production and utility yield well behaved supply and demand functions, so existence of equilibrium is guaranteed for a fully specified model. CGE models have also been specified to allow for price rigidities in commodity or factor markets, and these extensions are routine if the institutional features of a particular application warrant this.[64]

### *3.8 Income and Government Revenue*

The national income identities in the simplified specification are especially simple. In expression (3.17), aggregate income of the representative consumer includes wages, rental income, and government revenue less transfers abroad. Government revenue in the present example

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[63] The subject of calibration is treated more extensively in Mansur and Whalley (1986). An example of dynamic calibration is Erlich, Ginsburgh, and van der Heyden (1987).

(expression 3.18) accrues only from domestic indirect taxes and tariffs, less export subsidies. In more general specifications, such as the prototype model, private households enterprises, and government are disaggregated in their income and expenditure specifications, and a wide variety of fiscal instruments is captured. As indicated in equation (3.1), investment and government spending are usually specified exogenously. Some effort has been made recently to endogenize investment, but has thus far yielded mixed results.[65]

Generalization of CGE models for fiscal analysis has been an area of extensive research for a decade.[66] Just about every conceivable domestic and trade tax has been evaluated with CGE models, from redistributive cash grants to export drawback schemes.[67] The usual tax instruments in a disaggregated empirical model include import tariffs, export taxes, sectoral indirect taxes, income taxes, factor and value added taxes, and trade and transport margins. Many of these can be studied with equal facility as (negative) subsidies. It is hardly coincidental that CGE models have enjoyed rapid and extensive acceptance in the tax literature. To the extent that they can be properly specified, estimated, and implemented, they are an attractive tool for incidence analysis. By definition, a CGE model traces a policy's impact through myriad linkages in the economy. Not only does this give an accounting of extensive indirect effects but, if the model is disaggregated, it clearly details the composition of those effects. In trade theory and policy, it is well known that aggregate policy effects often obscure dramatic adjustments in the composition of income and product. Likewise, focusing on a single sector, as in partial equilibrium analysis, can obscure substantial induced adjustments elsewhere in the economy. Trade taxes are of particular relevance to the present exercise, but they should not be considered in isolation of other domestic fiscal instruments.[68] For this reason, the prototype model will include a fully specified set of indirect, income, and other observed domestic taxes.

The inclusion of additional fiscal instruments has direct, but not obvious implications for equation (3.18). Indeed, the general equilibrium revenue effects of trade policy are one of its more interesting but least elucidated facets. Most advocates of trade liberalization promise real output growth in the aggregate, but the revenue and especially the distributional implications of these

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[64] See Dewatripont and Robinson (1985) and Devarajan, Jones, and Roemer (1989).
[65] See Abel (1979), Chirinko (1986), and Bovenberg and Goulder (1989) for discussion and examples. A large OECD project is now under way on this, as exemplified by Bourguignon, Branson, and de Melo (1989), Fargeix and Sadoulet (1989), and Roland-Holst and Thorbecke (1989).
[66] See Ballard, Fullerton, Shoven, and Whalley (1985) and Hendersen (1989).
[67] Ballard (1988) covers the former, Behrman and Levy (1988) the latter.
[68] This point is emphasized by Rousslang (1987) and can be traced back to Diamond and Mirlees (1971).

policies are not well understood.[69] One appealing simulation exercise with the prototype model would be to evaluate the potential revenue gains or losses from liberalization or protection and assess whether they could be coupled with compensation or subsidy schemes for damaged sectors or households.[70] Although a good theoretical literature exists on public finance and trade, empirical contributions have been less forthcoming.[71] Most CGE applications are quite parsimonious in their specification of fiscal instruments. The result in the case of those that deal with trade distortions is that they cannot capture interactions with other components of revenue and the potential linkages between trade and domestic distortions.[72] Ironically, much of the extant applied work looks at the problem in reverse, evaluating the effect of domestic fiscal policy on trade.[73]

### *3.9 Foreign Balance*

Equation (3.19) gives a simplified balance of payments condition, where the current account, net of expatriated rent payments, is equal to a fixed initial level, B. An alternative closure of the foreign balance is to fix exchange rates and allow B to be endogenous. Either way, the trade balance is exactly determined, but each closure convention corresponds to a different institutional setting. The general idea of fixing the foreign balance by either means applies only to comparative static experiments, i.e. we want either "foreign borrowing" or the exchange rate to be *ceteris paribus* features of the policy experiment. In the case of intertemporal analysis, a foreign imbalance need not be viewed as a real disequilibrium, but simply as a means of exploiting gains from intertemporal trade.[74] In this case, both e and B are endogenous and B must be specified separately as part of an intertemporal behaviour or consistency equation.

### *3.10 Foreign Commodity Prices*

The import and export price equations, (3.20) and (3.21) reflect a simplified set of tariff instruments, and might more generally include trade and transport margins and endogenous quota or

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[69] Some recent progress on this question can be seen in Bovenberg (1989).
[70] This is the logic, for example, behind lump-sum by-backs of import licenses in some newly industrialized countries.
[71] For the former, see Dixit (1985) and Newbery and Stern (1988).
[72] Dalh, Devarajan, and van Wijnbergen (1989) and Fullerton and Hendersen (1989) give indications for extension in this direction.
[73] Bovenberg (1989) is a recent example.

VER premia.[75] Import tariffs $t_M$ and export subsidy rates $t_E$ are exogenous policy parameters. The premia ($\rho_M$) are the endogenous wedges in import prices which can arise from binding quantitative restrictions on imports. The determination of world prices themselves of course depends upon the markets for traded goods, export supply and import demand (already specified), as well as export demand and import supply conditions. The last two are specified generically as response functions which can be equated with their domestic counterparts and inverted to obtain world prices of imports and exports, unless of course they are perfectly elastic, whence the corresponding world price is fixed. This circumstance corresponds to the well-known small country assumption, which holds that the country under consideration is too small to influence world prices in its import or export markets.

### *3.11 Foreign Commodity Supply and Demand Functions*

The small country assumption is ubiquitous in CGE modelling and can foster a variety of misleading conclusions. Its prevalence arises from a combination of simple expedience and the more defensible observation that most early models were indeed applied to small developing countries. Whichever rationale was really in the minds of those who relied on it in the past, the small country assumption will clearly not do as an *a priori* supposition about some trade linkages. It should be emphasized though that the assumption itself is in no way intrinsic to CGE modeling. Import supply and export demand functions (expressions 3.22 and 3.23, respectively) are already specified for the prototype model and await econometric estimates of their respective elasticities.[76] It is sometimes mistakenly supposed that neoclassical one country models are not capable of capturing induced terms-of-trade effects, but this need not be the case if empirically sound and finite values of $\sigma_f$ and $\tau_f$ can be estimated.

### *3.12 Numéraire*

The last equation of the simplified model, (3.24), specifies the composite domestic price level as numéraire. This is the normalized index against which other relative prices in the economy are

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[74] Dixit and Norman (1980) expand on this point.
[75] The latter specification is discussed in de Melo and Tarr (1989).
[76] The procedure and data for such elasticity estimation are discussed in Reinert and Roland-Holst (1989).

measured. Indeed, there is a variety of numéraire to choose from in a typical general equilibrium model (e.g average wage rate, exchange rate, etc.), and one must be quite careful about this convention when interpreting results and, especially, when comparing models. As with most general equilibrium systems, the standard CGE model deals only in real magnitudes and relative prices. Monetary variables and macroeconomic phenomena like inflation have no direct interpretation here, although changes in real income, output, and employment are all well defined at any level of aggregation.[77] Attempts to include nominal effects have not been more successful in CGE modeling than in its parent discipline, general equilibrium theory.

This concludes the overview of a simplified CGE model. Emphasis here has been on established standards for a general equilibrium specification which includes the main institutional components. The adaptability of the general framework should be borne in mind throughout this discussion. The best model usually is the one tailored to the problem at hand, and the simplified model only represents a basic and sufficient initial specification from which to develop more detailed and diverse models.

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[77] A detailed discussion of the numéraire concept can be found in theoretical terms in Arrow and Hahn (1970), chapter 2, and in practical terms in Dixon et al (1972), chapter 3.

# 4. An Introduction to GAMS

This chapter provides a brief introduction to a software tool which is often used in CGE modeling. Generalized Algebraic Modeling System (GAMS) is a high-level programming language which allows nonspecialist computer users to specify and implement economywide models calibrated to datasets of the kind described in the preceding chapters.[78] While the GAMS language is relatively easy to learn for a computer-literate individual with some knowledge of linear algebra, it is flexible enough to implement very large models on a PC platform.[79] In the following discussion, the GAMS language will be introduced via a practical example, i.e. the specification and calibration of a simple CGE specification.

One of the first computable general equilibrium (CGE) models was that of Johansen (1960). A Johansen-style CGE model is written as a system of equations linear in proportional changes of the variables. CGE models of this form include Taylor and Black (1974), Dixon et al. (1982), and Deardorff and Stern (1986).

Perhaps the best-known analytical statement of this type of model was given by Jones (1965). In fact, the Jones algebra and the Johansen CGE formulation are completely analogous techniques. Both are designed to solve nonlinear equation systems by using local first-order approximations. GAMS will be applied to an elementary example of the Johansen-Jones approach to general equilibrium modeling. We first set out the Jones algebra and then describe its translation into the GAMS language. An appendix gives the full listing of the GAMS program.

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[78] GAMS is the property of the GAMS Development Corporation, 1217 Potomac Street NW, Washington DC 20007, who has sole authority over its use and entitlement to fees derived therefrom. See Brooke, Kendrick, and Meeraus (1988) for more details.

[79] See e.g. Devarajan et al (1994), and Lee and Roland-Holst (1994) for models in excess of 10,000 equations.

*4.1 The Jones Algebra*

Consider a two-sector model with the following production structure $Y_j=F_j(L_j,K_j)$, where j=1,2, the first sector produces importable goods ($Y_1$), and the second produces exportable goods ($Y_j$).[80] The factors are defined by $L_j$, labor input into sector-j production, with $L_1 + L_2 = L$, where L is the employment level, and $K_j$, capital input into sector-j production, and $K_1 + K_2 = K$, where K is the current stock of capital.

In order to formulate a complete model, more notation is needed. Let w denote the wage rate, r the capital rental rate. Now let $p_j$ and $p_{wj}$ denote the domestic and world prices of good j, respectively, while $a_{ij}$ is the input coefficient for input i into the production of good j. Finally, let $t_1$ denote an import tariff and $s_2$ is an export subsidy.

This notation and the assumptions of constant returns to scale in production and perfect competition yield the following general equilibrium system:

Fixed-employment conditions:

$$a_{L1}Y_1 + a_{L2}Y_2 = L \tag{6.1}$$

$$a_{K1}Y_1 + a_{K2}Y_2 = K \tag{6.2}$$

Average-cost pricing conditions:

$$wa_{L1} + ra_{K1} = p_1 \tag{6.3}$$

$$wa_{L2} + ra_{K2} = p_2 \tag{6.4}$$

Conditional input coefficient functions:

$$a_{L1} = a_{L1}(w,r) \tag{6.5}$$

$$a_{L2} = a_{L2}(w,r) \tag{6.6}$$

$$a_{K1} = a_{K1}(w,r) \tag{6.7}$$

$$a_{K2} = a_{K2}(w,r) \tag{6.8}$$

[80] It is possible to include both nontraded and intermediate goods into the Jones algebra. For an example of this, see Tobey and Reinert (1991).

Domestic price equations:

$$p_1 = (1+t_1)p_{w1} \tag{6.9}$$

$$p_2 = (1+s_2)p_{w2} \tag{6.10}$$

In the above ten-equation system, the exogenous variables are L, K, $p_{w1}$, and $p_{w2}$, the endogenous variables are $Y_1$, $Y_2$, $a_{L1}$, $a_{L2}$, $a_{K1}$, $a_{K2}$, w, r, $p_1$. The terms $p_2$. $t_1$ and $s_2$ are parameters.

In order to put the equations into proportional change form, we need to introduce some additional notation. The circumflex, "^", denotes percentage change in the indicated variable. The parameter $\lambda_{ij}$ denotes the proportion of factor i used in sector j, while $\theta_{ij}$ denotes the share of factor i in the output of sector j and $\sigma_j$ denotes the elasticity of substitution between labor and capital in sector j.

With these conventions in mind, one can obtain the following system of equations by total differentiation of equations (6.1)-(6.10):[81]

$$\lambda_{L1}\hat{Y}_1 + \lambda_{L2}\hat{Y}_2 = \hat{L} - \lambda_{L1}\hat{a}_{L1} - \lambda_{L2}\hat{a}_{L2} \tag{6.11}$$

$$\lambda_{K1}\hat{Y}_1 + \lambda_{K2}\hat{Y}_2 = \hat{K} - \lambda_{K1}\hat{a}_{K1} - \lambda_{K2}\hat{a}_{K2} \tag{6.12}$$

$$\theta_{L1}\hat{w} + \theta_{K1}\hat{r} = \hat{p}_1 \tag{6.13}$$

$$\theta_{L2}\hat{w} + \theta_{K2}\hat{r} = \hat{p}_2 \tag{6.14}$$

$$\hat{a}_{L1} = \theta_{K1}\sigma_1(\hat{r} - \hat{w}) \tag{6.15}$$

$$\hat{a}_{L2} = \theta_{K2}\sigma_2(\hat{r} - \hat{w}) \tag{6.16}$$

$$\hat{a}_{K1} = \theta_{L1}\sigma_1(\hat{w} - \hat{r}) \tag{6.17}$$

$$\hat{a}_{K2} = \theta_{L2}\sigma_2(\hat{w} - \hat{r}) \tag{6.18}$$

$$\hat{p}_1 = \hat{p}_{w1} + dt_1/(1+t_1) \tag{6.19}$$

$$\hat{p}_2 = \hat{p}_{w2} + ds_2/(1+s_2) \tag{6.20}$$

---

[81] Equations 6.13 and 6.14 require the application of the envelope theorem. See Jones (1965).

## 4.2 GAMS Implementation

The next step is to translate the system 6.11-6.20 into the GAMS programming language. Before doing so, some discussion of solution strategy, arithmetic operators, and relational operators is warrented. Since the above system is linear and square (number of endogenous variables equals number of equations), it can be solved by matrix inversion, which is how Johansen models generally have been solved.[82] The GAMS software, however, was designed to solve more general linear and nonlinear programming problems. We adapt it to exactly determined CGE models by simply specifying the model's equations as the system of constraints and including an arbitrary objective function. The latter is superfluous since a fully specified general equilibrium model should have a unique solution.[83]

Like most programming languages, GAMS has a variety of operators. These are divided into three principal groups, arithmetic, relational, and conditional. The arithmetic operators used in GAMS are of the following:

| | |
|---|---|
| ** | exponentiation |
| * / | multiplications and division |
| + - | addition and subtraction |

These are listed in order of the precedence which would be applied in the absence of parentheses. Exponentiation is performed first, and multiplication and division precede addition and subtraction. Finally, computation proceeds from right to left through an open (i.e. parentheses-free) expression.

Relational operators used in GAMS are as follows:

[82] See Dervis, de Melo, and Robinson (1982), Appendix B.3.

[83] The optimization features of GAMS have been used by a number of authors to study policy responses to changing eonomic conditions. See e.g. Lee and Roland-Holst (1993).

| | |
|---|---|
| lt, le, eq, ne, ge, gt | less than, less than or equal, not equal, etc. |
| not | not |
| and | and |
| or xor | or, either or |

These again are listed in order of open precedence. Liason between arithmetic and logical operations is provided by the usual zero-false, nonzero-true standard.

GAMS programs consist of a series of statements followed by semicolons:

```
Statement ;
      .
      .
      .
Statement ;
```

GAMS programs are commonly structured as follows:

```
Data:
        SAM
        Parameters and other data

Definitions:
        Sets
        Parameters
        Initial values
        Variables
        Equations

Model:
Solution:
Display:
```

We begin the example general equilibrium program with the data input. This data consists of two components, a social accounting matrix and supporting tables of structural parameters and other data. Generally, these components are loaded into the model from two separate files with the GAMS "include *filename* ;" statement. In the present, simpler Jones model, we omit these two files an proceed directly with definitions. The first type of definition is a set declaration, which generally take the form:

```
sets
        setname name1   text  /elements/
                        .
                        .
                        .
        setname namen text  /elments/
        ;
```

In the example model, indices are required for sectors and factors, which leads to the following sets definition:

```
sets
        i               industries  / 1*2 /
        f               factors / L,K /
;
```

Note that there are two ways to list set elements. They may be listed individually, separated by commas, or they may be listed as a range, indicated by an asterisk. These two options also can be used together. For example, a more complex set of elements might be / e1*e10, e12, e14 /.

There are essentially four ways of introducing data into a GAMS program:

1) A scalars statement;

2) A parameters statement with assigned values;

3) A parameters statement without assigned values, followed by a table statement;

4) A parameters statement without assigned values, followed by assignment statements.

The present CGE example will utilize all four means of entering data, beginning with a scalars statement.

A scalars statement can be used to declare and assign a value to a parameter with zero dimension (i.e. not indexed by a set) and takes the form:

```
scalars
        scalar        name1  text  /value/
                      .
                      .
                      .
        scalar  namen  text  /value/
;
```

As mentioned above, a dummy objective function is usually used to solve a square CGE model with the GAMS optimization software. It is often convenient to simply assign this function a constant scalar value as follows:

```
scalars
        dummy  named  / 1.0 /
;
```

Now consider the parameters statement, which declares and (optionally) assigns values to the parameters of the model. The parameters of the example model are $\lambda_{ij}$, $\theta_{ij}$, $\sigma_j$, $t_1$, $s_2$, $dt_1$, and $ds_2$. We assign values for $\sigma_j$ directly in the parameters statement. Values for $\lambda_{ij}$ and $\theta_{ij}$ will be assigned in table statements. Values for the remaining parameters will be given in assignment statements. In order to illustrate particular GAMS features, we also introduce three further parameters with the labels "tarhat," "subhat," and "cphat."

The parameters statement has the general form:

```
parameters
        parameter  name1  text  /values/
                .
                .
                .
        parameter namen  text  /values/
;
```

For the Johansen/Jones model, the statement takes the form:

```
parameters
        lambda(f,i)     factor allocation
        theta(f,i)      factor income share
        sigma(i)        elasticity of factor substitution
                        / 1  0.8
                          2  0.9 /
        t(i)                    initial tariff
        s(i)                    initial subsidy
        dt(i)                   change in tariff
        tarhat(i)       proportional change in tariff
        subhat(i)       proportional change in export subsidy
        cphat(i)                proportional change in price due to commercial policy
        ;
```

The assignment statements used to enter parameter values have been designed to feature the GAMS dollarsign control character, which can be used in two ways. A $ on the left-hand-side of an assignment statement is a conditional assignment: "[I]f the logical relationship is true, the assignment is made; if it is not, however, the existing value is retained, zero being used if no previous value has been given".[84] A $ on the right-hand-side of an assignment statement implies an if-then-else sequence and an assignment is always made.[85]

---

[84] Brooke, Kendrick, and Meeraus (1988), p.72.
[85] The reader might find it useful to think of the $ operator as a "such that" operator.

The assignment statements for the Johansen/Jones model are

```
t('1') = 0.20 ;
t('2') = 0.30 ;
dt('1') = 0.10 ;
dt('2') = 0.15 ;

tarhat(i) $ ( t(i)  gt  0 )  =  dt(i)/(1 + t(i)) ;
subhat(i) $ ( s(i) gt 0 )  =  ds(i)/(1 + s(i)) ;

cphat(i)  =  tarhat(i) $ t(i) + subhat(i) $ s(i) ;
```

The first four statements refer to specific elements of index i, and these elements must be put in single or double quotations. The fifth and sixth statements make assignments to tariff and subsidy proportional change variables, respectively, if the conditions following the dollar operators are true. If the conditions are not true, no assignment is made; the existing value is retained, zero being the default if no previous value was assigned. In the seventh statement, the dollar operators on the right-hand-side of the equation govern which of the two values, tarhat(i) or subhat(i) are assigned to cphat(i). The expressions $ t(i) and $ s(i) are the conditions that t(i) and s(i), respectively, be nonzero.

Next, we will demonstrate how values for $\lambda_{ij}$ and $\theta_{ij}$ can be entered with a table statement. Table statements can come in many different forms, of which only one example is provided here:

```
table  lambda(f,i)

                         1          2
           L           0.50       0.50
           K           0.25       0.75
     ;

table theta(f,i)
                         1          2
           L           0.60       0.40
           K           0.40       0.60
     ;
```

The first line of a table statement begins with the word 'table'. This is followed by the variable name, including set domains. Labels are used to generate a grid, and values are entered into this grid. Any blanks in the grid denote zeros. It is not necessary to list all elements of a set as row or column labels. Where an element is left out, the corresponding row or column will be a vector of zeros. Labels cannot be repeated, however. The table statement ends with a semicolon. In contrast to the scalars and parameters statements, only one parameter can by initialized in a table statement. Therefore, separate table statements are required for each parameter to be initialized.

Next, we will display the parameters using a GAMS display statement. The important thing to remember about a display statement is that, in listing the parameters to be displayed, set domains are not included. For the present example, the parameters are displayed using the following statement:

```
display lambda, theta, sigma, t, dt ;
```

This completes the data component of our GAMS general equilibrium model. This is generally followed by the model component, which begins with a variables declaration statement. The general form of the GAMS variables statement is as follows:

```
variables
        variable  name1  text
                    .
                    .
                    .
        variable  namen  text
        ;
```

In the case of our model, the variables to be declared are the endogenous variables, the exogenous variables, and a dummy variable. These are declared as follows:

```
variables
        yhat(i)        proportional change in production
        ahat(f,i)      proportional change in input
        what           proportional change in wage rate
        rhat           proportional change in capital rental rate
        phat(i)        proportional change in domestic price

        lhat           proportional change in labor endowment
        khat           proportional change in capital endowment
        psthat(i)      proportional change in world price

        omega          dummy variable for objective function
        ;
```

Equation identifiers are declared in a GAMS program using an equations statement. In general, the equations statement appears as:

equations

    equation *name1* text

                .

                .

                .

    equation *namen* text

    ;

For the present CGE model, the equations statement is as follows:

```
equations
        fxelab          fixed employment of labor
        fxecap          fixed employment of capital
        acp(i)          average cost pricing
        linp(i)         labor input
        kinp(i)         capital input
        domp(i)         domestic prices
        obj             objective
        ;
```

Next, equations must be defined. This is done in a series of statements. For equations which are equalities, the general form is as follows:

equation *name1*.. left-hand side =e= right-hand side ;

.

.

.

equation *namen*.. left-hand side =e= right-hand side ;

Two decimal or period points '..' are required between the equation name and the equation algebra. The '=e=' notation represents the equality sign for equation definitions. It is distinct from the more usual '=' symbol used in parameter assignments. Each equation definition is a GAMS statement and ends in a semicolon. Equation definitions may be indexed in those cases where the variable being determined is defined as a set.

For our model, the definitions are as follows:

```
fxelab..   sum(i, lambda('l',i)*yhat(i)) =e= lhat -  sum(i, lambda('l',i)*ahat('l',i));

fxecap..   sum(i, lambda('k',i)*yhat(i)) =e= khat - sum(i, lambda('k',i)*ahat('k',i));

acp(i)..   theta('l',i)*what + theta('k',i)*rhat =e= phat(i);

linp(i)..  ahat('l',i) =e= theta('k',i)*sigma(i)*(rhat-what);

kinp(i)..  ahat('k',i) =e= theta('l',i)*sigma(i)*(what-rhat);

domp(i)..  phat(i) =e= psthat(i) + cphat(i);

obj..      omega =e= dummy;
```

Note that, when referring to a particular element in an assignment statement or an equation definition statement, the element name is put in quotation marks. The 'sum' function is used to calculate sums over the domain of a set. Its general form is sum(set name, expression). It is used in the first two equation definitions to sum expressions over set i. It is also possible to include a dollar control operator after the set name in a sum function in order to restrict the elements of the set which are included in the summation.

The above set of equations determine the ten endogenous variables and the dummy variable. Still to be specified is the model closure.[86] The closure is given as follows:

```
lhat.fx = 0.00 ;
khat.fx = 0.00;
psthat.fx('1') = 0.00;
psthat.fx('2') = 0.00;
```

[86] "(P)rescribing closure boils down to stating which variables are endogenous or exogenous in an equation system" (Taylor, 1990, pp. 15-16).

While a GAMS parameter has a single value associated with it, a GAMS variable has four such values. They are

```
.lo    the lower bound
.up    the upper bound
.l     the activity level
.m     the marginal value
```

The lower and upper bounds are the minimum and maximum values, respectively, that a variable can take on during optimization. The activity level is the current value of a variable, and the marginal value is the effect of the variable value after optimization on the objective function. In cases where the lower and upper bound coincide, the variable is fixed, and the suffix 'fx' is used to assign the fixed value. This is what is done in the above model closure. The first two equations address factor market closure, fixing factor supplies, while the second two equations address external sector closure, fixing world prices. The user can introduce exogenous changes in any or all of these four variables.[87]

Finally, we need a model statement, a solve statement, and a final display statement for the activity levels of the variables after solution. These are as follows:

```
model simple /all/;

solve simple maximizing omega using nlp;

display yhat.l, ahat.l, what.l, rhat.l, phat.l, lhat.l,
        khat.l, psthat.l;
```

[87] Other types of closures are, of course, possible. For example, Tobey and Reinert (1991) use an export demand function to specify rest-of-the world behavior. This replaces the fixed world export price used here.

The model statement declares a model named 'simple' which consists of all the declared equations. The model is solved by maximizing omega. Since omega is set equal to the dummy parameter, the outcome of this maximization procedure is simply to solve the ten constraint equations of the maximization problem for the ten endogenous variables. The term 'nlp' refers to non-linear programing. The solve statement invokes a solver called MINOS. Since the system of equations in our model is linear, it solves very quickly.

### *4.3 Why GAMS?*

This module presented a linearized, Johansen-Jones approach to general equilibrium modeling. As we mentioned above, it is possible to solve this class of CGE models using matrix inversion. What, then, is the utility of GAMS? The linearization technique is a local approximation, useful for small changes in exogenous variables. A more general approach to CGE modeling is to specify functional forms, constructing a square but *nonlinear* system of equations. Such a system is not solvable by matrix inversion. For these problems, the GAMS package and the MINOS solver are quite useful.

## APPENDIX A: GAMS PROGRAM LISTING

```
$title   a simple general equilibrium model using gams
$offsymlist offsymxref

sets
   i     industries    /1 * 2/
   f     factors       /L, K/
   ;

scalars
   dummy         dummy parameter       /1.00/
   ;

parameters
   lambda(f,i)   factor allocation share
   theta(f,i)    factor income share
   sigma(i)      elasticity of substitution
      /1  0.8
       2  0.9/
   t(i)          initial tariff
   s(i)          initial subsidy
   dt(i)         change in tariff
   ds(i)         change in export subsidy
   tarhat(i)     proportional change in tariff
   subhat(i)     proportional change in export subsidy
   cphat(i)      proportional change in price due to commercial policy
   ;

     variables
   yhat(i)       proportional change in production
   ahat(f,i)     proportional change in input
   what          proportional change in wage rate
   rhat          proportional change in capital rental rate
   phat(i)       proportional change in domestic price

   lhat          proportional change in labor endowment
   khat          proportional change in capital endowment
   psthat(i)     proportional change in world price

   omega         dummy variable
   ;
```

```
equations
    fxelab       fixed employment of labor
    fxecap       fixed employment of capital
    acp(i)       average cost pricing
    linp(i)      labor input equations
    kinp(i)      capital input equations
    domp(i)      domestic prices
    obj          objective
    ;

* calibration
t('1')  = 0.20;
s('2')  = 0.30;
dt('1') = 0.10;
ds('2') = 0.15;

tarhat(i) $ (t(i) gt 0) = dt(i)/(1+t(i));

subhat(i) $ (s(i) gt 0) = ds(i)/(1+s(i));

cphat(i) = tarhat(i) $ t(i) + subhat(i) $ s(i);


table lambda(f,i)

          1              2
     L    0.50           0.50
     K    0.25           0.75
     ;


table theta(f,i)

          1              2
     L    0.60           0.40
     K    0.40           0.60
     ;

display lambda, theta, sigma, t, dt;
```

```
* equation definitions

fxelab..   sum(i, lambda('l',i)*yhat(i)) =e= lhat
                 - sum(i, lambda('l',i)*ahat('l',i));

fxecap..   sum(i, lambda('k',i)*yhat(i)) =e= khat
                 - sum(i, lambda('k',i)*ahat('k',i));

acp(i)..   theta('l',i)*what + theta('k',i)*rhat =e= phat(i);

linp(i)..  ahat('l',i) =e= theta('k',i)*sigma(i)*(rhat-what);

kinp(i)..  ahat('k',i) =e= theta('l',i)*sigma(i)*(what-rhat);

domp(i)..  phat(i) =e= psthat(i) + cphat(i);

obj..      omega =e= dummy;


* model closure (exogenous variables)

lhat.fx = 0.00;
khat.fx = 0.00;
psthat.fx('1') = 0.00;
psthat.fx('2') = 0.00;


* model declaration

options solprint=off;
options iterlim=100,limrow=0,limcol=0,domlim=0;

model simple /all/;


solve simple maximizing omega using nlp;


display yhat.l, ahat.l, what.l, rhat.l, phat.l, lhat.l,
        khat.l, psthat.l;
```

# 5. Bibliography

What follows is a survey bibliography consisting of most of the leading references to CGE literature in the last two decades. There are many more works listed here than have been cited in this report, and they are included to give interested researchers access to the larger literature on modeling methods and applications.

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# 6. APPENDIX

This appendix details the 4 digit International Standard Industrial Classification used in building the activity account in the 1991 SAM, the country grouping of the 6 regions composing the ROW account and the list of the traditional export goods.

**International Standard Industrial Classification**

The following is the complete list of the 4 digit sectors that is employed by the Central Statistical Bureau in its international trade statistics.

| | |
|---|---|
| 0000 | ACTIVIDADES NO BIEN ESPECIFICADAS |
| 1110 | PRODUCCION AGROPECUARIA |
| 1120 | SERVICIOS AGRICOLAS |
| 1130 | CAZA ORDINARIA Y MEDIANTE TRAMPAS Y REPOBLACION DE ANIMALES |
| 1210 | SILVICULTURA |
| 1220 | EXTRACCION DE MADERA |
| 1301 | PESCA DE ALTURA Y COSTERA |
| 1302 | PESCA, N.E.P. |
| 2100 | EXPLOTACION DE MINAS DE CARBON |
| 2200 | PRODUCCION DE PETROLEO CRUDO Y GAS NATURAL |
| 2301 | EXTRACCION DE MINERAL DE HIERRO |
| 2302 | EXTRACCION DE MINERALES NO FERROSOS |
| 2901 | EXTRACCION DE PIEDRA, ARCILLA Y ARENA |
| 2902 | EXTRACCION DE MINERALES PARA FABRICACION DE ABONOS Y ELABORACION DE PRODUCTOS QUIMICOS |
| 2903 | EXPLOTACION DE MINAS DE SAL |
| 2909 | EXTRACCION DE MINERALES, N.E.P. |
| 3111 | MATANZA DE GANADO Y PREPARACION Y CONSERVACION DE CARNE |
| 3112 | FABRICACION DE PRODUCTOS LACTEOS |
| 3113 | ENVASADO Y CONSERVACION DE FRUTAS Y LEGUMBRES |
| 3114 | ELABORACION DE PESCADO, CRUSTACEOS Y OTROS PRODUCTOS MARINOS |
| 3115 | FABRICACION DE ACEITES Y GRASAS VEGETALES Y ANIMALES |
| 3116 | PRODUCTOS DE MOLINERIA |
| 3117 | FABRICACION DE PRODUCTOS DE PANADERIA |
| 3118 | FABRICAS Y REFINERIAS DE AZUCAR |
| 3119 | FABRICACION DE CACAO, CHOCOLATE Y ARTICULOS DE CONFITERIA |
| 3121 | ELABORACION DE PRODUCTOS ALIMENTICIOS DIVERSOS |
| 3122 | ELABORACION DE ALIMENTOS PREPARADOS PARA ANIMALES |
| 3131 | DESTILACION, RECTIFICACION Y MEZCLA DE BEBIDAS ESPIRITUOSAS |
| 3132 | INDUSTRIAS VINICOLAS |
| 3133 | BEBIDAS MALTEADAS Y MALTA |
| 3134 | INDUSTRIAS DE BEBIDAS NO ALCOHOLICAS Y AGUAS GASEOSAS |
| 3140 | INDUSTRIA DEL TABACO |
| 3211 | HILADO, TEJIDO Y ACABADO DE TEXTILES |

3212 ARTICULOS CONFECCIONADOS CON MATERIALES TEXTILES, EXCEPTO PRENDAS DE VESTIR
3213 FABRICAS DE TEJIDOS DE PUNTO
3214 FABRICACION DE TAPICES Y ALFOMBRAS
3215 CORDELERIA
3219 FABRICACION DE TEXTILES, N.E.P.
3220 FABRICACION DE PRENDAS DE VESTIR, EXCEPTO CALZADO
3231 CURTIDURIAS Y TALLERES DE ACABADO
3232 INDUSTRIA DE LA PREPARACION Y TENIDO DE PIELES
3233 FABRICACION DE PRODUCTOS DE CUERO Y SUCEDANIOS DE CUERO, EXCEPTO EL CALZADO Y OTRAS PRENDAS DE VESTIR
3240 FABRICACION DE CALZADO, EXCEPTO EL DE CAUCHO VULCANIZADO O MOLDEADO O DE PLASTICO
3311 ASERRADEROS, TALLERES DE ACEPILLADURA Y OTROS TALLERES PARA TRABAJAR LA MADERA
3312 FABRICACION DE ENVASES DE MADERA Y DE CANA Y ARTICULOS MENUDOS DE CANA
3319 FABRICACION DE PRODUCTOS DE MADERA Y DE CORCHO, N.E.P.
3320 FABRICACION DE MUEBLES Y ACCESORIOS, EXCEPTO LOS QUE SON PRINCIPALMENTE METALICOS
3411 FABRICACION DE PULPA DE MADERA, PAPEL Y CARTON
3412 FABRICACION DE ENVASES Y CAJAS DE PAPEL Y DE CARTON
3419 FABRICACION DE ARTICULOS DE PULPA, PAPEL Y CARTON, N.E.P.
3420 IMPRENTAS, EDITORIALES E INDUSTRIAS CONEXAS
3511 FABRICACION DE SUSTANCIAS QUIMICAS INDUSTRIALES BASICAS, EXCEPTO ABONOS
3512 FABRICACION DE ABONOS Y PLAGUICIDAS
3513 FABRICACION DE RESINAS SINTETICAS, MATERIAS PLASTICAS Y FIBRAS ARTIFICIALES, EXCEPTO EL VIDRIO
3521 FABRICACION DE PINTURAS, BARNICES Y LACAS
3522 FABRICACION DE PRODUCTOS FARMACEUTICOS Y MEDICAMENTOS
3523 FABRICACION DE JABONES Y PREPARADOS DE LIMPIEZA, PERFUMES, COSMETICOS Y OTROS PRODUCTOS DE TOCADOR
3529 FABRICACION DE PRODUCTOS QUIMICOS, N.E.P.
3530 REFINERIAS DE PETROLEO
3540 FABRICACION DE PRODUCTOS DIVERSOS DERIVADOS DEL PETROLEO Y DEL CARBON
3551 INDUSTRIAS DE LLANTAS Y CAMARAS
3559 FABRICACION DE PRODUCTOS DE CAUCHO, N.E.P.
3560 FABRICACION DE PRODUCTOS PLASTICOS, N.E.P.
3610 FABRICACION DE OBJETOS DE BARRO, LOZA Y PORCELANA
3620 FABRICACION DE VIDRIO Y PRODUCTOS DE VIDRIO
3691 FABRICACION DE PRODUCTOS DE ARCILLA PARA CONSTRUCCION
3692 FABRICACION DE CEMENTO, CAL Y YESO
3699 FABRICACION DE PRODUCTOS MINERALES NO METALICOS, N.E.P.
3710 INDUSTRIAS BASICAS DE HIERRO Y ACERO
3720 INDUSTRIAS BASICAS DE METALES NO FERROSOS
3811 FABRICACION DE CUCHILLERIA, HERRAMIENTAS MANUALES Y ARTICULOS GENERALES DE FERRETERIA
3812 FABRICACION DE MUEBLES Y ACCESORIOS PRINCIPALMENTE METALICOS
3813 FABRICACION DE PRODUCTOS METALICOS ESTRUCTURALES
3819 FABRICACION DE PRODUCTOS METALICOS, N.E.P., EXCEPTUANDO MAQUINARIA Y EQUIPO
3821 CONSTRUCCION DE MOTORES Y TURBINAS
3822 CONSTRUCCION DE MAQUINARIA Y EQUIPO PARA LA AGRICULTURA
3823 CONSTRUCCION DE MAQUINARIA PARA TRABAJAR LOS METALES Y LA MADERA
3824 CONSTRUCCION DE MAQUINARIA Y EQUIPO ESPECIALES PARA LAS INDUSTRIAS, EXCEPTO LA MAQUINARIA PARA TRABAJAR LOS METALES Y LA MADERA
3825 CONSTRUCCION DE MAQUINAS DE OFICINA, CALCULO Y CONTABILIDAD

| | |
|---|---|
| 3829 | CONSTRUCCION DE MAQUINARIA Y EQUIPO, N.E.P., EXCEPTUANDO LA MAQUINARIA ELECTRICA |
| 3831 | CONSTRUCCION DE MAQUINAS Y APARATOS INDUSTRIALES ELECTRICOS |
| 3832 | CONSTRUCCION DE EQUIPO Y APARATOS DE RADIO, DE TELEVISION Y DE COMUNICACIONES |
| 3833 | CONSTRUCCION DE APARATOS Y ACCESORIOS ELECTRICOS DE USO DOMESTICOS |
| 3839 | CONSTRUCCION DE APARATOS Y SUMINISTROS ELECTRICOS, NE.E.P. |
| 3841 | CONSTRUCCIONES NAVALES Y REPARACION DE BARCOS |
| 3842 | CONSTRUCCION DE EQUIPO FERROVIARIO |
| 3843 | FABRICACION DE VEHICULOS AUTOMOVILES |
| 3844 | FABRICACION DE MOTOCICLETAS Y BICICLETAS |
| 3845 | FABRICACION DE AERONAVES |
| 3849 | CONSTRUCCION DE MATERIAL DE TRANSPORTE, N.E.P. |
| 3851 | FABRICACION DE EQUIPO PROFESIONAL Y CIENTIFICO E INSTRUMENTOS DE MEDIDA Y DE CONTROL, N.E.P. |
| 3852 | FABRICACION DE APARATOS FOTOGRAFICOS E INSTRUMENTOS DE OPTICA |
| 3853 | FABRICACION DE RELOJES |
| 3901 | FABRICACION DE JOYAS Y ARTICULOS CONEXOS |
| 3902 | FABRICACION DE INSTRUMENTOS DE MUSICA |
| 3903 | FABRICACION DE ARTICULOS DE DEPORTES Y ATLETISMO |
| 3909 | INDUSTRIAS MANUFACTUREREAS, N.E.P. |
| 4101 | LUZ Y FUERZA ELECTRICA |
| 4102 | PRODUCCION Y DISTRIBUCCION DE GAS |
| 4103 | SUMINISTROS DE VAPOR Y AGUA CALIENTE |
| 4200 | OBRAS HIDRAULICAS Y SUMINISTRO DE AGUA |
| 4312 | NO ESPECIFICADO POR FALTA DE MAESTRA |
| 5000 | CONSTRUCCION |
| 6100 | COMERCIO POR MAYOR |
| 6200 | COMERCIO POR MENOR |
| 6310 | RESTAURANTES, CAFES Y OTROS ESTABLECIMIENTOS QUE EXPENDEN COMIDAS Y BEBIDAS |
| 6320 | HOTELES, CASAS DE HUESPEDES, CAMPAMENTOS Y OTROS LUGARES DE ALOJAMIENTO |
| 7111 | TRANSPORTE FERROVIARIO |
| 7112 | TRANSPORTES URBANO, SUBURBANO E INTERURBANO DE PASAJEROS POR CARRETERA |
| 7113 | OTROS SERVICIOS TERRESTRES DE TRANSPORTE DE PASAJEROS |
| 7114 | TRANSPORTE DE CARGA POR CARRETERA |
| 7115 | TRANSPORTES POR OLEODUCTOS O GASODUCTOS |
| 7116 | SERVICIOS RELACIONADOS CON EL TRANSPORTE TERRESTRE |
| 7121 | TRANSPORTE OCEANICO O DE CABOTAJE |
| 7122 | TRANSPORTE POR VIAS DE NAVEGACION INTERIOR |
| 7123 | SERVICIOS RELACIONADOS CON EL TRANSPORTE POR AGUA |
| 7131 | EMPRESAS DE TRANSPORTE AEREO |
| 7132 | SERVICIOS RELACIONADOS CON EL TRANSPORTE AEREO |
| 7191 | SERVICIOS RELACIONADOS CON EL TRANSPORTE |
| 7192 | DEPOSITO Y ALMACENAMIENTO |
| 7200 | COMUNICACIONES |
| 8101 | INSTITUCIONES MONETARIAS |
| 8102 | OTROS ESTABLECIMIENTOS FINANCIEROS |
| 8103 | SERVICIOS FINANCIEROS |
| 8200 | SEGUROS |
| 8310 | BIENES INMUEBLES |
| 8321 | SERVICIOS JURIDICOS |
| 8322 | SERVICIOS DE CONTABILIDAD, AUDITORIA Y TENEDURIA DE LIBROS |
| 8323 | SERVICIOS DE ELABORACION DE DATOS Y DE TABULACION |
| 8324 | SERVICIOS TECNICOS Y ARQUITECTONICOS |
| 8325 | SERVICIOS DE PUBLICIDAD |

8329 SERVICIOS PRESTADOS A LAS EMPRESAS, N.E.P., EXCEPTUANDO EL ALQUILER Y ARRENDAMIENTO DE MAQUINARIA
8330 ALQUILER Y ARRENDAMIENTO DE MAQUINARIA Y EQUIPO
9100 ADMINISTRACION PUBLICA Y DEFENSA
9200 SERVICIOS DE SANEAMIENTO Y SIMILARES
9310 INSTRUCCION PUBLICA
9320 INSTITUTOS DE INVESTIGACIONES Y CIENTIFICOS
9331 SERVICIOS MEDICOS Y ODONTOLOGICOS Y OTROS SERVICIOS DE SANIDAD
9332 SERVICIOS DE VETERINARIA
9340 INSTITUCIONES DE ASISTENCIA SOCIAL
9350 ASOCIACIONES COMERCIALES, PROFESIONALES Y LABORALES
9391 ORGANIZACIONES RELIGIOSAS
9399 SERVICIOS SOCIALES Y SERVICIOS COMUNALES CONEXOS, N.E.P.
9411 PRODUCCION DE PELICULAS CINEMATOGRAFICAS
9412 DISTRIBUCION Y EXHIBICION DE PELICULAS CINEMATOGRAFICAS
9413 EMISIONES DE RADIO Y TELEVISION
9414 PRODUCTORES TEATRALES Y SERVICIOS DE ESPARCIMIENTO
9415 AUTORES, COMPOSITORES Y OTROS ARTISTAS INDEPENDIENTES, N.E.P.
9420 BIBLIOTECAS, MUSEOS, JARDINES BOTANICOS Y ZOOLOGICOS Y OTROS SERVICIOS CULTURALES, N.E.P.
9490 SERVICIOS DE DIVERSION Y ESPARCIMIENTO, N.E.P.
9511 REPARACION DE CALZADO Y OTROS ARTICULOS DE CUERO
9512 TALLERES DE REPARACIONES ELECTRICAS
9513 REPARACION DE AUTOMOVILES Y MOTOCICLETAS
9514 REPARACION DE RELOJES Y JOYAS
9519 OTROS SERVICIOS DE REPARACION, N.E.P.
9520 LAVANDERIAS Y SERVICIOS DE LAVANDERIA, ESTABLECIMIENTO DE LIMPIEZA Y TENIDO
9530 SERVICIOS DOMESTICOS
9591 PELUQUERIAS Y SALONES DE BELLEZA
9592 ESTUDIOS FOTOGRAFICOS, INCLUIDA LA FOTOGRAFIA COMERCIAL
9599 SERVICIOS PERSONALES, N.E.P.
9600 ORGANIZACIONES INTERNACIONALES Y OTROS ORGANISMOS EXTRATERRITORIALES

## Country Codes and Regional groups

The following section presents the complete listing of the Costa Rican trade partners grouped by macro region.

NAFTA

| | |
|---|---|
| 1003 | CANADA |
| 1005 | ESTADOS UNIDOS |
| 1007 | MEXICO |

CENTRO

| | |
|---|---|
| 2102 | EL SALVADOR |
| 2103 | GUATEMALA |
| 2104 | HONDURAS |
| 2106 | BELICE |
| 2107 | NICARAGUA |
| 2108 | PANAMA |
| 2109 | ZONA LIBRE PUERTO CORTES |
| 2201 | ZONA DEL CANAL DE PANAMA |
| 2202 | ZONA LIBRE DE COLON |

SOUTH AMERICA AND CARIBE

| | |
|---|---|
| 2303 | BARBADOS |
| 2311 | CUBA |
| 2331 | HAITI |
| 2341 | JAMAICA |
| 2354 | REPUBLICA DOMINICANA |
| 2367 | TRINIDAD Y TOBAGO |
| 2402 | ANTIGUA Y DEPENDENCIAS |
| 2406 | BAHAMAS, ISLAS |
| 2408 | BERMUDAS |
| 2411 | CAIMAN, ISLAS |
| 2413 | DOMINICA, ISLA |
| 2431 | GRANADA, ISLA |
| 2434 | MONTSERRAT, ISLA |
| 2436 | SAN CRISTOBAL, NIEVES, ANGUILLA, ISLAS, Y DEPENDENCIA |
| 2437 | SANTA LUCIA, ISLA |
| 2438 | SAN VICENTE, ISLA |
| 2451 | TURCAS Y CAICOS, ISLAS |
| 2461 | VIRGENES, ISLAS BRITANICAS |
| 2501 | GUADALUPE Y DEPENDENCIAS |
| 2502 | MARTINICA |
| 2503 | SAINT KITTS |
| 2601 | CURAZAO |
| 2602 | ARUBA |
| 2701 | VIRGENES, ISLAS NORTEAMERICANAS |
| 2706 | PUERTO RICO |
| 3101 | COLOMBIA |
| 3102 | ECUADOR |
| 3103 | GUYANA |
| 3104 | GUAYANA FRANCESA |

3106 SURINAM
3107 VENEZUELA
3201 BRASIL
3301 ARGENTINA
3304 MALVINAS, ISLAS Y DEPENDENCIAS
3307 TERRITORIO ANTARTICO BRITANICO
3308 URUGUAY
3401 BOLIVIA
3403 PARAGUAY
3503 CHILE
3507 PERU

EUROPE

4101 ALEMANIA OCCIDENTAL REPUBLICA FEDERAL DE ALEMANIA
4102 ALEMANIA ORIENTAL REPUBLICA DEMOCRATICA ALEMANA
4103 ANDORRA
4106 AUSTRIA
4107 BELGICA-LUXEMBURGO
4108 CIUDAD DEL VATICANO, ESTADO DE LA
4110 LIECHTESTEIN
4112 DINAMARCA
4113 ESPANA
4114 FEROE, ISLAS
4116 FRANCIA
4117 GIBRALTAR
4118 IRLANDA EIRE
4121 ISLANDIA
4122 ITALIA
4123 MALTA
4126 NORMANDAS ISLAS ISLAS DEL CANAL
4127 NORUEGA
4128 PAISES BAJOS HOLANDA
4131 PORTUGAL
4132 REINO UNIDO
4133 SUECIA
4134 SUIZA
4201 ALBANIA
4202 BULGARIA
4203 CHECOSLOVAQUIA
4204 FINLANDIA
4206 GRECIA
4207 HUNGRIA
4208 POLONIA
4211 RUMANIA
4213 YUGOSLAVIA

OTHER PACIFIC

5307 FILIPINAS
5312 INDONESIA
5314 LAOS
5316 LEBUAN, ISLA
5321 MALASIA
5323 NAVIDAD CHRISTMAS , ISLA
5331 SABAH
5332 SARAWAK

| | |
|---|---|
| 5333 | SINGAPUR |
| 5341 | TAILANDIA |
| 5344 | TIMOR PORTUGUEZ |
| 5351 | VIETNAM |
| 5401 | COREA DEL NORTE |
| 5402 | COREA DEL SUR |
| 5404 | CHINA CONTINENTAL |
| 5406 | CHINA- TAIWAN FORMOSA |
| 5408 | HONG KONG |
| 5411 | JAPON |
| 5413 | MACAO |
| 8001 | AUSTRALIA |
| 8002 | KIRIABATI |
| 8004 | MICRONESIA |
| 8006 | COCOS KEELING , ISLAS |
| 8007 | COOK, ISLAS |
| 8012 | GUAM |
| 8014 | HAWAII |
| 8018 | TUVALU |
| 8021 | NAURU, ATOLON |
| 8024 | NIUE, ISLA |
| 8026 | NORFOLK, ISLA |
| 8027 | NUEVA CALEDONIA |
| 8030 | VANUATU |
| 8032 | NUEVA GUINEA ADMINISTRACION AUSTRALIANA |
| 8034 | NUEVAS HEBRIDAS CONDOMINIO |
| 8038 | NUEVA ZELANDIA |
| 8041 | PACIFICO, ISLAS DEL ADMINISTRACION DE LOS E.E.U.U |
| 8042 | PACIFICO, ISLA DEL POSESIONES DE LOS E. E. U. U. |
| 8044 | PACIFICO, ISLAS DEL TERRITORIOS DE LOS E. E. U. U. |
| 8051 | PAPUA, TERRITORIO DE |
| 8054 | PITCAIRN, ISLA |
| 8057 | POLINESIA FRANCESA |
| 8064 | SAMOA OCCIDENTAL, ESTADO INDEPENDIENTE DE |
| 8071 | TERRITORIOS DE LA ALTA COMISION DEL PACIFICO OCC. |
| 8072 | TOKELAU UNION , ISLAS |
| 8074 | TONGA, ISLAS REINO DE TONGA |
| 8081 | VITI FIDJI , ISLAS |
| 8086 | WALLIS Y FUTUNA, ISLAS |

ROW (Rest Of the World)

| | |
|---|---|
| 1006 | GROENLANDIA |
| 1008 | SAN PEDRO Y MIQUELON |
| 5101 | ADEN Y EL PROTECTORADO DE ARABIA DEL SUR |
| 5102 | EMIRATOS ARABES |
| 5103 | ARABIA SAUDITA |
| 5106 | BAHREIN, ISLA |
| 5107 | CHIPRE |
| 5111 | IRAK |
| 5112 | IRAN |
| 5113 | ISRAEL |
| 5118 | JORDANIA |
| 5121 | KUWEIT |
| 5124 | LIBANO |
| 5131 | MASCATE Y OMAN |
| 5136 | OMAN BAJO TREGUA |

| | |
|---|---|
| 5141 | QATAR |
| 5158 | SIRIA |
| 5168 | TURQUIA |
| 5172 | YEMEN |
| 5201 | AFGANISTAN |
| 5204 | BUTAN |
| 5207 | CACHEMIRA |
| 5208 | CEILAN |
| 5211 | INDIA |
| 5213 | JAMMU |
| 5222 | MALDIVAS, ISLAS |
| 5223 | NEPAL |
| 5236 | PAKISTAN |
| 5238 | SIKKIM |
| 5239 | BANGLADESH |
| 5302 | BIRMANIA |
| 5303 | BRUNEI |
| 5306 | KAMPUCHEA |
| 5414 | MONGOLIA REPUBLICA POPULAR MONGOLA |
| 6001 | UNION DE REPUBLICAS SOCIALISTAS SOVIETICAS |
| 6002 | ESTONIA |
| 6004 | LETONIA |
| 6006 | LITUANIA |
| 7101 | ALBORAN Y PEREJIL, ISLAS |
| 7106 | ARGELIA |
| 7111 | CEUTA |
| 7121 | FEZZAN |
| 7131 | LIBIA |
| 7137 | MARRUECOS |
| 7141 | MELILLA Y DEPENDENCIAS |
| 7161 | REPUBLICA ARABE UNIDA EGIPTO |
| 7171 | SUDAN |
| 7181 | TUNEZ |
| 7206 | ALTO VOLTA |
| 7207 | ANGOLA |
| 7211 | BURUNDI |
| 7216 | CABO VERDE, ISLAS DE |
| 7217 | CAMERUN |
| 7221 | CONGO BRAZZAVILLE |
| 7222 | CONGO KINSHASA REPUBLICA DEMOCRATICA DE |
| 7224 | COSTA DE MARFIL |
| 7227 | CHAD |
| 7231 | DAHOMEY |
| 7232 | GABON |
| 7236 | GAMBIA |
| 7237 | GHANA |
| 7241 | GUINEA |
| 7242 | GUINEA ECUATORIAL ESPANOLA |
| 7243 | GUINEA PORTUGUESA |
| 7247 | LIBERIA |
| 7251 | MALI |
| 7253 | MAURITANIA |
| 7261 | NIGER |
| 7262 | NIGERIA |
| 7266 | REPUBLICA CENTROAFRICANA |
| 7268 | RWANDA |
| 7271 | SAHARA ESPANOL |

| | |
|---|---|
| 7272 | SANTA ELENA |
| 7273 | SANTO TOME Y PRINCIPE, ISLAS |
| 7276 | SENEGAL |
| 7277 | SIERRA LEONA |
| 7284 | TOGO |
| 7306 | COMORAS, ISLAS |
| 7314 | ETIOPIA |
| 7320 | DJIBOUTI |
| 7323 | KENIA |
| 7334 | MADAGASCAR |
| 7336 | MAURICIO Y DEPENDENCIAS |
| 7338 | MOZAMBIQUE |
| 7341 | REUNION, ISLA |
| 7351 | SEYCHELLES, ISLAS |
| 7352 | SOMALIA |
| 7353 | SOMALIA FRANCESA |
| 7361 | TANZANIA ZANZIBAR |
| 7372 | UGANDA |
| 7404 | BOTSWANA |
| 7414 | LESOTHO |
| 7421 | MALAWI |
| 7437 | RODESIA |
| 7441 | SUDAFRICA, REPUBLICA DE |
| 7442 | BOPHUTHASWANA |
| 7444 | CISKEY |
| 7446 | NAMIBIA |
| 7448 | SWAZILANDIA |
| 7450 | TRANSKEY |
| 7452 | VENDA |
| 7471 | ZAMBIA |
| 9001 | COMBUSTIBLES PARA NAVES |
| 9007 | ALTA MAR |

**Traditional exportable goods**

What follows is the list of Customs codes and product description of those exportables that are considered *traditional* by the Costa Rican law on export subsidies.

| | |
|---|---|
| 0102800000 | GANADO |
| 0103800000 | GANADO |
| 0101800000 | GANADO |
| 0201020000 | CARNE DA VACUNO |
| 0301800100 | ATUN, MACARELA SARDINA. |
| 0301800200 | OTRO ATUN |
| 0705010000 | FRIJOLES |
| 0801010000 | BANANOS |
| 0901010200 | CAFE EN PERGAMINO Y ORO |
| 1005010000 | MAIZ PARA LA SIEMBRA |
| 1006010000 | ARROZ PARA LA SIEMBRA |
| 1006800000 | ARROZ |
| 1007010000 | MIJO Y SORGO PARA SIEMBRA |
| 1007800000 | OTHER CEREALES |
| 1701000000 | AZUCARES DE REMOLACHA DE CANA |
| 1801000000 | CACAO EN GRANO |
| 2401000000 | TABACO EN RAMA O SIN ELABORAR |
| 2501020000 | SAL |
| 2501800000 | OTROS SALES |
| 2505000000 | ARENAS NATURAL CUALQUIER CLASE |
| 2507000000 | ARCILLAS CAOLIN BENTONITA ETC |
| 2508000000 | CRETA |
| 2512000000 | HARINAS SILICEAS FOSILES |
| 2513000000 | PIEDRA POMEZ; ESMERIL ETC |
| 2517000000 | CANTOS Y PIEDRAS TRITURADOS |
| 2519000000 | CARBONATO DE MAGNESIO NATURAL |
| 2520000000 | YESO NATURAL, ANHIDRITA |
| 2521000000 | CASTINAS PIEDRAS FABRI CEMENTO |
| 2526000000 | MICA Y DESPERDICIOS DE MICA |
| 2527000000 | ESTEATITA NATURAL, EN BRUTO |
| 2531000000 | FELDESPATO; LEUCITA ETC |
| 2532000000 | MATERIAS MINERALES NO EXPRESAD |
| 2601010000 | MINERAL METALURG DE ORO Y PLAT |
| 2601800000 | MINERALES DE HIERRO |
| 4101000000 | CUEROS Y PIELES EN BRUTO |
| 4109000000 | DESPERDICIOS DE CUERO NATURAL |
| 4403000000 | MADERA |
| 4405000000 | MADERA |
| 4404000000 | MADERA |
| 4413000000 | MADERA |
| 5501000000 | ALGODON |
| 5502000000 | ALGODON |
| 5503000000 | ALGODON |
| 5504000000 | ALGODON |
| 7107000000 | ORO Y SUS ALEACIONES |
| 7303000000 | CHATARRA DE HIERRO |
| 3803000000 | MIN NO FER Y SU CONCENTRADOS |
| 7204000000 | CHATARRA MET NO FER |
| 7401000000 | CHATARRA MET NO FER |
| 7501000000 | CHATARRA MET NO FER |
| 7601000000 | CHATARRA MET NO FER |

| | |
|---|---|
| 7701000000 | CHATARRA MET NO FER |
| 7801000000 | CHATARRA MET NO FER |
| 7901000000 | CHATARRA MET NO FER |
| 8001000000 | CHATARRA MET NO FER |
| 2601010000 | VALORES |
| 4907010000 | VALORES |
| 4907800000 | VALORES |
| 7108000000 | VALORES |
| 7111000000 | VALORES |
| 7201000000 | VALORES |