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Exporting Economic Models: CoPS' Experience in South Africa and Asia

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The Centre of Policy Studies (COPS) is a research centre at Monash University devoted to economy-wide modelling of economic policy issues.

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EXPORTING ECONOMIC MODELS: COPS' EXPERIENCE IN SOUTH AFRICA AND ASIA

by

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1. INTRODUCTION

The research program of the Centre of Policy Studies (CoPS) at Monash University is oriented to the development and application of computable general equilibrium (CGE) models which are useful to economic decision makers. Locally the main focus is on the MONASH model of the Australian economy (Adams, Dixon, McDonald, Meagher and Parmenter, 1994). We are using MONASH, a dynamic version of ORANI (Dixon, Parmenter, Sutton and Vincent, 1982), for forecasting and policy analysis. The development of MONASH is supported by funds from the University, from government sponsors (principally the Industry Commission) and from subscribers to a briefing service run by CoPS in conjunction with Syntec Economic Services.

Recently we have been extending our modelling activities to other countries. In conjunction with the Industrial Development Corporation of South Africa, we have developed IDC-GEM, a model of the South African economy. IDC-GEM has already been used to project the effects on the South African economy of a number of policy proposals. With the assistance of CoPS, a team from Chulankongkorn University in Bangkok has developed the CAMGEM model of the Thai economy and has used it for forecasting. We are also developing a prototype model of Vietnam with a view to interesting the Vietnamese government and the international aid agencies in a larger modelling program to assess economic development policies.

Our ability to export our modelling techniques to other environments was greatly enhanced by our construction of a generic ORANI-style model which can easily be implemented on personal computers *via* GEMPACK, a flexible system for handling CGE models (Codsi and Pearson, 1988; Harrison and Pearson, 1993). The generic model is documented by Horridge, Parmenter and Pearson (1993) in a style designed to take the reader through all the steps required for implementation of such a model, including its computer representation.

In this paper, we report our experiences with these new ventures. In section 2, we review Horridge, Parmenter and Pearson (1993), highlighting the features which facilitate its role as a template for the foreign models. Then, in section 3, we describe the first version of IDC-GEM including results from an illustrative application. These results were the basis for public presentations given in Johannesburg and Cape Town in October 1993. Preliminary work for Thailand and Vietnam is outlined in section 4. Section 5 contains concluding remarks.

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2. ORANI-F AND GEMPACK

2.1. The model

Horridge, Parmenter and Pearson (1993) describe ORANI-F, a model consisting of a static CGE core and several accumulation relationships which link the values of stocks (capital by industry and net foreign debt) over time, relating them to initial conditions and to the values of the relevant accumulating flows (investment and depreciation by industry, and foreign borrowing). By suitable choices of closure, the model can be used for comparative statics or for projecting the growth rates of variables over time.

The static core of ORANI-F has a theoretical structure which is typical of CGE models. It consists of equations describing, for some time period:

- producers' demands for produced inputs and primary factors;
- demands for inputs to capital formation;
- household demands;
- export demands;
- government demands;
- the relationship of basic values to production costs and to purchasers' prices;
- market-clearing conditions for commodities and primary factors; and
- numerous macroeconomic variables and price indices.

Demand and supply equations for private-sector agents are derived from the solutions to the optimisation problems (cost minimisation, utility maximisation, etc.) which are assumed to underlie the behaviour of the agents in conventional neoclassical microeconomics. The agents are assumed to be price takers, with producers operating in competitive markets which prevent the earning of pure profits.

2.2. The solution method

Many of the ORANI-F equations are non-linear—demands depend on price ratios, for example. However, following Johansen (1960), the model is solved by representing it as a series of linear equations relating percentage changes in model variables. The linearised form can be used to generate exact solutions of the underlying, non-linear, equations, as well as to compute linear approximations to those solutions. The model can be represented in the levels as:

$$\mathbf{F}(\mathbf{Y},\mathbf{X}) = \mathbf{0}, \tag{1}$$

where $\mathbf{Y}$ is a vector of endogenous variables, $\mathbf{X}$ is a vector of exogenous variables and $\mathbf{F}$ is a system of non-linear functions. The problem is to compute $\mathbf{Y}$, given $\mathbf{X}$. Normally we cannot write $\mathbf{Y}$ as an explicit function of $\mathbf{X}$.

Several techniques have been devised for computing $\mathbf{Y}$. The linearised approach starts by assuming that we already possess some solution to the system, $\{\mathbf{Y}^0,\mathbf{X}^0\}$, i.e.,

$$\mathbf{F}(\mathbf{Y}^0,\mathbf{X}^0) = \mathbf{0}. \tag{2}$$

Normally the initial solution $\{\mathbf{Y}^0,\mathbf{X}^0\}$ is drawn from historical data—we assume that our equation system was true for some point in the past. With conventional assumptions about the forms of the $\mathbf{F}$ functions it will be true that for small changes $\mathbf{dY}$ and $\mathbf{dX}$:

$$\mathbf{F}_Y(\mathbf{Y},\mathbf{X})\mathbf{dY} + \mathbf{F}_X(\mathbf{Y},\mathbf{X})\mathbf{dX} = \mathbf{0}, \tag{3}$$

where $\mathbf{F}_Y$ and $\mathbf{F}_X$ are matrices of the derivatives of **F** with respect to **Y** and **X**, evaluated at $\{\mathbf{Y}^0,\mathbf{X}^0\}$. For reasons explained below, we find it more convenient to express **dY** and **dX** as small percentage changes **y** and **x**. Thus y and x, some typical elements of **y** and **x**, are given by:

$$y = 100dY/Y \quad \text{and} \quad x = 100dX/X. \tag{4}$$

Correspondingly, we define:

$$G_Y(\mathbf{Y},\mathbf{X}) = F_Y(\mathbf{Y},\mathbf{X})\hat{\mathbf{Y}} \quad \text{and} \quad G_X(\mathbf{Y},\mathbf{X}) = F_X(\mathbf{Y},\mathbf{X})\hat{\mathbf{X}}, \tag{5}$$

where $\hat{\mathbf{Y}}$ and $\hat{\mathbf{X}}$ are diagonal matrices. Hence the linearised system becomes:

$$\mathbf{G}_Y(\mathbf{Y},\mathbf{X})\mathbf{y} + \mathbf{G}_X(\mathbf{Y},\mathbf{X})\mathbf{x} = \mathbf{0}. \tag{6}$$

Such systems are easy to solve, using standard techniques of linear algebra. But they are accurate only for small changes in **Y** and **X**. Otherwise, linearisation error may occur. The error is illustrated by Figure 1, which shows how some endogenous variable Y changes as an exogenous variable X moves from X^0 to X^F. The true, non-linear relation between X and Y is shown as a curve labled "Exact". The linear, or first-order, approximation:

$$y = -\mathbf{G}_Y(\mathbf{Y},\mathbf{X})^{-1}\mathbf{G}_X(\mathbf{Y},\mathbf{X})x \tag{7}$$

leads to the Johansen estimate Y^J—an approximation to the true answer, Y^{exact}.

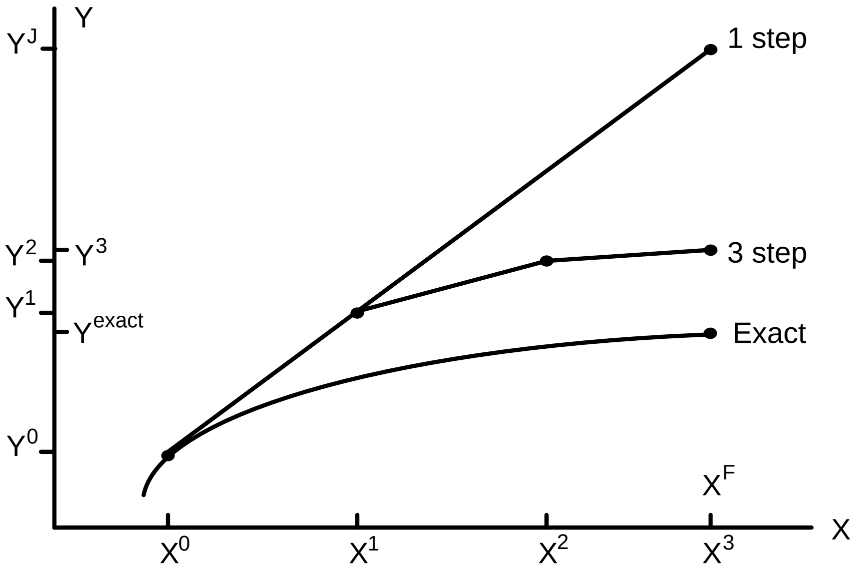

Figure 1. Multistep process to reduce linearisation error

Figure 1 suggests that, the larger is x, the greater is the proportional error in y. This observation leads to the idea of breaking large changes in X into a number of steps. For each sub-change in X, we use the linear approximation to derive the consequent sub-change in Y. Then, using the new values of X and Y, we recompute the coefficient matrices $\mathbf{G}_Y$ and $\mathbf{G}_X$. The process is repeated for each step. If we use 3 steps (see Figure 1), the final value of Y, Y^3, is closer to Y^{exact} than was the Johansen estimate Y^J. We can show, in fact, that given sensible restrictions on the derivatives of $\mathbf{F}(\mathbf{Y},\mathbf{X})$, we can obtain a solution as accurate as we like by dividing the process into sufficiently many steps. This technique is known as the Euler method.

The accuracy of multistep solution techniques can be improved by extrapolation. Suppose the same experiment were repeated using 4-step, 8-step and 16-step Euler computations, yielding the following estimates for the total percentage change in some endogenous variable Y:

y(4-step) = 4.5%,
y(8-step) = 4.3% (0.2% less), and
y(16-step) = 4.2% (0.1% less).

Extrapolation suggests that the 32-step solution would be:

y(32-step) = 4.15% (0.05% less),

and that the exact solution would be:

y(∞-step) = 4.1%.

The extrapolated result requires 28 (= 4+8+16) steps to compute but would normally be more accurate than that given by a single 28-step computation. Alternatively, extrapolation enables us to obtain given accuracy with fewer steps. Each step of a multi-step solution requires: computation from data of the percentage-change derivative matrices $\mathbf{G}_Y$ and $\mathbf{G}_X$; solution of the linear system (6); and use of that solution to update the data $(\mathbf{X},\mathbf{Y})$.

The computations required to formulate and solve ORANI-F by the Euler method are performed using GEMPACK, which automates the process of translating the model specification into a model solution program. The GEMPACK user needs no programming skills. Instead, he/she creates a text file, listing the equations of the model. The syntax of this file resembles ordinary algebraic notation. The GEMPACK program TABLO then translates this text file into a model-specific FORTRAN program, which, when executed, solves the model.

2.3. The TABLO representation

Horridge, Parmenter and Pearson (1993) document the structure of ORANI-F *via* the TABLO file which implements the model in GEMPACK. The TABLO language in which the file is written is essentially conventional algebra, with names for variables and coefficients chosen to be suggestive of their economic interpretations. The TABLO notation is no more complex than alternative means of setting out the model—the sort of notation employed for ORANI in Dixon, Parmenter, Sutton and Vincent (1982), for example. Acquiring the familiarity with the notation allows ready access to the GEMPACK programs used to conduct simulations with the model and to convert the results to human-readable form. Both the input and the output of these programs employ the TABLO notation. Moreover, familiarity with the TABLO format is essential for users who may wish to make modifications to the model's structure.

Another compelling reason for using the TABLO Input file to document the model is that it ensures that our description is complete and accurate: complete because the only other data needed by the GEMPACK solution process is numerical (the model's database and the exogenous inputs to particular forecasts or policy experiments); and accurate because GEMPACK is nothing more than an equation solving system, incorporating no economic assumptions of its own.

A computer diskette is available containing the TABLO Input file for the 22-sector version of ORANI-F described by Horridge, Parmenter and Pearson (1993). It contains also an executable version of the model. A demonstration version of the complete GEMPACK system is also available.

To illustrate the representation of the model in TABLO form, consider a small subset of the equation system of a typical CGE model: the input demand equations for a producer who makes output Z using a constant-returns-to-scale CES production function with N inputs X_k, k=1,...,N, with prices P_k. In percentage changes of the variables (denoted by lower-case characters), the linearised equations are:

$$x_k = z - \sigma\left(p_k - p_{ave}\right), \qquad k=1,...,N \qquad (8)$$

and $$p_{ave}\sum_{i=1}^{N} V_i = \sum_{i=1}^{N} V_i p_i, \qquad (9)$$

where σ is the elasticity of substitution, a positive parameter. According to (8), the producer's demand for input k will change at the same percentage rate as his output level in the absence of changes in relative input prices. If the price of input k falls relative to the average price of inputs (p_{ave}), then the producer will substitute input k for other inputs. Equation (9) defines the percentage change in the average price of inputs as a cost-share-weighted sum of percentage changes in input prices. The initial values of the flows $V_k=P_kX_k$ which comprise the weights are taken from historical data. After each change they are updated by:

$$V_{k,new} = V_{k,old} + V_{k,old}(x_k + p_k)/100 . \qquad (10)$$

In TABLO language, equations (8) and (9), appear as:

```
Equation E_x # input demands #
    (All, f, FAC)  x(f) = z - SIGMA{p(f) - p_f};
Equation E_p_f # input cost index #
    V_F*p_f = Sum(f,FAC,V(f)*p(f));
```

The first word, 'Equation', is a keyword which defines the statement type. Then follows the identifier for the equation, which must be unique. The descriptive text between '#' symbols is optional—it appears in certain report files. The expression '(All, f, FAC)' signifies that the equation is a matrix equation, containing one scalar equation for each element of the set FAC.

Within the equation, the convention is followed of using lower-case letters for the percentage-change variables (x, z, p and p_f), and upper case for the coefficients (SIGMA, V and V_F). Since GEMPACK ignores case, this practice assists only the human reader. An implication is that we cannot use the same sequence of characters, distinguished only by case, to define a variable and a coefficient. The '(f)' suffix indicates that variables and coefficients are vectors, with elements corresponding to the set FAC. A semicolon signals the end of the TABLO statement.

To facilitate portability between computing environments, the TABLO character set is quite restricted—only alphanumerics and a few punctuation marks may be used. The use of Greek letters and subscripts is precluded, and the asterisk, '∗', must replace the multiplication symbol '×'.

Sets, coefficients and variables must be explicitly declared, *via* statements such as:

```
Set FAC # inputs # (capital, labour, energy);
Coefficient (All, f, FAC)   V(f)        # cost of inputs #;
                            V_F         # total cost #;
                            SIGMA       # substitution elasticity #;
Variable    (All, f, FAC)   p(f)        # price of inputs  #;
            (All, f, FAC)   x(f)        # demand for inputs  #;
                            z           # output #;
                            p_f         # input cost index #;
```

As the last two statements in the 'Coefficient' block and the last three in the 'Variable' block illustrate, initial keywords (such as 'Coefficient' and 'Variable') may be omitted if the previous statement was of the same type.

Coefficients must be assigned values, either by reading from file:

```
Read V from file FLOWDATA;
Read SIGMA from file PARAMS;
```

or in terms of other coefficients, using formulae:

```
Formula V_F = Sum(f, FAC, V(f));  ! used in cost index equation !
```

The right hand side of the last statement employs the TABLO summation notation, equivalent to the Σ notation used in standard algebra. It defines the sum over an index f running over the set FAC of the input-cost coefficients, V(f). The statement also contains a comment, i.e., the text between exclamation marks (!). TABLO ignores comments in computation.

Some of the coefficients will be updated during multistep computations. This requires the inclusion of statements such as:

```
Update (All, f, FAC) V(f) = x(f)∗p(f);
```

which is the default update statement, causing V(f) to be increased after each step by [x(f) + p(f)]%, where x(f) and p(f) are the percentage changes computed at the previous step.

These sample statements introduce most of the types of statement required for the TABLO representation of the model.

2.4. The input-output database

Figure 2 is a schematic representation of the model's input-output database. It reveals the basic structure of the model. The columns in the main part of the figure (an absorption matrix) identify the following agents:

(1) domestic producers divided into I industries;
(2) investors divided into I industries;
(3) a single representative household;
(4) an aggregate foreign purchaser of exports;

(5) an 'other' demand category, broadly corresponding to government; and
(6) changes in inventories of domestically produced goods.

The rows show the structure of the purchases made by each of the agents identified in the columns. Each of the C commodity types identified in the model can be obtained locally or imported from overseas. The source-specific commodities are used by industries as inputs to current production and capital formation, are consumed by households and governments, are exported, or are added to or subtracted from inventories. Only domestically produced goods appear in the export and inventory columns. M of the domestically produced goods are used as margins services (wholesale and retail trade, and transport) which are required to transfer commodities from their sources to their users. Commodity taxes are payable on the purchases. As well as intermediate inputs, current production requires inputs of three categories of primary factors: labour (divided into O occupations), fixed capital, and agricultural land. The 'other costs' category covers various miscellaneous industry expenses.

		Absorption Matrix					
		1	2	3	4	5	6
		Producers	Investors	Household	Export	Other	Change in Inventories
	Size	← I →	← I →	← 1 →	← 1 →	← 1 →	← 1 →
Basic Flows	↑ C×S ↓	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margins	↑ C×S×M ↓	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
Taxes	↑ C×S ↓	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
Labour	↑ O ↓	V1LAB					
Capital	↑ 1 ↓	V1CAP					
Land	↑ 1 ↓	V1LND					
Other Costs	↑ 1 ↓	V1OCT					

C = Number of Commodities
I = Number of Industries
S = 2: Domestic,Imported,
O = Number of Occupation Types
M = Number of Commodities used as Margins

	Joint Production Matrix
Size	← I →
↑ C ↓	MAKE

	Import Duty
Size	← 1 →
↑ C ↓	V0TAR

Figure 2. The ORANI-F Flows Database

Each cell in the absorption matrix contains the name of the corresponding matrix of the values (in some base year) of flows of commodities, indirect taxes or primary factors to a group of users. For example, V2MAR is a 4-dimensional array showing the cost of M margins services on the flows of C goods, both domestically produced and imported (S), to I investors.

In principle, each industry is capable of producing any of the C commodity types. The MAKE matrix at the bottom of Figure 2 shows the value of output of each commodity by each industry. Finally, import taxes are assumed to be levied at rates which vary by commodity but not by user. The revenue obtained is represented by the tariff vector V0TAR.

The ORANI-F documentation reviewed in this section has proved a reliable template for economists wishing to implement models of other economies. It includes a theoretical structure comprehensive enough to be used as at least a prototype model and describes a computing system in which relatively inexperienced modellers can conduct simulations and implement changes to the model structure. It sets out fully the structure of the required database. The linear solution method employed for the model is capable of producing accurate solutions to the non-linear model but is very flexible from the users' point of view. The ability to change model closures is particularly useful in adapting the model to a wide variety of applications.

3. IDC-GEM

3.1. Theory

The theoretical structure of IDC-GEM is modelled closely on that of ORANI-F. Its main characteristics are listed below.

3.1.1. Assumptions about producers

- single-product industries
- price takers
- minimise costs
- nested Leontief/CES production functions allowing substitution between
  - sources of produced inputs
  - labour, capital and land
  - occupations
  - ethnic groups

3.1.2. Assumptions about investors

- price takers
- minimise costs
- production functions allow substitution between sources
- aggregate investment normally exogenous but composition depends on relative rates of return

3.1.3. Assumptions about households

- disaggregated by ethnic group and income
- consumption proportional to disposable income.
- substitution between commodities and between sources

3.1.4. International exports

- downward-sloping demand curves for individual traditional exports and for a composite non-traditional export

3.1.5. Government

- consumption exogenous
- articulation of revenue sources

3.1.6. Trade and transport margins

- fixed proportions to commodity flows

3.1.7. Prices

- zero pure profits conditions and constant returns to scale imply basic values are functions just of input prices
- purchasers' prices are sums of basic values, sales taxes and margins

3.1.8. Market clearing

- for commodities
- labour market need not clear

3.1.9. Identities define macro variables

- e.g., GDP, trade balance, price indexes
- macro equation system structured around a SAM

3.1.10. Regional disaggregation

- tops-down disaggregation to nine provinces

Note that IDC-GEM contains more disaggregated specifications of the labour market and of the household sector than does ORANI-F. The workforce is disaggregated by occupation and segmentation by ethnic group is recognised. The model's nested production functions specify an industry's aggregate labour input as a CES combination of occupation-specific labour inputs, each of which is a CES combination of labour drawn from the different ethnic groups. Hence, if relative wages change, employers will substitute between occupations and between ethnic groups. The household sector in IDC-GEM is also disaggregated by ethnic group. Within each ethnic group are recognised income levels, defined as quantiles of the group's income distribution. With these labour-market and household disaggregations, the model can project the effects of economic developments on the distribution of employment and income in South Africa. These distributional issues are critical in South Africa.

3.2. Data

IDC-GEM contains 103 single-product industries, 2 margins commodities, 65 categories of labour (13 occupations by 5 ethnicities) and 24 households (4 ethnicities by six income levels. The input-output database was compiled by Claude van der Merwe of Economic Analysis Systems Pty Ltd, working from Van Seventer, Eckert and de Lange (1992). Van der Merwe also supplied data for the occupational and ethnic disaggregation of employment and for the ethnic and income-level disaggregation of the household sector. To date no program for econometric estimation of the elasticities required for the model has been undertaken. Elasticities for this first version of the model were assigned on the basis of literature reviews or guesstimation. "Armington" elasticities of substitution between domestically produced commodities and imports, the elasticity of substitution between primary factors, the elasticity of substitution between occupations and the elasticities in the household demand system were all adapted from the ORANI data files. The elasticity of substitution between ethnic groups in labour demand was set at 2. Export demand elasticities were supplied by researchers at the IDC.

3.3. Illustrative Application

3.3.1. Shocks and closure

In this section we report the results of a simulation in which IDC-GEM was used to project the short-run, comparative-static effects on the South African economy of a program of trade liberalisation negotiated as part of the GATT Uraguay round. The program involves a flattening of the protection-rate structure and a reduction of about 20 per cent in the average rate of protection. The main features of the program are reported in Table 1. In common with the trade-liberalisation programs of countries with similar industrial structures (Australia, for example), the South African program involves heavy cuts in high rates of protection enjoyed by industries in the textiles, clothing and footwear sector and the transport equipment sector.

Table 1: Main Changes in Protection

	Industry	Percentage change in power of tariff equivalent
20	WOOL_COTTON	-23.69
21	SPIN_WEAVE	-23.69
22	TEXTILES_NW	-11.46
23	GARMENT_KNIT	-18.85
24	OTH_KNITTING	-18.85
25	CARPETS_RUGS	-11.76
26	CORD_ROPE	-22.68
27	TEXTILES_NEC	-18.01
28	CLOTHING	-18.23
31	FOOTWEAR	-8.14
39	FERTILIZERS	6.96
42	DRUGS_MEDICN	7.49
47	TYRES_ETC	7.18
62	AGRICLT_MCHN	6.62
73	MOTOR_VEHICL	-20.00
75	MOT_VEH_PART	-15.00

Table 2 lists the main assumptions adopted in configuring the model for the simulation. These assumptions are implemented by an appropriate choice of model closure (i.e., selection of exogenous variables) and by assigning appropriate values to the exogenous variables.

Table 2: Main Assumptions Adopted for the Simulation

Fixed availability of capital and land in each industry
No induced technical change
No induced changes in real wage rates
Slack labour markets for all categories of labour
Tariff changes are revenue neutral *via* a change in the income-tax rate
Consumption in each household moves with disposable income
No induced changes in aggregate investment or government consumption
25 traditional exports and a composite non-traditional export
Nominal exchange rate is the numeraire

3.3.2. Macroeconomic results

Selected macroeconomic results are reported in Table 3. In its short-run comparative-static configuration, the equations and variables in IDC-GEM all refer implicitly to the economy at a future time period T, say two years after the imposition of the trade liberalisation. This interpretation is illustrated by Figure 3, which graphs the values of some variable, say employment, against time. A is the level of employment in the base period (period 0) and B is the level which it would attain in period T if the trade liberalisation were not implemented. With liberalisation, employment would reach C, all other things being equal. The result is reported as the percentage change in employment 100(C-B)/B, showing how employment in period T would be affected by trade liberalisation alone.

The results are typical of general-equilibrium calculations of the effects of tariff cuts. They indicate that the cuts stimulate imports but, by reducing domestic costs relative to world prices, stimulate exports. With the nominal exchange rate as the *numeraire* (Table 2), the reduction in the GDP deflator in Table 3 is the appropriate indicator of the real exchange rate depreciation associated with the tariff reform. In these results, the expansion of output and employment associated with expansion of the export sector just outweighs the contraction of the import-competing sector which makes way for the increase in imports. Hence, there is a small increase in real GDP and in aggregate employoment.

Export-demand elasticities in the current IDC-GEM database are rather low. Hence, stimulation of exports leads to a deterioration in the terms of trade. With this deterioration, the GDP deflator (which includes export prices but excludes import prices) declines relative to the domestic-absorption deflator (a weighted average of the price indexes for consumption, investment and government spending).

Table 3: Results for Macro Variables

Computer name	Variable	Percent change
x0gdpexp	Real GDP (Expenditure Side)	0.38
employ_i	Aggregate Employment	0.47
x3tot_hr	Real Household Consumption	0.36
x2tot_i	Real Investment	0.0
x5tot	Real Government Consumption	0.0
x4tot	Export Volume Index	1.65
w4tot	Rand Border Value of Exports	0.52
x0cif_c	Import Volume Index	1.06
w0cif_c	CIF Rand Value of Imports	1.06
delB	(Balance of Trade)/GDP	-0.0004
p0toft	Terms of Trade	-1.12
p3tot_hr	Consumer Price Index	-2.06
p2tot_i	Investment Price Index	-1.63
p5tot	Government Price Index	-1.83
p0gdpexp	GDP Price Index	-2.14

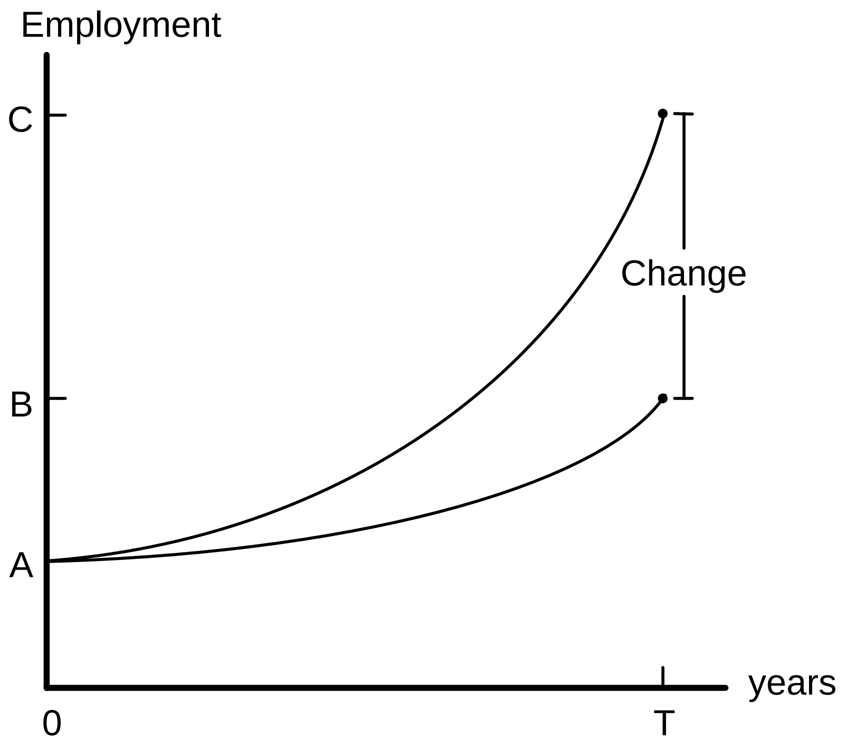

Figure 3. Comparative-static interpretation of results

3.3.3. Structural results

Results for some structural variables are reported in Table 4. Rather than report results at the 103 industry/commodity level, we have aggregated variables to 36 sectors.

Table 4: Percent changes in structural variables (36 sectors)

	Sector	Output	Employt	Imports	Exports
1	Agriculture	0.32	1.07	-0.81	1.70
2	Gold	1.01	1.85	0.00	1.02
3	Other mining	1.11	2.08	0.46	1.30
4	Food	0.22	0.42	-0.42	2.58
5	Beverages	0.25	0.50	-2.32	3.19
6	Tobacco	0.13	0.23	-1.67	3.19
7	Textiles	-6.77	-10.07	17.46	3.19
8	Clothing	0.42	0.53	17.37	3.19
9	Leather	0.83	1.44	-5.94	2.29
10	Footwear	-2.46	-4.26	17.00	3.19
11	Wood etc	0.47	0.64	0.55	2.47
12	Furniture	0.62	0.75	-0.35	3.19
13	Paper	0.43	1.36	-0.81	0.57
14	Printing	0.52	0.69	-3.35	3.19
15	Chemicals	0.57	1.15	-1.72	2.45
16	Rubber	1.22	1.90	-1.84	3.19
17	Plastics	-0.08	-0.13	4.51	3.19
18	Non metallic minerals	0.40	0.63	-0.72	2.48
19	Basic metals	1.03	2.11	-2.76	1.01
20	Fabricated metals	1.27	1.62	-4.64	1.99
21	Machinery	0.82	1.22	-0.62	2.24
22	Electrical machinery	0.92	1.32	-0.74	3.19
23	Transport equipment	-1.08	-4.59	10.85	3.06
24	Other manufacturing	0.77	1.55	0.12	1.83
25	Electricity	0.31	1.09	0.00	3.19
26	Construction	-0.01	-0.01	0.03	3.19
27	Civil engineering	0.01	0.02	0.14	3.19
28	Trade	0.44	0.68	0.39	3.19
29	Accommodation	0.43	0.65	-0.12	3.19
30	Transport	0.74	1.23	-1.08	2.51
31	Communications	0.36	0.74	0.27	3.19
32	Finance	0.26	0.54	0.29	3.19
33	Community services	0.13	0.18	0.00	3.19
34	Gov industries	0.00	0.00	0.00	3.19
35	servants	0.55	0.55	0.00	3.19
36	Non classified	0.52	0.93	0.00	3.19

The last two columns decompose the strong induced growth in imports and exports which was noted in the macroeconomic results in Table 3. Import growth is stongest in the Textiles (7), Clothing (8), Footwear (10) and Transport equipment (23) sectors. Recall from Table 1 that these are the sectors facing the largest cuts in protection. In some other sectors imports fall. These falls reflect increases in some rates of protection and the depreciation of the real exchange rate which is induced by the fall in the average rate of protection.

The real exchange rate depreciation also explains the rise in exports. Expansion of traditional exports from agricultural and mining is inhibited by the large shares of fixed factors (land and capital) in their cost structures. Non-traditional exports from the manufacturing and services sectors are projected to expand at more rapid rates following the trade liberalisation. (Note that this has also been the experience in Australia in recent years.) The results in the last column of Table 4 reflect the model's rather rudimentary treatment of non-traditional exports. As noted in section 2, the model endogenises only an aggregate of non-traditional exports with exports of all commodities comprising the aggregate assumed to expand at the same rate.

Many of the output projections in column 1 of Table 4 reflect the trade results. Hence, the sectors facing large tariff cuts and rapid import expansion experience, in general, declines in output. Sectors participating in export growth or able to replace imports experience expansions of output. The service sectors face little or no international competition. With small expansions of GDP and private consumption, most of these experience small output gains. Exceptions are Construction, Engineering and the Government industries. With aggregate investment and government spending assumed invariant to the trade liberalisation, these show almost no change in output.

The relationship between the output results and the employment results in the second column of the table follows from the short-run assumption underlying the simulation. With the availability of capital and land fixed, industries expand (contract) output by working the fixed factors more (less) intensively. Hence, changes in labour productivity are inversely related to output changes.

3.3.4. Distributional results

Table 5 contains projections of changes in real household consumption disaggregated by ethnic group and by income group. It shows that for all income levels the trade liberalisation favours White and Black households relative to Coloured and Asian households. For each ethnic group high-income households are favoured relative to low-income households.

Table 5: Percent Changes in Real Household Consumption

	Ethnic Groups			
Income Groups	White	Coloured	Asian	Black
q1	0.26	-0.04	-0.44	0.35
q2	0.17	-0.09	-0.34	0.28
q3	0.21	0.03	-0.27	0.34
q4	0.42	0.02	-0.09	0.46
d9	0.30	0.06	-0.23	0.55
d10	0.50	0.15	0.18	0.64

The first of these distributional results is explained largely by differences in the income sources of the ethnic groups. Coloured and particularly Asian households are relatively heavily concentrated in the textile and footwear industries which experience sharp reductions in employment and returns to fixed factors (Table 4). Another illustration of the effects of this across ethnic groups is shown in Table 6. It shows that employment prospects for the Coloured and particularly the Asian workforce are poorly affected by the trade liberalisation.

Table 6: Percent Changes in Employment by Ethnic Group

Ethnic Group	Percent change in employment
White	0.54
Coloured	0.11
Asian	-0.04
Black	0.53
Migrant	0.72

The effect of the policy change across income groups is explained largely by differences in the expenditure patterns of the income groups. Table 7 shows that the tariff reform reduces the the cost of the consumption bundles consumed by the high-income households more than it reduces the cost of low-income groups' consumption. This is mainly because the share of motor vehicles in the consumption bundles of high-income households exceeds the motor-vehicle share in low-income households' consumption.

Table 7: Percent Changes in Consumption Price Indexes

Income Groups	Ethnic Groups: White	Coloured	Asian	Black
q1	-1.83	-1.74	-1.71	-1.94
q2	-1.82	-1.75	-1.83	-1.78
q3	-1.91	-1.92	-1.91	-1.86
q4	-2.15	-2.02	-2.06	-2.01
d9	-2.10	-2.09	-1.89	-2.15
d10	-2.30	-2.17	-2.31	-2.25

Further evidence that these factors explain the results is provided by Tables 8 and 9. These show the effects on real household consumption of the cuts in protection for textiles and motor vehicles alone. Table 8 shows that effects of the Textile cuts are fairly even across income levels but favour White and Black households relative to Coloured and Asian households. Table 9 shows that the Motor-vehicle cuts favour high-income over low-income groups with little variation between ethnic groups.

Table 8: Percent changes in Real Household Consumption (Textile Cuts Only)

	Ethnic Groups			
Income Groups	White	Coloured	Asian	Black
q1	0.11	-0.09	-0.33	0.34
q2	0.03	-0.08	-0.41	0.27
q3	-0.06	-0.09	-0.34	0.26
q4	-0.07	-0.18	-0.35	0.32
d9	-0.12	-0.21	-0.29	0.30
d10	-0.12	-0.20	-0.35	0.19

Table 9: Percent changes in Real Household Consmption (Motor Vehicle Cuts Only)

	Ethnic Groups			
Income Groups	White	Coloured	Asian	Black
q1	0.06	0.08	-0.08	-0.07
q2	-0.11	-0.01	0.10	0.01
q3	-0.05	0.11	0.04	0.09
q4	0.16	0.10	0.15	0.14
d9	-0.01	0.06	-0.17	0.22
d10	0.18	0.14	0.16	0.40

4. PROGRESS IN ASIA

In 1992 Kwanjai Arun-Smit of Chulankongkorn University requested a version of ORANI-F which could be adapted to the Thai economy. This provided the initial stimulus for us to construct and document the generic version of the model described in Horridge, Parmenter and Pearson (1993). Arun-Smit and her colleagues have now constructed a 28-sector model called CAMGEM. A feature of the model is its explicit treatment of Thailand's large international tourism industry. CAMGEM is being used for forecasting and so retains the dynamic accumulation relationships for capital and foreign debt used in ORANI-F. With these dynamics, initial conditions reflecting high investment levels associated with the current rapid growth of the Thai economy play a large role in the forecasts. Arun-Smit's preliminary forecasts show a contraction of investment from the recent high levels.

Monash University is heavily involved in the reform of the Vietnamese higher education system. In November 1993 a Monash delegation visited Hanoi for discussions about the establishment of a Western-style multidisciplinary First National University of Vietnam. As an adjunct to Monash's involvement in Vietnam, we have begun an economics program based around the development of a CGE model of the Vietnamese economy. The project is less well advanced than our South African project but eventually we plan to use the Vietnamese model for analysis of economic policy issues in Vietnam and as the basis for a training program for Vietnamese policy analysts. During our visit to Hanoi as part of the Monash delegation, we held discussions with a number of economic research agencies, gave some seminars on economic modelling and secured a 50-sector input-output database from the Vietnamese central statistical agency. The input-output database, which refers to 1990, has been constructed with the assistance of Dr Viet of the United Nations as part of a project to develop national accounts for Vietnam according to UN SNA conventions.

Using the 1990 input-output tables, we have implemented a prototype CGE model of Vietnam. As for IDC-GEM, we used the version of ORANI-F described by Horridge, Parmenter and Pearson (1993) as a template. We are now in the process of computing illustrative simulations with the prototype model. Results from these simulations will be the basis of a series of workshops which we will run for economists in Vietnam during a return visit later this year. We hope that these will attract enough interest for us to proceed to mount a much larger project to convert the prototype into a model which can be used for practical policy analysis and for forecasting in Vietnam.

5. CONCLUSION

The availability of the template described in Horridge, Parmenter and Pearson (1993) and of the GEMPACK software has greatly facilitated the transfer of our modelling technology to foreign environments. But it would be naive to assume that a model developed to represent conditions prevailing in the Australian economy could be useful for policy analysis in Vietnam (say) without substantial amendment. The role of the prototype is to introduce the basic modelling techniques and to serve as a basis from which amendments to reflect local conditions can be made with relative ease. For economies with structures similar to that of Australia (South Africa, for example) the prototype model might be more directly applicable to policy analysis.

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