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Input-Output Model for a Small, Open Economy Applied to Mauritius

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ABSTRACT

This paper describes the economic module used in the IIASA/UNFPA Mauritius Project. The Project developed a population-development-environment (PDE) model which includes a demographic, an economic, a land use, and a water module. The economic is an input-output model, a choice which reflects the need to distinguish a larger number of economic sectors when looking at the interaction of the economy with the population and the environment. The model is set up to function for a small, open economy. It seeks a household consumption and income equilibrium, and an investment and savings-plus-loans equilibrium. It distinguishes three income groups by level of education with different consumption patterns depending on the level of income. It includes labor productivity changes resulting from a changing educational structure of the labor force.

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INPUT-OUTPUT MODEL FOR A SMALL, OPEN ECONOMY
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1. INTRODUCTION

The economic model presented in this paper was developed as part of the Population-Development-Environment (PDE) Study which was applied to the island of Mauritius. The basic objective of the study was to understand the interactions between the population, the environment, and development. Among other results of the study is an interactive model of the population, economy and environment with which scenarios can be calculated. This paper describes the economic module.

The module has an input-output model structure, which was chosen over the more commonly-used general equilibrium model because of our particular interest in the environmental and social effects of differential sectoral developments in the economy. In input-output models, the main concern is with material flows in the economy, although these flows are translated into prices. The concern with material flows allows input-output results to be directly transferred to models of the (material) environment. It matters to the environment whether the people are engaged in growing sugar, dyeing woolens or international banking. Sugar production requires large amounts of land and water, and dumps great quantities of organic waste into the rivers; dyeing woolens requires little land, a lot of water, and dumps chemical waste into the rivers; international banking by itself, on the other hand, requires almost no interaction with the environment (although the consequences of international banking action on a country's economy may very well affect the environment). Our concern with the different effects of various economic sectors led us to choose the input-output model structure.

The input-output model calculates the output of the economy by sectors. There can be, for example, 100 or 200 sectors. This model has 15 sectors, which makes it a relatively aggregated input-output model. The model calculates total production by sector based on the final demand by sector. Final demand is consumption by end-users of a product.

Each sector has population and environment coefficients. To produce a million Rupees worth of sugar requires different labor input than a million Rupees turnover at an international bank. For each sector, unit requirements of labor by education are provided. Similarly, for each sector the unit requirements for land, water, and the unit emissions of waste are provided. Depending on the structure of the economy by sector, the interaction with the population and the environment is completely different, and this is quickly reflected in the model.

The labor coefficients are affected by the education of the labor force. A better educated labor force is assumed to be more productive than a less educated labor force, all else being equal.

In the complete model, the interaction with the population and the environment prompts response from the environment, the population, or the government policy. For example, it is very well possible--and was often the case--that in scenario building the results show e.g. more land or more laborers with tertiary education demanded than available. The calibration of imbalances or impossibilities in the interface population-economy and environment-economy is a fascinating learning process described in Holm et al. (1993).

2. GENERAL MODEL STRUCTURE

The model is one in which exports and education are the main driving forces. The size of the population is also important. Population influences government expenditure and the composition of private consumption demand.

The structure of the model is such that it can be applied only to economies which are very open--where import and export value is a large portion of the GNP--and which have relatively small domestic markets, because of the way consumption and investment multipliers are specified.

The main model assumptions are:

1) Export demand is exogenous, provided by the scenario-maker. Government demand is a function of population and exogenously provided per capita expenditure. Private consumption and investment demand are endogenous. Gross output is calculated from export demand, government demand, private consumption and investment demand. GDP and imports are calculated from gross output.

2) The labor coefficients--number of people needed to produce one unit of output in each sector--are driven by the education of the labor force: the more educated people, the fewer are needed to produce one unit of output. They are further influenced by an exogenous variable, technological change.

3) The private consumption is a function of per capita income, spending on housing, food and other goods, and the exogenous consumption distribution within these three goods. The model distinguishes three main income classes: low, with primary education; medium, with secondary education; and high, with tertiary education.

4) The environmental coefficients--land and water necessary per unit of output, amount of pollution emissions per unit of output--are exogenous to the economic model and determined in the land and water models.

5) In each period, private consumption demand equals value added minus taxes minus savings.

6) Investment demand is devoted to increasing or maintaining the desired stock of capital. The desired capital stock depends on the level of (desired) gross output. A part of the desired capital stock exists in the form of vintage capital. Considerations such as interest and profit are not included. Investments equal savings plus net borrowing from abroad.

7) The savings rate is an endogenous variable which is adjusted to satisfy both 5) and 6) simultaneously. Maximum and minimum possible savings rates are provided by the scenario-maker. Investments which cannot be paid for when the maximum savings rate is reached are paid for by borrowing abroad. Interest is paid on loans, and loans are amortized as quickly as possible.

8) The model is a series of single period models with changes occurring between periods. The model calculates exactly what production is needed to fulfil final demand, and therefore, by definition, all goods produced are sold in the same year.

9) Prices are fixed.

3. THE MAURITIUS INPUT-OUTPUT TABLE

The aggregated 1987 input-output table was compiled by the Mauritian Central Bureau of Statistics, shown in Table 1. This empirical input-output matrix is the basis for the technical coefficients matrix used in the model.

With a given coefficients matrix and varied vectors of final demand, different output scenarios can be calculated. The reader will note that in these scenarios there is no technological change. This inflexibility has often been used as an argument against input-output models. However, technological change is elsewhere in the model.

Labor productivity changes through an explicit scenario variable, which is exogenous, and through endogenous change in labor productivity via education. This is discussed in Section 6 on labor productivity. The education profile of the labor force is a result of the population module (see Lutz and Prinz 1993; Prinz 1992).

Capital productivity is changed through an exogenous capital ratio variable. There is no endogenous connection between labor and capital productivity, as could be provided in a Cobb-Douglas type of output calculation. Section 7 on capital productivity discusses how labor and capital productivity changes should be combined.

Emission treatment, costs of treatment, and levels of emission are explicitly dealt with in the water module (see Toth 1992). Energy efficiency was studied by Beeharry (1992) using the Mauritius model. Changes in the land productivity are in the land-use module (see Holm 1993).

The technical coefficients matrix of the model can be changed, but because prices are fixed, this should be done with caution. In the scenarios, we have kept the technical coefficients constant. Technically, the effects of price changes could have been included in the model, as they have been in other input-output models (see e.g. Bulmer-Thomas 1982, Section 14.4). Earlier research with input-output tables showed that the coefficients matrices are rather constant and change little over geographic distance and only slowly over time. This is not unexpected because, as Wassily Leontief, founding father of input-output analysis says,

> Each of the industries in this combined table has its own peculiar input requirements, characteristic of that industry not only in the U.S. and Europe but also wherever it happens to be in operation. The recipes for satisfying the appetite of a blast furnace, a cement kiln, or a thermoelectric power station will be the same in India or Peru as, say in Italy or California. (Leontief 1966, p. 49)

The Mauritius coefficients matrices for 1981 and 1987 are similar to each other and to coefficients matrices of Taiwan 1986 and Austria 1970. As expected in a small, open and developing economy, the import coefficients for Mauritius are much higher than for the other two countries.

Table 1. Input-output table of Mauritius, 1987. Prepared for IIASA by the Central Bureau of Statistics, Port Louis, Mauritius.

MAURITIUS INPUT-OUTPUT TABLE 1987 INCLUDING EMPLOYEES AND WAGES

	INTERMEDIATE GOODS ROWS 1-15															INTERM.	FINAL DEMAND					TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	DEMAND	Cons.	Govt.	Inv.	Stock	Export	DEMAND
1 SUGAR CANE	15		2843													2858						2858
2 OTHER AGRICULTURE	26	8	11		87	183					70			4	4	393	577				49	1019
3 SUGAR MILLING	4	3	39		2	55	16	16			10					145	73			133	4409	4760
4 EPZ-TEXTILE				748	23											771	110			400	5544	6825
5 EPZ-OTHER						12										12					1123	1135
6 OTHER MANUFACTURING	167	196	18	32	6	253	3	2	459	86	90	122	29	40	60	1563	3050		60		270	4943
7 ELECTRICITY	7	7	7	48	7	59	12	12	3	55	31	17	10	15	23	313	147					460
8 WATER	6	6	6	48	6	58	12	12	3	54	31	17	10	14	22	305	147					452
9 CONSTRUCTION	11	6	9	6	3	102	8	7	62	5	8	1	100	1	6	335	856	195	1526	-92		2820
10 WHOLESALE AND RETAIL	49	19	40	26	9	465	34	33	187	35	65	278	53	75	25	1393	1561		340		106	3400
11 HOTELS & REST'S	4		5	4	1	3			1	3	1	6	1	4	6	39	150				1091	1280
12 TRANSPORT & COMM.	290	31	268	78	9	50	4	4	261	317	36	118	44	33	48	1591	875				1585	4051
13 FINANCE, ETC.	30	2	20	42	13	43	3	3	61	64	30	72	418	4	1	806	407				734	1947
14 GOV'T SERVICES																	14	2527				2541
15 OTHER SERVICES	2	7	8	9	5	20	5	5	6	30	15	51	5	10	5	183	1051				78	1312
LOCAL INT. CONS.	611	285	3274	1041	171	1303	97	94	1043	649	387	682	670	200	200	10707	9018	2722	1926	441	14989	39803
PETROLEUM IMPORTS	4	4	3	14		22	35	35	3	4	12	300	1	10	6	453	103					556
OTHER IMPORTS	98	71	151	3537	612	1264	57	57	528	297	191	651	307	261	66	8148	3598		1759	430	650	14585
IMPORT DUTIES	21	11	44			414	24	23	185	49	35	327	50	35	52	1270	1150		331			2751
TOTAL INT. CONS.	734	371	3472	4592	783	3003	211	211	1759	999	625	1960	1028	506	324	20578	14395	2722	4016	871	15639	58221
WAGES & OTHER	993	195	200	1124	151	610	97	96	652	735	225	935	437	2035	410	8895						
NET INDIRECT TAXES		-113	612			361			-9	-26	120	16	37		132	1130						
SURPLUS	1131	566	476	1109	201	969	149	148	418	1692	310	1140	445		446	9200						
VALUE ADDED	2124	648	1288	2233	352	1940	246	244	1061	2401	655	2091	919	2035	988	19225	TOTAL VALUE ADDED = GNP					
GROSS OUTPUT	2858	1019	4760	6825	1135	4943	457	455	2820	3400	1280	4051	1947	2541	1312	39803	TOTAL GROSS OUTPUT					
EMPLOYEES BY EDUCATION																						
PRIMARY	43000	28000	2000	51000	5000	15000	2000	0	20000	18000	5000	10000	0	27000	15000	241000						
SECONDARY	5000	3000	3000	26000	3000	8000	1000	2000	8000	21000	7000	18000	8000	23000	13000	149000						
TERTIARY	1000	1000	1000	1000	0	1000	1000	0	2000	1000	0	2000	9	5000	2000	18009						

4. CALCULATION OF GROSS OUTPUT, VALUE ADDED AND FINAL DEMAND

The gross output in millions of 1987 Rupees in each of the 15 sectors, vector G, can be written in terms of final demand and the Leontief matrix derived from the technical coefficients matrix:

$$G = L \cdot [E + C + I_f] \tag{1}$$

and

$$L = [I - A]^{-1} \tag{2}$$

where E, C, and I_f are the vectors for final exogenous export and government demand of domestic goods, domestic private consumption, and domestic investment, respectively. A is the technical coefficients matrix, and I the identity matrix. The technical coefficients matrix and the Leontief matrix are shown in Appendix Tables A.1 and A.2, respectively.

Through the introduction of a matrix multiplier derived below, gross output can be written wholly in terms of E only and the vintage capital stock vector, V. The vectors for C and I_f are then derived from gross output.

4.1. Exogenous Export and Government Demand

Export demand is an exogenous variable in the model. The scenario-makers specify what they believe will be, or might be, the export demand for Mauritius. This does not mean that Mauritius has no influence over the kind of goods it will export. As a matter of fact, the government policy of the past few decades undoubtedly helped the observed export expansion. The user can play with different export policies and the success or failure thereof. The exports are paid for in the same year as delivery. The exports provided by the scenario-maker are elements of the 15x1 vector E_x.

Government final demand is a function of the population size and scenarios specified for the per capita expenditure on school education, university education, public health, and general services. It is equal to general government consumption in national accounts tables. In Mauritius in 1987, this spending was about half of total government spending. School education expenditure applies only to the number of children in school; university education to the calculated number of enrolled people aged 20 and over; public health expenditure to the whole population but follows the age pattern observed in 1987 for hospital treatment; and general expenditure applies to the whole population equally. See Appendix C for data.

$$Gv = \sum_{i=1}^{15} P_i \cdot [H_i + Tr_i + Gl_i + Ps_i \cdot Sc_i] \tag{3}$$

where Gv is the total government consumption, an integer; P_i is the population in five-year age group i; H_i is the per capita spending on health by age group i. Spending increases by age with local maxima in the first 0-4 years and the last 85+ age group. Tr_i is the amount of per capita transfers, which are only pension transfers assumed to be equal for all persons over 65 years of age. Gl_i is per capita general government service expenditure, which is the same for all age groups. Ps_i is the proportion of the population in school in the five-year age group i. Sc_i is the per capita school expenditure at age i. Expenditure on schooling is lowest in the age groups 5-9 and 10-14, then increases to a maximum in the age group 25-29. Beyond age 29, there are no more persons in school.

One could argue that public consumption is budgeted the other way around: the government specifies how much it would like to spend, and then depending on the size of the population, per capita expenditure goes up and down. However, we feel that the public budget is very much pushed and pulled by the size of the population and by the bulges and dips in the age structure. Health expenditures soar as the population of elderly people increases because each elderly person has a "right" to a certain level of treatment and if there is not enough equipment or personnel, more is bought. Schools are opened and closed depending on the size of the classes and the number of pupils.

Gv is redistributed to a final demand vector E_g, exogenous final demand from government, via the diagonal redistribution matrix R_g, whose ith element shows the proportion of Gv that is demanded in sector i. The vector E_g is written:

$$E_g = R_g \cdot Gv \quad . \tag{4}$$

The total exogenous demand is:

$$E = E_x + E_g \quad . \tag{5}$$

The government tax income in the model is only that portion which is tabulated in the input-output table, namely taxes and import duties. It is not total government revenue, which includes revenue from other sources such as state enterprises. The model does not balance government consumption and government tax income automatically. We will return to this in the section on exogenous balances.

4.2. Gross Output with Endogenous Investments

The relationship between the vector of capital stock and the gross output is specified by using the diagonal capital/gross output matrix, KR:

$$K = KR \cdot G \quad . \tag{6}$$

Considerations such as interest rates and profit are not included. The KR matrix used is provided in Appendix Table A.3. The capital ratios are **not** the usual capital/output ratios, which relate to value added. The capital ratios relate to gross output and are therefore much smaller than the usual capital/output ratios. The elements of KR in the starting year are found using the value of vintage capital in millions of Rupees plus investments in the starting year divided by the gross output. The values for KR are a scenario variable and can be changed according to the user's preferences. The calculations for the starting year vintage capital are explained in Appendix C.

Investment in each sector is the difference between the vector of K in equation 6 above and the vintage capital available:

$$I_d = \max\,(0, K - V) \quad . \tag{7}$$

Capital put in place in this period becomes vintage capital in future periods. It is depreciated in constant annual steps of 1/20 of the original value.

These investments are not final demand as such, which would be necessary to calculate gross output. For example, say 100 million Rupees are invested in demanding sector *d*. This amount is spent on goods, say 40 million on buildings and 60 million on new machinery. To obtain the investment final demand vector for domestic goods, the I_d vector is redistributed by the R_i matrix. The *j*th column of the R_i matrix shows how each unit of investment in sector *j* is distributed over the *i* producing sectors. The sum of the *j*th column shows the proportion of investment going to domestic goods. In the Mauritius model, the columns are identical and the sum of the R_i matrix columns is .46. Most of the domestic investment is in the construction sector (see Appendix Table A.4). With this redistribution, the investment final demand vector is:

$$I_f = R_i \cdot I_d \ . \tag{8}$$

In what follows, we are going to assume that all elements of *K* are larger than the corresponding elements of *V*, and therefore that $I_d = K - V$. If some elements of *K* are smaller than the corresponding elements of *V*, the formulae have to be adjusted accordingly. Then we can write:

$$I_f = R_i \cdot K - R_i \cdot V \ . \tag{9}$$

Now, the expression for capital needed can be rewritten:

$$K = KR \cdot L \cdot [E + C + R_i \cdot K - R_i \cdot V] \ . \tag{10}$$

By separating out the expressions with *K*, and solving for *K*, we obtain:

$$K = [I - MI]^{-1} \cdot KR \cdot L \cdot [E + C - R_i \cdot V] \tag{11}$$

where $MI = KR \cdot L \cdot R_i$.

Capital is always positively related to any increase of *E* and *C*, and negatively to any increase of *V*. This means that each single element of *E*, *C* and -*V* has to be non-negatively related to every element of *K*. In other words, the inverse matrix $[\ I - MI\ ]^{-1}$ can have only non-negative elements. Such matrices are called non-negative matrices. A necessary and sufficient condition for a matrix to be non-negative is that the absolute value of the largest eigenvalue of *MI*, the Perron-Frobenius eigenvalue, is between zero and one. A sufficient condition for the Perron-Frobenius eigenvalue to be less than one is that all of the columns in the matrix sum to less than one. This condition is not necessary.

A rough and quick test that the largest eigenvalue of *MI* is between zero and one is to sum up all the elements of the *MI* matrix and divide by the number of sectors. If the result is between zero and one, in our experience, $[\ I - MI\ ]^{-1}$ is non-negative. If this condition is not met, the user needs to reconsider the scenario formulation. Appendix Table A.5 shows the *MI* matrix used for the model starting year. The inverse matrix is shown in Appendix Table A.6.

Substituting equation 10 into equation 9, we obtain the equation for investment final demand in terms of *E*, *C* and *V* only:

$$I_f = R_i\, [[I - MI]^{-1} \cdot KR \cdot L \cdot [E + C - R_i \cdot V]] - R_i \cdot V \ . \tag{12}$$

The right-hand side of the equation can be simplified by multiplying the right-most $R_i \cdot V$ expression with $[\ I - MI\ ]^{-1} \cdot [\ I - MI\ ]$,

$$I_f = R_i\,[I - MI]^{-1} \cdot KR \cdot L \cdot [E + C] \\ - R_i\,[I - MI]^{-1} \cdot KR \cdot L \cdot R_i \cdot V \\ - R_i\,[I - MI]^{-1} \cdot [I - MI] \cdot V \quad , \tag{13}$$

then separating out the last expression,

$$I_f = R_i\,[I - MI]^{-1} \cdot KR \cdot L \cdot [E + C] \\ - R_i\,[I - MI]^{-1} \cdot KR \cdot L \cdot R_i \cdot V \\ - R_i\,[I - MI]^{-1} \cdot V \\ + R_i\,[I - MI]^{-1} \cdot MI \cdot V \quad , \tag{14}$$

and, since $MI = KR \cdot L \cdot R_i$, canceling out the second and the fourth expressions, which leaves:

$$I_f = R_i\,[I - MI]^{-1} \cdot KR \cdot L \cdot [E + C] - R_i \cdot [I - MI]^{-1} \cdot V \ . \tag{15}$$

By writing the matrix $[\,I - MI\,]^{-1}$ more simply as KI:

$$I_f = R_i \cdot KI \cdot [KR \cdot L \cdot [E + C] - V] \ . \tag{16}$$

Equation 16 can be substituted into equation 1 for gross output, yielding:

$$G = L \cdot [E + C + R_i \cdot KI \cdot [KR \cdot L \cdot [E + C] - V]] \ . \tag{17}$$

4.3. Gross Output with Endogenous Private Consumption and Investments

Equation 17 expresses output in terms of the exogenous E and V and the endogenous C. It now remains to write C in terms of E. Let us assume that private consumption is equal to disposable income (income minus tax), minus savings, S. Income by sector, denoted by Y, is equal to the value added portion of gross output. We assume there is no external income from interest or transfers from abroad. The model desegregates consumption in two ways. One is consumption by sector in which income is earned, C_y. The other is consumption by sector in which income is spent, C.

The income vector Y can be written:

$$Y = VR \cdot G \tag{18}$$

where VR is the 15 x 15 diagonal matrix whose ith element is the ratio of value added in sector i to gross output in that sector. Note that income includes all wages and profits.

C_y is that part of Y that is not taxed and not saved, and can be written:

$$C_y = TS \cdot VR \cdot G \tag{19}$$

where TS is a diagonal matrix whose ith element is $(1\text{-}t_i\text{-}s)$ where t_i is the tax rate in sector i and s is the national savings rate. A $VR \cdot TS$ matrix with the actual value added and tax rates from the 1987 input-output table and an assumed national savings rate of .4 is shown in Appendix Table A.7.

Analogously to the I_s vector from the previous section, the C_y vector provides the source of income used for private consumption, but not the final demand vector. To obtain the final demand vector, C_y is pre-multiplied with the redistribution matrix R_c. The R_c matrix provides the consumption distribution. The *i,j*th element of each column shows the proportion of income earned in sector *j* consumed privately in sector *i*. The columns of the R_c matrix sum to less than unity because a portion of private consumption demand goes to imports. Presently, about one-third of private demand is for imported goods (see Table 1, and National Accounts publications from Mauritius). The R_c matrix in future scenario years depends on the income distribution, which will be discussed in the next section. Appendix Table A.8 shows an R_c matrix using 1987 data.

There are also transfers from the government to the consumers. These transfers depend on the number of persons above 65 years and the exogenously determined pension transfers. These transfers are redistributed to consumption by multiplication with a vector where each element *i* is an average of all the *j* elements *i* in the R_c matrix. The sectoral amounts consumed out of transfers by sector form the elements of the vector *Tr*.

Private consumption by sector in which income is spent is to be written as:

$$C = R_c \cdot TS \cdot VR \cdot G + Tr \quad . \tag{20}$$

The R_c, *TS*, and *VR* matrices are known and exogenous, and can be reduced to one known output-to-consumption matrix, *OTC*. Then:

$$C = OTC \cdot G + Tr \quad . \tag{21}$$

Inserting equation 21 into equation 17 gives a new gross output equation:

$$\begin{aligned} G = L \cdot [E + Tr + OTC \cdot G + R_i \cdot KI \cdot \\ [KR \cdot L \cdot [E + Tr + OTC \cdot G] - V]] \end{aligned} \tag{22}$$

or, written out:

$$\begin{aligned} G = & L \cdot [E + Tr] + L \cdot OTC \cdot G \\ & + L \cdot R_i \cdot KI \cdot KR \cdot L \cdot [E + Tr] \\ & + L \cdot R_i \cdot KI \cdot KR \cdot L \cdot OTC \cdot G \\ & - L \cdot R_i \cdot KI \cdot V \quad . \end{aligned} \tag{23}$$

Solving for G gives:

$$\begin{aligned} G = & [I - L \cdot OTC - L \cdot R_i \cdot KI \cdot KR \cdot L \cdot OTC]^{-1} \\ & \cdot L \, [E + Tr + R_i \cdot KI \cdot [KR \cdot L \cdot [E + Tr] - V]] \end{aligned} \tag{24}$$

and, writing $MC = L \cdot OTC - L \cdot R_i \cdot KI \cdot L \cdot OTC$ gives:

$$G = [I - MC]^{-1} \cdot L \cdot [E + Tr + R_i \cdot KI \; [KR \cdot L \cdot [E + Tr] - V]] \quad . \qquad (25)$$

This is gross output is written solely in terms of exogenous demand and known vectors and matrices.

As with $[I - MI]^{-1}$ it must be the case that $[I - MC]^{-1}$ is non-negative. The user can check whether this condition holds using the same rule of thumb as described in the discussion of *MI.*

Appendix Table A.9 shows the *MC* matrix, and Appendix Table A.10 shows the inverse matrix.

4.4. Balanced Savings and Investments

It is also a model assumption that the savings rate (s) is endogenous and such that it satisfies 5) and 6) of the model assumption. The model calculates Y and private consumption, C, investments, I_f and savings, S, and checks if saving is equal to investment. If not, then the savings rate is raised or lowered and the economy is recalculated, until equality or the maximum or minimum savings rate is reached. When the user-specified maximum is reached, there is borrowing from abroad. If there is a surplus of funds, these are lent to foreign borrowers. The credits and debits are carried over to the next period where they are added to or subtracted from savings or investments.

5. PRIVATE CONSUMPTION DEMAND, AND INCOME DISTRIBUTION BY EDUCATION--CALCULATION OF R_c

It is evident that it is important to know the R_c matrix, the redistribution matrix for private consumption, as an exogenous variable. At the same time, it is empirically known that the distribution of private consumption over a collection of goods is dependent on the level of income and the distribution of income, both endogenous. The distribution of private consumer demand is one of the points where the size and the education distribution of the population affects the total output of the economy.

Private consumer demand is, of course, mainly determined by the level of income. It is known that as people become more wealthy and more educated, they not only spend more income, but also spend it on different goods. Poor people spend a far greater portion of their income on basic items such as food; whereas the more wealthy spend large portions of their income on leisure goods. The distribution of income spending has a great effect on the environment. For example, as per capita income goes down, the relative consumption of food goes up and with it the demand for domestic agricultural produce, which needs water, fertilizers, and land.

To implement such changes in consumption patterns depending on wealth, we propose to distinguish between three types of consumption--food, housing and "other"--and three income classes--low, middle, high--given by the three education groups--primary, secondary and tertiary. It is observed that, in general, as per capita income increases, the proportion of income spent on food decreases, and the proportion spent on other things increases. By contrast, there is evidence that, at least on Mauritius, the proportion of income spent on housing is much less variable.

5.1. Income in Three Groups

The vector of consumption by income source C_y is distributed over the workers of the three education groups primary, secondary, and tertiary by the 3x15 distribution vector D, which gives the 3x1 vector:

$$DC = D \cdot C_y \quad . \tag{26}$$

The elements $d_{i,j}$ of the matrix D are the proportions of consumption by income generated in sector j going to workers with education i who are working in sector j. These elements are a composite of the unit labor demand coefficients, $l_{i,j}$ and the relative income coefficients, y_i.

The $l_{i,j}$ provide the number of workers of education i necessary to produce one unit of gross output in sector j. The $l_{i,j}$ used for the starting year of the Mauritius model are shown in Appendix Table A.11.

The y_i provides information about the relative income of each education group i. It is assumed that in all sectors workers with tertiary education earn four times as much as workers with primary education, and workers with secondary education twice as much, so, $y_1 = 1, y_2 = 2$, and $y_3 = 4$. This assumption was confirmed by Mauritian experts.

Each element of the D matrix is given by:

$$d_{i,j} = \frac{y_i l_{i,j}}{y_1 l_{1,j} + y_2 l_{2,j} + y_3 l_{3,j}} \quad . \tag{27}$$

In words, $d_{i,j}$ is the share of income generated in sector j going to workers with education i.

It is assumed that workers of education i provide for other household members who have the same education level i. Children, who have not finished school are distributed to the adult population according to the relative fertility and size of each education group. Income earned by workers of education i is distributed over the whole adult population of education i and their children. This provides consumed per capita income in each of the three groups, $YCAP_i$.

$$YCAP_i = DC_i \ / \ P_i \tag{28}$$

where DC_i is the income going to education group i and P_i is the total population in education group i.

5.2. Consumption in Three Broad Groups

We aggregated the data in the Mauritian Household Survey into three main consumption categories. The observed proportion of income spent on housing, h, in the household survey is only one-tenth when imputed rent is excluded. This may be low, but home ownership is very high on Mauritius--98% of households in the 1990 census--and expenditure includes almost only relatively simple construction costs and very little rent.

$$h = .1 \tag{29}$$

The observed monthly proportion of per capita income spent on food, f, in the household survey by per capita income is shown in Figure 1. A logarithmic regression through the observed points fits well the relationship between percentage of income spent on food and monthly per capita income. We assume that the maximum income spent on food is .9 and the minimum is .25 at high levels of income. The percentage of **annual** per capita income spent on food, $f(YCAP_i)$ is given by:

$$
\begin{aligned}
f(YCAP_i) &= .9 \,, & YCAP_i &< 72\ Rs/year \,, \\
f(YCAP_i) &= [-.1 \ln (YCAP_i/12) + 1.08] \,, & 72 < YCAP_i &< 48286\ Rs/year \,, \\
f(YCAP_i) &= .25 \,, & YCAP_i &> 48286\ Rs/year \,,
\end{aligned}
\qquad (30)
$$

for each of the three education groups i. The proportion of income spent on other is the residual:

$$oth = 1 - h - f(YCAP_i) \ . \qquad (31)$$

From this, a 3x3 matrix is made with the three broad consumption groups, h, f and o in the rows and the three education groups in the columns. The matrix X looks like:

$$X = \begin{bmatrix} .1 & .1 & .1 \\ f(YCAP_1) & f(YCAP_2) & f(YCAP_3) \\ 1-.1-f(YCAP_1) & 1-.1-f(YCAP_2) & 1-.1-f(YCAP_3) \end{bmatrix} \ . \qquad (32)$$

It shows the proportions of income in each of the three education groups that is spent on each of the three broad consumption groups. The columns of the matrix sum to 1.

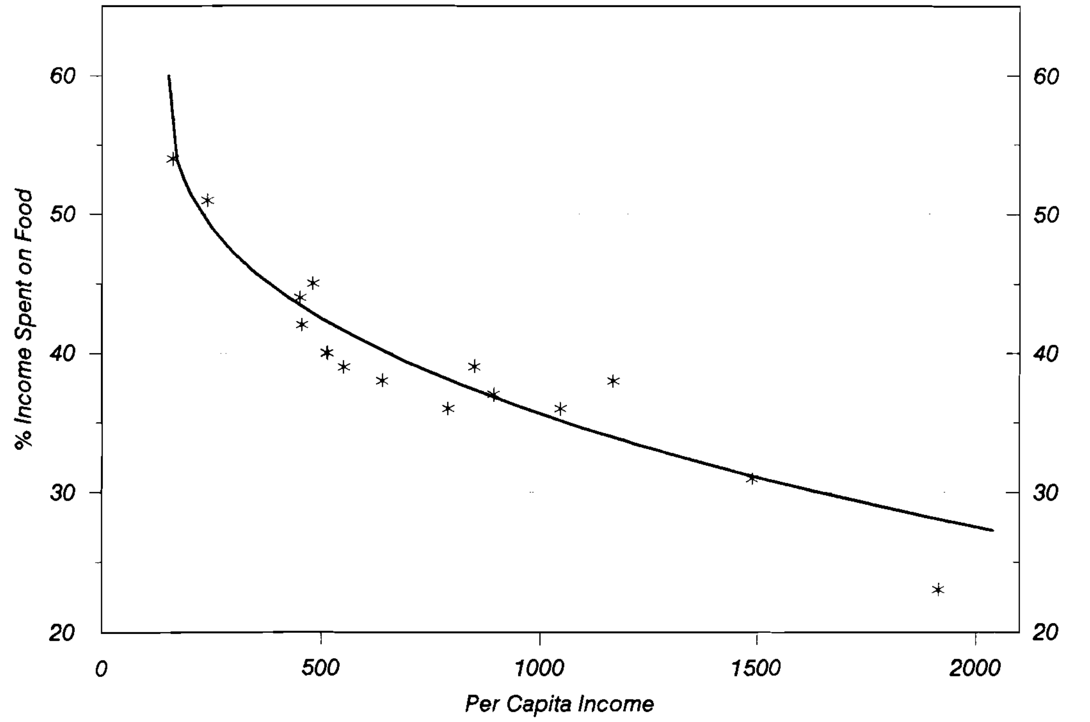

Figure 1. Observed expenditure on food in households of different monthly per capita income consumed, and a line fitted through the observation points. Source for points: Central Bureau of Statistics 1989.

5.3. A Short Digression: Preliminary Estimation of YCAP

The observant reader will have noted that $YCAP_i$ cannot be solved analytically without knowing C_y, and thus the matrix X cannot be found without knowing C_y. Knowing X, however, is crucial to finding the R_c matrix. $YCAP_i$ is estimated by making a preliminary estimation of the income distribution by taking a known part of C_y.

The preliminary estimation of C_y, C_y*, is the consumed income provided by exogenous demand from exports and government, E:

$$C_y* = TS \cdot VR \cdot L \cdot [E + R_i \cdot KI\ [KR \cdot L \cdot E - V]] \quad . \tag{33}$$

The preliminary income in each of the three education groups is:

$$DC* = D \cdot C_y* \quad . \tag{34}$$

Income from exogenous demand is empirically about half of the total income, and to obtain an estimate of the per capita income, half of the population in each group is taken. Then $YCAP$* is:

$$YCAP_i* = DC_i* \ / \ .5P_i \quad . \tag{35}$$

This $YCAP$* is used in the equations for proportions of income spent on food and on other. Thus, the X matrix is found using a preliminary estimation of C_y which depends on exogenous demand. This estimation can only be valid if the proportion of total income in an economy is heavily dependent on exports and government demand, as it is, for example, in the economy of Mauritius.

5.4. Finding the R_c Matrix

The 15x15 R_c matrix is found using D, the 3x15 income distribution matrix; X, the 3x3 three consumption good matrix; and RR_c, the 15x3 matrix which distributes the consumption in each of the three consumption groups.

Each element $rr_{i,j}$ of the RR_c matrix shows what the proportion of consumption in broad consumption good j is spent in sector i. This distribution is given exogenously. Appendix Table A.12 shows the distribution vectors of the three consumption groups used in the starting year of the model. In most of the scenarios, this distribution was assumed to stay the same. The RR_c matrix shows domestic consumption only, and so, all the columns sum to unity or less. The R_c matrix is given by:

$$R_c = RR_c \cdot X \cdot D \quad . \tag{36}$$

The multiplication of RR_c by the X matrix is a 15x3 matrix where each element shows the weighted proportion of the income spent in sector i given the broad consumption group expenditure in the three income groups j.

The multiplication of this matrix with the 3x15 D matrix shows the weighted proportion of income earned in sector j spent in each sector i, which is what we wanted.

The reader is reminded that the R_c matrix is an exogenous portion of the multiplier MC matrix, and that $[I - MC]^{-1}$ is a non-negative matrix. This puts restrictions on the R_c matrix. For example, all other things being equal, when the proportion of private consumption on imports is reduced from about 37% to 1%, the model no longer converges.

6. EDUCATION AND LABOR PRODUCTIVITY

Increasing labor productivity is one of the keys to a higher GDP, and one of the keys to increasing labor productivity is increasing the educational attainment of the labor force. This is reflected in the model via the unit labor demand coefficients. It is assumed that workers with higher education are more productive, even in the same sector. Further, it is assumed that changes in the educational distribution of the employed mirror the changes in the distribution of education in the whole labor force.

A more educated labor force means more educated employed, and more educated employed are more productive. When the labor force is more productive, the unit labor coefficients decrease (fewer people necessary to produce one unit of output).

The model assumes that workers in each sector are not identically productive. It divides the workers in each sector into three levels of productivity: the lowest are those with primary education, then the secondary, and the highest productivity is attained by workers with tertiary education. It assigns a relative productivity weight to each education group: 1 for workers with primary education; 2 for workers with secondary; and 4 for workers with tertiary education.

Following educational changes in the labor force, there are two changes in employment distribution. One is a redistribution of employment in each sector, which mirrors the educational distribution change of the labor force. The second is a productivity change, which is induced by the redistribution of employment. Putting the two together gives the new labor coefficients.

Let us follow these steps one at a time using a one sector numerical example, because each sector's labor coefficients are adjusted independently and in the same manner.

6.1. A Numerical Example

The labor productivity changes can be best illustrated by a numerical example. Table 2 shows the hypothetical situation in time 0. The labor unit coefficients for primary workers in sector j are 30; for secondary 15; for tertiary 5. The relative productivity weights are 1, 2, 4, respectively for each education group. This gives an absolute productivity weight of 30 x 1 = 30 to the workers with primary education; an absolute productivity weight of 15 x 2 = 30 to the workers with secondary education; and an absolute productivity weight 5 x 4 = 20 to the workers with tertiary education. Total absolute productivity is the sum of the absolute productivity weights in each group divided by the sum of the three labor coefficients units times 100: 100 x (30 + 30 + 20) ÷ (30 + 15 + 5) = 160. The education distribution of the labor force in time 0 is shown in the fifth column of the table. Sixty percent of the labor force in time t=0 has primary education only; 30% has secondary education; and 10% has tertiary education.

Between $t=0$ and $t=1$ the educational distribution of the labor force changes. In $t=1$, 50% of the labor force has primary education only; 45% has secondary; and 20% has tertiary.

Table 2. Numerical example of labor productivity and educational distribution of the labor force in sector *j* in time 0. See text for explanation.

Labor group	Labor Coefficients	Relative Productivity Weights	Absolute Productivity Weights	Labor Education Distribution
$l_{1,j,0}$	30	1	30	60
$l_{2,j,0}$	15	2	30	30
$l_{3,j,0}$	5	4	20	10
$All_{j,0}$	50		160	100

The first step of the change in labor coefficients is to mirror the educational changes. The interim labor coefficients for each educational group are multiplied by the changes in the weight of each educational group in the labor force:

$$\begin{aligned} l*_{1,j,t} &= 30\ x\ (.50 \div .60) = 25 \\ l*_{2,j,t} &= 15\ x\ (.40 \div .30) = 20 \\ l*_{3,j,t} &= 5\ x\ (.20 \div .10) = 10 \\ All_{j,t} &= 25 + 20 + 10 = 55 \quad . \end{aligned} \tag{37}$$

The new productivity weight is (25 x 1 + 20 x 2 + 10 x 4) ÷ (55 x 100) = 191. The productivity weight is higher in time *t* than in time 0 because of the higher proportion of better educated workers. There is an increase in productivity, which is the ratio between the new productivity weight and the old one:

$$\textit{Productivity increase } 0 \rightarrow t = 191 \div 160 = 1.19 \quad . \tag{38}$$

The interim labor coefficients *l** are reduced by the amount of productivity increase. This gives the new actual labor coefficients, which reflect both the new educational distribution and the productivity increase between time *t* and time 0.

$$\begin{aligned} l*_{1,j,t} &= 25 \div 1.19 = 21.0 \\ l*_{2,j,t} &= 20 \div 1.19 = 16.8 \\ l*_{3,j,t} &= 10 \div 1.19 = 8.4 \\ All_{j,t} &= 21 + 16.8 + 8.4 = 46.2 \quad . \end{aligned} \tag{39}$$

This distribution considers both the productivity increase, and the educational redistribution. Note, however, that the relative decrease in labor coefficients, from 50 to 46.2, = 1.08, is less than the productivity increase 1.19. The above method is an approximation that 1) could probably be improved by using exponential for changes, and 2) underestimates the decrease in labor coefficients.

6.2. A Second Numerical Example

This underestimation leads to paradoxical results when the educational changes are very extreme, as the following example shows. We begin with the same labor coefficients, but with a different educational distribution in the labor force in time 0 and time *t*. These are shown in Table 3.

Table 3. Second numerical example.

Labor Group	Labor Coefficients in time t	Labor Education Distribution in time 0	Labor Education Distribution in time t
$l_{1,j}$	30	70	10
$l_{2,j}$	15	29	45
$l_{3,j}$	5	1	45
All_j	50	100	100

Step one of the redistribution to the interim labor coefficients produces:

$$
\begin{aligned}
l*_{1,j,t} &= 30 \; x \; (.10 \div .70) = 4.29 \\
l*_{2,j,t} &= 15 \; x \; (.45 \div .29) = 23.28 \\
l*_{3,j,t} &= 5 \; x \; (.45 \div .01) = 225 \quad .
\end{aligned}
\tag{40}
$$

Step two to calculate productivity increase:

$$
\begin{aligned}
PW_0 &= 160 \\
PW_t &= (4.29 + 2 \; x \; 23.28 + 4 \; x \; 225) \div (4.29 + 23.28 + 225) \; x \; 100 = 376 \quad .
\end{aligned}
\tag{41}
$$

And the resulting labor coefficients for time t:

$$
\begin{aligned}
l_{1,j,t} &= 4.29 \div (376/160) = 1.83 \\
l_{2,j,t} &= 23.28 \div (376/160) = 9.93 \\
l_{3,j,t} &= 225 \div (376/160) = 96 \\
All_{j,t} &= 107.76 \quad .
\end{aligned}
\tag{42}
$$

There are more people needed for one unit of output with the more educated labor force than with the less educated labor force. Thus the user needs to check if the results are not paradoxical. We found that the changes in our scenarios led to reasonable results with this method.

6.3. Changed Labor Productivity from Technological Innovation

Labor productivity can also change exogenously from technological innovation. The scenario-maker gives a proposed increase in productivity which is supposed to come from some technical innovation. This is exogenous.

The labor coefficients which are found as above are multiplied with the inverse of the exogenous change in productivity, as above with the productivity weights.

Higher productivity would result in the paradox of increased unemployment **if the economy stagnates.** However, in cases of relatively full employment and a growing economy, increased productivity is the only way to increase per capita wealth.

7. CHANGES IN CAPITAL INTENSITY

The capital ratio vector *KR*, discussed in Section 4, is a measure of the amount of capital and the efficiency of the capital used for production. It indicates how much capital (in present money value) is needed per unit production of output in a given year. A change in the capital ratio is one of the indicators of technological change. Conceptually, technological change can be divided into two categories: increasing capital intensity and increasing capital efficiency.

More capital intensive production means that you use **more** capital to produce a given value of output. This development must always be accompanied by higher labor productivity, and lower labor costs, or a decrease in other costs, in order to be economically rational. An economy with a traditional, artisan type of production has a very low capital ratio--say needles and scissors for the output of dresses. But in these economies per capita output or labor productivity is also low. The introduction of new machines increases the capital ratio, and therewith capital costs, but it also increases labor productivity and this is one of the main sources of increased economic wealth. The decision to invest in a machine is only rational if one can save costs elsewhere in labor or in materials, so that ultimate profit increases. With a sewing machine, each worker can make five dresses a day compared to only one in the days of hand-sewing. A more advanced machine increases output even more.

In the model, the elements of the *KR* vector can be changed as desired. However, because of the condition that all elements of $(I\text{-}IM)^{-1}$ must be non-negative, there are limits to these changes. When the *kr* elements in all sectors are doubled, all else being equal from the starting year, the model no longer converges. The *kr* elements in selected sectors can be increased more, if others are less than doubled.

8. EXOGENOUS BALANCES

Throughout the economic module, there are pairs of variables that must have similar values or where only one of the pair can be larger than the other, such as labor supply and demand. Some of these pairs are automatically adjusted in the model--for example, consumer demand and disposable consumer income and, to a large extent investment spending and investment funds. Other pairs are not hard-wired together, and so the user must check them while making scenarios. These are:

- General government consumption and tax and import duty revenue. These are the two summary variables for the government budget which are calculated by the model and presented in the scenario results. These are the two values which appear in the input-output table, and that is why these values are used. They are not equal to total government spending or receipts. In 1987 they were both equal to half of total government spending and receipts (see Appendix Table A.13). In the calculation of GDP, the government spending is added to final demand gratuitously, (see equation 25 where government consumption is part of exogenous demand *E*) and taxes are removed from the calculation of GDP: consumer spending is equal to GDP minus savings minus taxes. The savings re-enter the economy as investments, but the taxes do re-enter the economy. So, government consumption is "free" in the model, and tax revenues are "lost". However, we assume that taxes are used to pay for government consumption, and that the two are equal. A scenario-maker can assume that there is a constant deficit between government consumption and taxes (a proxy for a real government deficit between spending and receipts). The model will account for the higher GDP which comes from over-spending, but does not account for the accumulated government debt. Although such an attribute was planned and designed and is simple to include in the model without changing the rest, due to time constraints, it was not included.

As it is, in the scenarios calculated in this project, the government consumption and tax revenue were balanced by the scenario-makers. This can be done by changing tax rates or per capita government expenditure.

- Labor demand cannot exceed labor supply, although the converse is allowed and just means unemployment. In case there is a shortage of labor, the model does not intervene, but results show there is an impossible situation. The user has to increase labor productivity, increase migration, or decrease demand to solve this problem. It is possible that shortages in skilled labor of a certain type--presently there is a shortage of technicians--constrain the economy, but this is beyond the immediate scope of the model. However, the model can be used to make estimations of the types of labor that will be needed. The model produces scenario estimates of the demand for labor in each sector. If the user has an idea of the types of skills needed in that sector, then he can use the model to estimate the requirements for specific labor skills. For example, if the model calculates a need for 2000 workers with tertiary education in the water sector, the user can say: Most of these will be engineers, and not persons with degrees in financial economics.

- Investment and saving. The model allows fluctuations in the proportion of GDP invested and saved depending on the calculated need for new capital, and largely equalizes this pair. When there is too much investment money available on the island, it is lent abroad, and when there is too little investment money, it is borrowed from abroad. The model keeps track of the debits and credits, and carries them over from period to period. The model calculates as if there is always enough lending capacity in the exogenous world to repay old debts. The user needs to check if the total accumulated debt or credit is remaining within reasonable bounds.

- The external trade balance should be roughly zero.

When the user makes a scenario, it usually takes a few steps of calibration before the first two pairs above fit, and a few more steps before the environment variables also fit. It is only when all pairs fit, that there is a realistic or possible scenario. In the course of this effort, the user will acquire a feeling for the interactions in the system. This is probably as important as the results of the final scenarios themselves. The use of the economic module in interaction with the population and the two environmental modules is described in Holm et al. (1993).

9. CONCLUSIONS

This model was developed for a specific purpose: to fit into a specific over-all conceptual model of the interactions between population, development, and the environment. It was also developed for a specific country: Mauritius. It was developed simultaneously with the development of modules for land, water and population, and to answer questions that came up in the course of the study.

An application of this model to a different setting would require looking at the specifications to see that the necessary conditions of the model hold as they do for Mauritius.

REFERENCES

Beeharry, Revin P. 1992. Decarbonization of Energy Supply in Small Developing Countries: A Study of Long Term Policy Options for Mauritius. Draft Manuscript. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Bulmer-Thomas, Victor. 1982. *Input-Output Analysis in Developing Countries.* London: John Wiley & Sons.

Central Bureau of Statistics (CBS). 1989. *Mauritian Household Survey, 1989.* Port Louis, Mauritius.

Central Statistical Office, Mauritius. 1990. *National Accounts of Mauritius, 1990.* Port Louis.

Dayal, Ram. 1981. *An Integrated System of World Models, Volume 2.* Amsterdam: North Holland Publishing Company.

Holm, Einar. 1993. Land use and regional distribution. Chapter in Wolfgang Lutz, ed. *Understanding Population-Development-Environment Interactions: A Case Study on Mauritius.* Berlin: Springer Verlag. Forthcoming.

Holm, Einar, Christopher Prinz, and Anne Babette Wils. 1993. Scenarios for Mauritius, 1990-2050. Chapter in Wolfgang Lutz, ed. *Understanding Population-Development-Environment Interactions: A Case Study on Mauritius.* Berlin: Springer Verlag. Forthcoming.

Leontief, Wassily. 1966. *Input-Output Economics.* Oxford: Oxford University Press.

Lutz, Wolfgang and Christopher Prinz. 1993. The population module. Chapter in Wolfgang Lutz, ed. *Understanding Population-Development-Environment Interactions: A Case Study on Mauritius.* Berlin: Springer Verlag. Forthcoming.

Prinz, Christopher. 1992. *Modeling the Population of Mauritius.* WP-92-43. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Toth, Ferenc. 1992. *Models of the Water Systems in Mauritius.* WP-92-71. Laxenburg, Austria: International Institute for Applied Systems Analysis.

United Nations. Various years. *National Accounts: Main Aggregates and Detailed Tables.* New York.

APPENDIX A. TABLES OF MODEL VALUES

Table A.1. Technical coefficients matrix.

Technical matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0.0052	0	0.5972	0	0	0	0	0	0	0	0	0	0	0	0
2	0.0090	0.0078	0.0023	0	0.0766	0.0370	0	0	0	0	0.0546	0	0	0.0015	0.0030
3	0.0013	0.0029	0.0081	0	0.0017	0.0111	0.0348	0.0353	0	0	0.0078	0	0	0	0
4	0	0	0	0.1095	0.0202	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0.0024	0	0	0	0	0	0	0	0	0
6	0.0584	0.1923	0.0037	0.0046	0.0052	0.0511	0.0065	0.0044	0.1627	0.0252	0.0703	0.0301	0.0148	0.0157	0.0457
7	0.0024	0.0068	0.0014	0.0070	0.0061	0.0119	0.0261	0.0264	0.0010	0.0161	0.0242	0.0041	0.0051	0.0059	0.0175
8	0.0020	0.0058	0.0012	0.0070	0.0052	0.0117	0.0261	0.0264	0.0010	0.0158	0.0242	0.0041	0.0051	0.0055	0.0167
9	0.0038	0.0058	0.0018	0.0008	0.0026	0.0206	0.0174	0.0154	0.0219	0.0014	0.0062	0.0002	0.0513	0.0003	0.0045
10	0.0171	0.0186	0.0084	0.0038	0.0079	0.0940	0.0740	0.0728	0.0663	0.0102	0.0507	0.0686	0.0272	0.0295	0.0190
11	0.0013	0	0.0010	0.0005	0.0008	0.0006	0	0	0.0003	0.0008	0.0007	0.0014	0.0005	0.0015	0.0045
12	0.1014	0.0304	0.0563	0.0114	0.0079	0.0101	0.0087	0.0088	0.0925	0.0932	0.0281	0.0291	0.0225	0.0129	0.0365
13	0.0104	0.0019	0.0042	0.0061	0.0114	0.0086	0.0065	0.0066	0.0216	0.0188	0.0234	0.0177	0.2146	0.0015	0.0007
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0.0006	0.0068	0.0016	0.0013	0.0044	0.0040	0.0108	0.0110	0.0021	0.0088	0.0117	0.0125	0.0025	0.0039	0.0038
imports	0.0430	0.0843	0.0415	0.5202	0.5392	0.3439	0.2527	0.2538	0.2539	0.1029	0.1859	0.3154	0.1838	0.1204	0.0945
VA	0.7431	0.6359	0.2705	0.3271	0.3101	0.3924	0.5359	0.5386	0.3762	0.7061	0.5117	0.5161	0.4720	0.8008	0.7530
Gross	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table A.2. Leontief matrix, L.

Leontief matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.0068	0.0036	0.6064	0.0004	0.0016	0.0079	0.0225	0.0227	0.0015	0.0010	0.0067	0.0005	0.0006	0.0004	0.0012
2	0.0119	1.0159	0.0099	0.0003	0.0782	0.0403	0.0009	0.0008	0.0070	0.0013	0.0588	0.0015	0.0013	0.0024	0.0053
3	0.0025	0.0061	1.0100	0.0007	0.0028	0.0132	0.0374	0.0379	0.0025	0.0016	0.0111	0.0009	0.0010	0.0007	0.0020
4	0.0000	0.0000	0.0000	1.1230	0.0227	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0001	0.0005	0.0001	0.0000	1.0000	0.0026	0.0000	0.0000	0.0004	0.0000	0.0002	0.0000	0.0000	0.0000	0.0001
6	0.0706	0.2113	0.0502	0.0070	0.0240	1.0715	0.0163	0.0137	0.1850	0.0328	0.0934	0.0372	0.0350	0.0193	0.0536
7	0.0048	0.0111	0.0052	0.0087	0.0080	0.0160	1.0298	0.0301	0.0059	0.0187	0.0290	0.0068	0.0085	0.0073	0.0201
8	0.0044	0.0101	0.0047	0.0087	0.0070	0.0157	0.0297	1.0300	0.0059	0.0184	0.0289	0.0068	0.0085	0.0068	0.0193
9	0.0067	0.0114	0.0067	0.0019	0.0048	0.0245	0.0201	0.0181	1.0287	0.0044	0.0117	0.0028	0.0682	0.0013	0.0068
10	0.0338	0.0449	0.0347	0.0078	0.0149	0.1094	0.0852	0.0836	0.0963	1.0246	0.0708	0.0779	0.0473	0.0343	0.0313
11	0.0016	0.0002	0.0021	0.0007	0.0009	0.0008	0.0002	0.0002	0.0007	0.0011	1.0010	0.0017	0.0008	0.0016	0.0047
12	0.1110	0.0409	0.1275	0.0148	0.0141	0.0278	0.0251	0.0249	0.1109	0.1008	0.0429	1.0396	0.0416	0.0176	0.0431
13	0.0179	0.0074	0.0181	0.0096	0.0162	0.0164	0.0126	0.0126	0.0353	0.0277	0.0347	0.0260	1.2779	0.0036	0.0040
14	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
15	0.0029	0.0090	0.0045	0.0020	0.0056	0.0064	0.0128	0.0130	0.0054	0.0110	0.0145	0.0142	0.0047	0.0047	1.0054

Table A.3. Capital ratio matrix, *KR*.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0.58	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0.62	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0.45	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0.39	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0.36	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0.45	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	3.43	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	3.43	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0.32	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0.47	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0.46	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	1.33	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0.76	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.97

Table A.4. Investment redistribution matrix, R_i.

Investment Redistribution Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
10	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A.5. Investment multiplier matrix, *MI*.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
2	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
3	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0333	0.0333	0.0333	0.0333	0.0333	0.0333	0.0333	0.0333	0.0333	0.0333	0.0333	0.0333	0.0333	0.0333	0.0333
7	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015
8	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015
9	0.1254	0.1254	0.1254	0.1254	0.1254	0.1254	0.1254	0.1254	0.1254	0.1254	0.1254	0.1254	0.1254	0.1254	0.1254
10	0.0512	0.0512	0.0512	0.0512	0.0512	0.0512	0.0512	0.0512	0.0512	0.0512	0.0512	0.0512	0.0512	0.0512	0.0512
11	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
12	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175
13	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
SUM	0.2396	0.2396	0.2396	0.2396	0.2396	0.2396	0.2396	0.2396	0.2396	0.2396	0.2396	0.2396	0.2396	0.2396	0.2396

Table A.6. $[I - MI]^{-1}$ matrix.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.0091	0.0061	0.6098	0.0025	0.0038	0.0104	0.0248	0.0250	0.0041	0.0032	0.0092	0.0027	0.0032	0.0024	0.0033
2	0.0189	1.0234	0.0202	0.0068	0.0848	0.0477	0.0080	0.0079	0.0151	0.0081	0.0665	0.0082	0.0095	0.0084	0.0119
3	0.0054	0.0092	1.0143	0.0033	0.0055	0.0163	0.0403	0.0408	0.0058	0.0044	0.0143	0.0036	0.0043	0.0032	0.0047
4	0.0000	0.0000	0.0000	1.1231	0.0227	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0006	0.0009	0.0007	0.0004	1.0004	0.0030	0.0004	0.0004	0.0009	0.0005	0.0007	0.0005	0.0006	0.0004	0.0005
6	0.1892	0.3390	0.2251	0.1173	0.1357	1.1973	0.1365	0.1334	0.3232	0.1485	0.2239	0.1503	0.1741	0.1216	0.1649
7	0.0127	0.0197	0.0169	0.0161	0.0155	0.0244	1.0378	0.0381	0.0152	0.0264	0.0378	0.0144	0.0178	0.0141	0.0276
8	0.0122	0.0185	0.0162	0.0159	0.0144	0.0240	0.0376	1.0379	0.0150	0.0260	0.0375	0.0142	0.0176	0.0136	0.0267
9	0.2568	0.2807	0.3754	0.2345	0.2404	0.2898	0.2737	0.2707	1.3200	0.2483	0.2870	0.2413	0.3615	0.2171	0.2416
10	0.1684	0.1897	0.2331	0.1328	0.1416	0.2521	0.2216	0.2195	0.2531	1.1558	0.2189	0.2062	0.2051	0.1504	0.1576
11	0.0023	0.0010	0.0032	0.0013	0.0016	0.0016	0.0009	0.0009	0.0016	0.0018	1.0018	0.0023	0.0016	0.0022	0.0054
12	0.1852	0.1207	0.2369	0.0837	0.0840	0.1065	0.1003	0.0998	0.1973	0.1731	0.1246	1.1103	0.1287	0.0816	0.1127
13	0.0446	0.0362	0.0575	0.0344	0.0414	0.0447	0.0397	0.0396	0.0665	0.0537	0.0641	0.0515	1.3092	0.0267	0.0290
14	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
15	0.0086	0.0151	0.0128	0.0072	0.0109	0.0124	0.0186	0.0187	0.0120	0.0165	0.0207	0.0196	0.0113	0.0096	1.0107

Table A.7. Value added minus indirect tax minus savings matrix, *VR* • *TS*.

Value Added Minus Tax and Savings

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0.4459	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0.4924	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0.0337	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0.1963	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0.1860	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0.1624	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0.3215	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0.3231	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0.2289	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0.4313	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0.2132	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0.3057	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0.2642	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4805	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3512
VA	0.7431	0.6359	0.2705	0.3271	0.3101	0.3924	0.5359	0.5386	0.3762	0.7061	0.5117	0.5161	0.4720	0.8008	0.7530
tax	0	-0.174	0.4751			0.1860			-0.008	-0.010	0.1832	0.0076	0.0402		0.1336
savings	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table A.8. Consumption redistribution matrix, R_c.

Consumption Redistribution Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0.0637	0.0626	0.0451	0.0577	0.0578	0.0552	0.0442	0.0471	0.0546	0.0526	0.0533	0.0489	0.0471	0.0502	0.0514
3	0.0080	0.0079	0.0057	0.0072	0.0073	0.0069	0.0055	0.0059	0.0069	0.0066	0.0067	0.0061	0.0059	0.0063	0.0065
4	0.0050	0.0051	0.0071	0.0057	0.0057	0.0060	0.0072	0.0070	0.0061	0.0063	0.0063	0.0067	0.0070	0.0066	0.0064
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0.2510	0.2493	0.2215	0.2419	0.2423	0.2378	0.2194	0.2257	0.2367	0.2340	0.2353	0.2279	0.2256	0.2297	0.2318
7	0.0067	0.0068	0.0095	0.0076	0.0076	0.0080	0.0096	0.0094	0.0081	0.0084	0.0084	0.0090	0.0094	0.0088	0.0086
8	0.0067	0.0068	0.0095	0.0076	0.0076	0.0080	0.0096	0.0094	0.0081	0.0084	0.0084	0.0090	0.0094	0.0088	0.0086
9	0.0677	0.0677	0.0677	0.0677	0.0677	0.0677	0.0677	0.0677	0.0677	0.0677	0.0677	0.0677	0.0677	0.0677	0.0677
10	0.1141	0.1138	0.1104	0.1132	0.1133	0.1126	0.1099	0.1115	0.1123	0.1123	0.1125	0.1115	0.1115	0.1115	0.1119
11	0.0068	0.0070	0.0097	0.0078	0.0078	0.0082	0.0098	0.0096	0.0083	0.0086	0.0085	0.0092	0.0096	0.0090	0.0088
12	0.0400	0.0409	0.0570	0.0458	0.0457	0.0480	0.0576	0.0559	0.0484	0.0505	0.0500	0.0539	0.0559	0.0525	0.0514
13	0.0322	0.0322	0.0322	0.0322	0.0322	0.0322	0.0322	0.0322	0.0322	0.0322	0.0322	0.0322	0.0322	0.0322	0.0322
14	0.0006	0.0006	0.0009	0.0007	0.0007	0.0007	0.0009	0.0009	0.0007	0.0008	0.0008	0.0008	0.0009	0.0008	0.0008
15	0.0482	0.0493	0.0686	0.0551	0.0551	0.0578	0.0693	0.0673	0.0582	0.0608	0.0602	0.0649	0.0673	0.0632	0.0619
SUM	0.6513	0.6508	0.6458	0.6509	0.6514	0.6497	0.6436	0.6500	0.6488	0.6500	0.6508	0.6485	0.6500	0.6478	0.6486

Table A.9. Consumption multiplier matrix, *MC*.

L.OTC + L.K1.KR.L.OTC

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0.0690	0.0800	0.0697	0.0280	0.0303	0.0388	0.1995	0.2027	0.0392	0.0519	0.0451	0.0797	0.0669	0.0607	0.0663
3	0.0087	0.0101	0.0088	0.0035	0.0038	0.0049	0.0252	0.0256	0.0049	0.0065	0.0057	0.0100	0.0084	0.0076	0.0083
4	0.0065	0.0076	0.0069	0.0030	0.0031	0.0044	0.0268	0.0264	0.0046	0.0064	0.0053	0.0104	0.0091	0.0078	0.0082
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0.2849	0.3315	0.2916	0.1200	0.1290	0.1696	0.9194	0.9241	0.1729	0.2325	0.1992	0.3634	0.3101	0.2760	0.2978
7	0.0087	0.0102	0.0092	0.0040	0.0042	0.0059	0.0358	0.0352	0.0061	0.0085	0.0071	0.0138	0.0122	0.0104	0.0110
8	0.0087	0.0102	0.0092	0.0040	0.0042	0.0059	0.0358	0.0352	0.0061	0.0085	0.0071	0.0138	0.0122	0.0104	0.0110
9	0.0791	0.0923	0.0817	0.0341	0.0364	0.0487	0.2724	0.2712	0.0499	0.0676	0.0574	0.1068	0.0917	0.0810	0.0868
10	0.1323	0.1543	0.1363	0.0567	0.0607	0.0808	0.4478	0.4481	0.0827	0.1119	0.0953	0.1762	0.1514	0.1336	0.1435
11	0.0088	0.0104	0.0094	0.0041	0.0043	0.0060	0.0365	0.0360	0.0063	0.0087	0.0072	0.0141	0.0124	0.0106	0.0112
12	0.0517	0.0609	0.0549	0.0240	0.0252	0.0353	0.2131	0.2099	0.0367	0.0509	0.0423	0.0826	0.0726	0.0623	0.0657
13	0.0376	0.0439	0.0388	0.0162	0.0173	0.0231	0.1295	0.1289	0.0237	0.0321	0.0273	0.0507	0.0436	0.0385	0.0413
14	0.0008	0.0009	0.0008	0.0003	0.0004	0.0005	0.0034	0.0033	0.0005	0.0008	0.0006	0.0013	0.0011	0.0010	0.0010
15	0.0623	0.0734	0.0660	0.0289	0.0304	0.0426	0.2565	0.2526	0.0442	0.0613	0.0510	0.0994	0.0874	0.0750	0.0791
SUM	0.7596	0.8863	0.7838	0.3273	0.3498	0.4672	2.6022	2.5998	0.4783	0.6480	0.5511	1.0229	0.8797	0.7755	0.8319

Table A.10. $(I - MC)^{-1}$ matrix.

(EYE - L.OTC - L.K1.KR.L.OTC)-1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0.2046	1.2383	0.2100	0.0869	0.0932	0.1232	0.6748	0.6766	0.1258	0.1696	0.1449	0.2661	0.2278	0.2020	0.2175
3	0.0258	0.0301	1.0265	0.0109	0.0117	0.0155	0.0852	0.0855	0.0159	0.0214	0.0183	0.0336	0.0287	0.0255	0.0274
4	0.0227	0.0266	0.0237	1.0100	0.0107	0.0145	0.0838	0.0833	0.0150	0.0205	0.0173	0.0327	0.0284	0.0248	0.0264
5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
6	0.8850	1.0325	0.9130	0.3810	0.4074	1.5437	3.0256	3.0240	0.5566	0.7540	0.6414	1.1897	1.0230	0.9020	0.9677
7	0.0303	0.0355	0.0316	0.0134	0.0142	0.0194	1.1118	0.1110	0.0200	0.0273	0.0230	0.0437	0.0379	0.0330	0.0352
8	0.0303	0.0355	0.0316	0.0134	0.0142	0.0194	0.1118	1.1110	0.0200	0.0273	0.0230	0.0437	0.0379	0.0330	0.0352
9	0.2527	0.2952	0.2615	0.1096	0.1170	0.1570	0.8822	0.8792	1.1610	0.2185	0.1854	0.3460	0.2981	0.2623	0.2808
10	0.4199	0.4902	0.4341	0.1818	0.1942	0.2601	1.4576	1.4548	0.2666	1.3619	0.3073	0.5724	0.4931	0.4338	0.4647
11	0.0309	0.0362	0.0322	0.0137	0.0145	0.0198	0.1142	0.1134	0.0204	0.0279	1.0235	0.0446	0.0387	0.0337	0.0359
12	0.1804	0.2113	0.1881	0.0800	0.0850	0.1157	0.6657	0.6611	0.1191	0.1629	0.1373	1.2601	0.2258	0.1968	0.2096
13	0.1201	0.1403	0.1243	0.0521	0.0556	0.0746	0.4193	0.4179	0.0765	0.1039	0.0881	0.1645	1.1417	0.1246	0.1335
14	0.0029	0.0033	0.0030	0.0012	0.0013	0.0018	0.0107	0.0106	0.0019	0.0026	0.0022	0.0041	0.0036	1.0031	0.0033
15	0.2172	0.2544	0.2265	0.0963	0.1023	0.1392	0.8014	0.7958	0.1434	0.1961	0.1653	0.3132	0.2718	0.2369	1.2523

Table A.11. Technical coefficients for labor by education, 1987.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
prim	15.05	27.48	0.42	7.47	4.41	3.03	4.38	0.00	7.09	5.29	3.91	2.47	0.00	10.63	11.43	6.05
sec	1.75	2.94	0.63	3.81	2.64	1.62	2.19	4.40	2.84	6.18	5.47	4.44	4.11	9.05	9.91	3.74
tert	0.35	0.98	0.21	0.15	0.00	0.20	2.19	0.00	0.71	0.29	0.00	0.49	0.00	1.97	1.52	0.45

Table A.12. Coefficients of consumption in three main consumption groups.

	house	food	other
1	0	0	0
2	0	11.79	0
3	0	1.49	0
4	0	0	1.41
5	0	0	0
6	0	35.21	16.98
7	0	0	1.88
8	0	0	1.88
9	67.78	0	0
10	0	13.47	11.54
11	0	0	1.92
12	0	0	11.19
13	32.22	0	0
14	0	0	0.18
15	0	0	13.47

Table A.13. Government expenditures and income in 1987 and 1988. Source: Central Statistical Office, Mauritius, 1990.

EXPENDITURE	1987	1988	INCOME	1987	1988
Final consumption	2722	3509	Operating surplus	103	79
Interest paid	917	897	Interests	403	423
Subsidies to producers	190	267	**Indirect taxes**	4071	4889
Transfers to households	903	1085	Direct taxes	918	1223
Savings	1298	1531	Fees, fines, penalties	66	71
Other	52	76	Social Security contributions	268	331
			Unfunded employee welfare contributions	223	275
TOTAL	6082	7365		6082	7365

APPENDIX B. CALCULATION OF STARTING YEAR VINTAGE CAPITAL STOCK

Data are available for direct investments in long-term capital for Mauritius from 1960-1990 in the *National Accounts: Main Aggregates and Detailed Tables* published annually by the United Nations. To estimate the present value of capital stock, assumptions are made about the depreciation rate.

Dayal (1981), who designed a world model focused on capital accumulation as a driving force for economic growth, suggests two main ways of calculating depreciation: 1) The perpetual inventory method assumes that "depreciation in a year is calculated as a fixed proportion of the capital stock existing at the beginning of that year" (Dayal 1981, p. 18); and 2) The straight-line method of depreciation assumes that "depreciation each year is a fixed proportion of the original value (not the remaining value) of each asset. At the end of the final year of the average lifetime, the asset is written off" (Dayal 1981, p. 23).

The straight-line method, which is used in this model, results in lower capital accumulation than the perpetual inventory method. When the average lifetime of a unit of capital is assumed to be 25 years, the ratio of capital stock estimated under the straight-line method to the perpetual inventory method is .8185 after 25 or more years (Dayal 1981, p. 25).

Using the straight-line method, the value of capital in any year is given by:

$$V = (1-N/N)I_{t-N} + (1-(1-N)/N)I_{t-N+1} + \dots + (1-1/N)I_{t-1} + I_t$$

where N is the average lifetime of capital, I_i is the investment in year i, and t is the present year.

Because the model runs in five-year steps, capital is aggregated into five-year blocks. The adjusted straight-line method calculation for vintage capital in any year is:

$$V = [(4N+0+1+2+3+4)/5N]I_{t-N} + [(4N+5+6+7+8+9)/5N]I_{t-N+5} + \\ + \dots + [(5N-5-4-3-2-1)/5N)I_{t-5} + I_t \quad .$$

The average lifetime of capital on Mauritius is assumed to be 20 years, which is short. Dayal assumes an average lifetime of 30 years for capital in developing countries. If investment is the same for a period of 30 years, the ratio of the value of accumulated capital with a 20-year lifetime to that of capital with 30 years is .7.

Both the straight-line method and the short average lifetime result in lower estimations for accumulated capital than some readers might expect.

The *National Accounts* provide data by seven sectors: agriculture, manufacturing, electricity and water, construction, sales and hotels, transport, finance and dwellings, social services, and government services. The investments in agriculture are divided over the sugar, other agriculture and sugar milling sectors according to the relative output in each sector. The investments in manufacturing are divided over the EPZ-textile, EPZ-other, and other manufacturing sectors. Electricity and water investments are divided equally over the two sectors. The investments for sales and hotels are divided over the two sectors relative to output.

The investments in 1972, 1977, and 1982 are shown in the first three columns of Table B.1. The estimated value of vintage capital at the end of 1987 (which excludes investments in 1987) is shown in the fourth column. The 1987 investments are shown in the last column.

Table B.1. Past investments by sector in Mauritius, total estimated value of vintage capital in 1987, total output by sector in 1987, and capital/output ratio. Source for investment data: *National Accounts Statistics: Main Aggregates and Detailed Tables,* United Nations, various years.

Sector	1972	1977	1982	Vintage capital	1987
Sugar Cane	217	183	100	1462	203
Other Agriculture	80	68	37	541	87
Sugar Milling	220	159	171	1754	394
EPZ-Textile	220	223	241	2078	557
Other EPZ	0	41	44	312	98
Other Manufacturing	220	164	177	1797	411
Electricity	88	142	185	1408	155
Water	88	142	185	1408	155
Construction	80	105	69	791	115
Wholesale & Retail	77	131	161	1251	354
Hotels & Restaurants	28	48	60	463	131
Transport	321	604	445	4423	945
Finance	67	213	130	1343	121
Govt Services	122	308	124	1723	200
Other Services	246	76	96	1188	90

APPENDIX C. PER CAPITA GOVERNMENT EXPENDITURE IN 1987 IN HEALTH AND EDUCATION BY AGE

Table C.1. Health expenditure, Mauritius, 1987. Source: Central Statistical Office, Mauritius, 1990.

	Per Capita (Rupees)		Total Expenditure (1000 Rupees)	
Age	Female	Male	Female	Male
0-4	372	372	16,722	17,663
5-9	280	280	15,768	16,176
10-14	280	280	13,274	14,185
15-19	363	372	17,182	18,530
20-24	464	372	25,386	20,537
25-29	464	372	22,974	18,444
30-34	464	372	20,133	15,508
35-39	464	372	16,533	13,691
40-44	559	559	14,480	13,027
45-49	559	559	10,992	10,523
50-54	651	651	12,434	12,579
55-59	651	651	10,083	10,018
60-64	744	744	11,381	11,351
65-69	1023	1023	10,929	8,880
70-74	1490	1398	11,957	8,933
75-79	2329	2049	10,556	5,875
80-84	3260	2795	9,055	3,970
85+	4937	3634	8,630	1,643
Total			258,468	221,532
Both sexes				480,000

Table C.2. Education expenditure by level of education. Approximations for expenditure by age were made using the age distribution in primary, secondary, and tertiary education. Source: Central Statistical Office, Mauritius, 1990.

Education Level	Expenditure in Millions of Rupees	Number of Students	Expenditure per Student in Rupees
Primary	349.6	137,935	2,535
Secondary	261.6	69,825	3,747
Tertiary	82.4	1,265	65,138

APPENDIX D. FIFTEEN ECONOMIC SECTORS OF THE MODEL

Table D.1. Economic sectors of the model by number.

1	Sugar Cane
2	Other Agriculture
3	Sugar Milling
4	EPZ-Textile
5	EPZ-Other
6	Other Manufacturing
7	Electricity
8	Water
9	Construction
10	Wholesale and Retail
11	Hotels and Restaurants
12	Transport and Communications
13	Finance
14	Government Services
15	Other Services