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Updating an input–output table for use in policy analysis†

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The long lag in the publication of input–output tables is one of the central constraints in applied general equilibrium analysis. Model builders often use out-dated databases leading to analyses that are inappropriate for the policy questions being addressed. This occurs particularly when there exists a significant structural change in the economy. We discuss the updating of an input–output table of the Philippines by simulation technique. A detailed computable general equilibrium model of the Philippine economy with comparative static and forecasting capabilities is utilised. The data are drawn from known percentage changes of macroeconomic variables such as those in the national accounts and structural variables such as employment and output by industry.

1. Introduction

One of the central constraints in applied general equilibrium analysis is the use of out-dated input–output (IO) tables. Generally, the IO tables are only occasionally published, sometimes after five years, the reason being that the construction of such tables via a survey is prohibitively expensive (Dewhurst 1992; Khan 1993). On the other hand, data on macroeconomic variables and industry aggregates are often published by statistical agencies on a yearly basis. Out-dated tables are unsuitable for policy analysis, especially when there is a significant structural change in the economy. They need to be updated so that the present structure of the economy is reflected in the table.

There are three popular methods of updating IO tables: the final demand method, transactions proportional to value added method, and the RAS

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method or iterative proportional method (Khan 1993). The first two methods assume constancy of IO coefficients of the present and forecasted IO table. In the final demand method, the gross output in a future year that corresponds with the future year's final demand is predicted using the known base year inter-industry relationship. In the transactions method, base period inter-industry transactions are made proportional to the base period value added. This matrix of proportions is multiplied by the diagonal matrix of the value added for the predicted year to form the transaction matrix for that year. The RAS method is well recognised and widely used in updating IO tables. RAS is a mechanical technique popularised by Bacharach (1970) in which the base year absorption matrix is adjusted to sum to given row and column totals for the update year, by successive prorating of the rows and columns until consistency is achieved. The main advantage of RAS is that the process updates the technical coefficients whereas in the two previously mentioned methods, the direct input coefficients are fixed. These three methods are basically mechanical procedures in updating IO tables.

In this article, we present a simulation technique based on Dixon and McDonald (1993a) to update an IO table of the Philippines from 1985 to 1992. A detailed computable general equilibrium (CGE) model of the Philippine economy with comparative static and forecasting capabilities is utilised. Updating an IO table using an existing CGE model is attractive since only relatively minor additions to an existing infrastructure are needed. For example, only a few equations and variables have to be added to the model to update the table. Additionally, an IO table in a CGE database transformed according to the model specifications can be updated while at the same time preserving the structure of the database and the table itself. This is convenient because the transformation of an original IO table to suit the model requirements is in itself costly. With an existing CGE infrastructure, the IO table is updated without going back to the original table.

Comparing with RAS, although both approaches utilise various adjustment factors in order to satisfy constraints imposed by the available target-year statistics, the adjustment factors needed in the simulation procedure have economic interpretation. These adjustment factors provide information on such unobservable variables of the economy as productivity changes, taste changes, shifts in export demand and technological changes. However, unlike the statistical approaches, the simulation technique needs more information. For example, to determine whether shifts in the composition of exports are due to the demand side or the supply side, the simulation approach needs data on changes in both export volumes and export prices.

We applied the technique to update the 1985 IO table of a CGE model of the Philippine economy to 1992 using known data from the national accounts and other statistical tables. The updated IO table is consistent with the economy's structure for the year 1992 and is compatible with the CGE model.[1] It is thus suitable for both comparative static analysis and forecasting purposes.

2. An overview of the model

The CGE model employed in this study was constructed by Buetre (1996)[2] based on the ORANI-F model of the Australian economy (Horridge, Parmenter and Pearson 1993). Aside from the comparative static and forecasting capabilities of the model, it is more disaggregated and more flexible or user-friendly than its Philippine counterparts. Philippine CGE models such as Habito (1984), and the more recent APEX model developed by Clarete and Warr (1992) are designed for comparative static analysis. They do not have update capabilities and other features that will allow data updating by simulation.

There are 59 industries in the model, eight of which are agricultural. They produce 59 commodities. The production side of the model allows the industries to produce more than one commodity, reflecting the production structure of most of the Philippine industries which are usually integrated. Producers are assumed to be price takers both for their outputs and inputs. They choose their output mixes to maximise revenue, subject to a constant elasticity of transformation function. They also minimise costs subject to a constant-returns-to-scale production function with a series of Leontief/constant elasticity of substitution (CES) nests. There is no substitution between inputs of different commodity categories or between produced inputs, primary factors and other inputs. Substitution takes place between alternative sources (that is, domestically produced goods and imports) of produced inputs of a given commodity category, and between aggregate labour (a CES combination of skilled and unskilled labour), capital and agricultural land. Hence, input demands are functions of activity variables and of the relative prices of substitutable inputs.

There are also 59 investors which are the industries themselves. An equation links industry investment to capital stock accumulation allowing

[1] The GEMPACK suite of modelling software was used in implementing the model (Harrison and Pearson 1994a, 1994b, 1994c).

[2] Modifications similar to the Monash model of the Australian economy were made to allow measurement of technological, taste and labour productivity changes, quantification of shifts in export demand, measurement of shifts in preferences between domestic and imported goods, updating of the database, and identification and quantification of sources of growth or structural change.

for the dynamics of capital stock accumulation. The dynamic accumulation equations are used to give relationships between the growth rates of sector-specific capital and sector-specific investment. Investors and households aggregate domestic and imported commodities in the same way as the commodity producers so that their demands for source-specific commodities are functions of the demands for the relevant composites and of source-specific commodity prices.

The foreign sector is modelled in a way similar to the small country assumption. That is, the export demand curve is virtually flat for most of the export commodities except for a few commodities where the Philippines is a major exporter. This implies that for most commodities, the quantities of Philippine exports have a very small effect on export price. The supply of imports is assumed to be perfectly elastic. That is, import requirements of the Philippines can be purchased at an unlimited quantity without any impact on import prices. Government is represented in the model, but its consumption level is essentially exogenous. It is assumed that government consumption moves at the same rate as aggregate household consumption.

The model includes market-clearing constraints for domestically produced commodities. This means that the output of domestically produced commodities is equal to the purchases of the five users, namely, producers, consumers, investors, exporters and government. Through the simple dynamics incorporated, the model can be used in forecasting where the percentage change results can be interpreted as changes through time as opposed to comparative static interpretation. In forecasting, many variables representing technical and taste coefficients, shifts in preferences, and the positions of foreign demand curves are set exogenously. Sectoral employment and outputs and prices, and macroeconomic aggregates are determined by the model.

An important feature of the model relevant to updating IO tables is its ability to replicate observed historical changes using a new closure where sectoral employment, outputs, other sectoral aggregates and prices, and macroeconomic aggregates are set exogenously and shocked at their observed levels. The variables which are exogenous in forecasting such as technical and taste coefficients, shifts in preferences, and the positions of foreign demand curves are endogenously determined. This swap between exogenous and endogenous variables facilitates the solution of the model equations or the endogenous–exogenous split of the model equations. This procedure replicates observed historical changes and generates a new or updated model database where data on changes in macro and industry aggregates are incorporated. At the same time, a series of estimates of technical changes, tastes, preferences and shifts in foreign demand is estimated. These variables, while not observable, are of interest by themselves and could be used to test the plausibility of the model and the acceptability of the data. The ability to replicate historical changes and the availability of historical data are the two main requirements in creating a new IO table by simulation.

3. Data

The data comprise the 1985 base IO table and the historical data which are percentage changes of the known variables during the period 1985 to 1992.

3.1 The 1985 IO table

The original 1985 IO table of the Philippines does not directly suit the specified model discussed earlier. For example, there is only one investor in the 1985 table, taxes are not separated from the purchases of users, and primary factors are not disaggregated into capital, skilled and unskilled labour, and land. A long process was undertaken to transform the IO table according to the specification of the model.[3] The resulting table with disaggregated investment, separated taxes and disaggregated primary factors is shown diagrammatically in figure 1.

The transformed table represents flows of commodities to various users, domestic taxes paid by users, payments to primary factors, commodity composition of industry outputs and tariffs on imported commodities. The basic flows from two sources (imported and domestic) represent the basic value of commodities used as intermediate inputs by industries, as inputs for capital creation by investors, as consumption goods, as exports, and for other demand. The basic value of a commodity is the price received by the producers. It excludes sales taxes. For imports, the basic values are inclusive of import taxes.

Summing over the basic flows of domestically produced commodities across the users gives the commodity supply. This is analogous to the commodity flows in the original IO accounts. The main difference is that the commodity valuation in the IO accounts includes taxes. The tax revenues summed over the users give the domestic tax revenues from all commodities from two sources.

The columns of figure 1 show the purchases made by the five users. For industries, it shows payments for intermediate inputs both for domestically produced and imported commodities, indirect taxes, primary factors composed of land, labour and capital, and other inputs. The purchases of investors, households, export and 'other'[4] are composed of basic values of

[3] The transformation process is discussed in detail in chapter 4 of Buetre (1996).

[4] The model has no theory on inventories. Thus 'other' consists of government and inventories. It is sometimes referred to as government in the text.

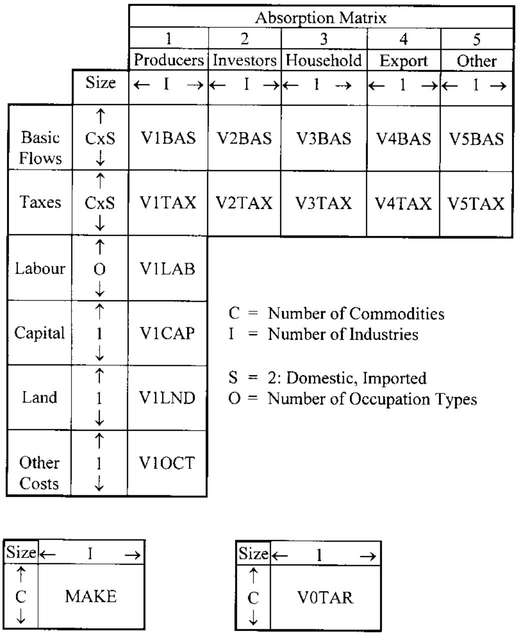

Figure 1 The database

where:

$V1BAS(c, s, i)$ — flow of commodity c in basic value from source s to industry i for intermediate use.

$V2BAS(c, s, i)$ — flow of commodity c in basic value from source s to industry i for investment.

$V3BAS(c, s)$ — flow of commodity c in basic value from source s for household consumption.

$V4BAS(c)$ — flow of export commodity c in basic value.

$V5BAS(c, s)$ — flow of commodity c in basic value from source s for government consumption.

$V1TAX(c, s, i)$ — sales tax imposed on commodity c from source s for intermediate use by industry i.

$V2TAX(c, s)$ — sales tax imposed on commodity c from source s for investment use by industry i.

$V3TAX(c, s)$ — sales tax imposed on commodity c from source s consumed by households.

$V4TAX(c)$ — sales tax imposed on export commodity c.

$V5TAX(c, s)$ — sales tax imposed on commodity c from source s for government consumption.

$V1LAB(i, o)$ — wage bill by industry i by occupation.

$V1CAP(i)$ — capital rentals by industry i.

$V1LND(i)$ — land rentals by industry i.

$V1OCT(i)$ — other costs incurred by industry i.

$MAKE(c, i)$ — make matrix by commodity c, by industry i.

$V0TAR(c)$ — tariff revenue by commodity c.

domestic and imported commodities and domestic taxes including tariffs on imports. Only the production sector requires primary factors.

The Make matrix represents the commodity composition of output of the industries net of indirect taxes. Summing it across industries yields the commodity output regardless of which industry produced it. This is equal to the domestic supply computed from the basic flows. The cost to each industry i in the absorption matrix is equal to the Make matrix summed over commodities. The industry costs are payments on inputs and taxes regardless of what commodity it is producing. For industries producing a single product, there is a one-to-one correspondence between industries and commodities. In this case, the cost to the industry equals the output of its principal commodity. In multi-product industries, commodity output c is not equal to industry output q. An important characteristic of figure 1 is that it is balanced. For example, commodity supply is equal to commodity demand and gross domestic products computed from expenditure and income sides are equal.

In sum, the transformed IO table which now suits the model specification, is a snapshot of the economy in 1985. This is what we attempt to update to 1992 by simulation using the CGE model described previously. Historical data are needed to achieve this end.

3.2 Data for historical simulations

The latest economic statistics available for 1992[5] are the historical data which we use to update the 1985 IO table presented in figure 1. These data inputs could be macroeconomic or sectoral data. Macroeconomic data include expenditures in the national accounts such as aggregate consumption, aggregate investment, aggregate exports and imports, and government consumption, and data on their respective price indices. Data on national income such as aggregate capital stock, compensation of labour and aggregate taxes are also among the macroeconomic variables which are usually published by statistical agencies. Sectoral data include industry and commodity outputs, commodity prices, imports and exports, and government and private consumption of goods and services, including tariffs. Most of these variables are usually endogenous or model-determined in simulations. That is, their changes are normally predicted.

The macroeconomic data we were able to collect are percentage changes in real aggregates from 1985 to 1992 from the demand and supply sides

[5] When the research project was conducted, the latest economic statistics available were for 1992. Given the economic statistics for 1985 and 1992, percentage changes of the variables were computed.

Table 1 Macroeconomic data for historical simulations [a]

Variable	1985	1992	Change (%)
Personal consumption expenditure	416,961	561,319	34.62
Government consumption	40,490	54,968	35.76
Capital formation	93,290	159,930	71.43
Exports	136,010	237,218	74.41
Imports	124,206	298,485	140.31
Gross national product	562,545	714,950	27.09
Gross national expenditure	550,741	776,217	40.94
Employment (1000 persons)	19,801	23,917	20.79
Population (1000 persons)	54,668	64,258	17.54
CPI			81.40

Source: *1993 Philippine Statistical Yearbook*.
Note: [a] Expenditures are in million Pesos, constant 1985 prices.

of the economy. These are private and government consumption, capital formation, exports and imports from the expenditure side, and employment and population from the supply side. We also have some data on the consumer price index. These data are presented in table 1.

The available sectoral data (table 2) in percentage changes from 1985 to 1992 are commodity imports, exports, export prices and industry output. The information on quantity and value of imports and exports for 1985 to 1992 is available from the *International Trade Statistics Yearbook* of the United Nations. This is supplemented by data from the *1993 Philippine Statistical Yearbook* and *1993 Philippine Yearbook*. There is no information on exports of services. We assumed that they moved along with the aggregate exports.

For industry output, we used the gross value added of each industry in constant prices. These data were taken from the *1993 Philippine Statistical Yearbook* and are shown in table 2. The industry classification in the *Yearbook* is the same as in the model. However, our procedure in putting information on output into the model is based on commodities. For this reason we transformed the observed percentage changes in industry output into output by commodity by using the structure of production in each industry which is available from the Make matrix.

Employment for industries is also available from the *Statistical Yearbook*. This is, however, on nine aggregate industries (table 3). We used a mapping between the nine aggregate industries and the 59 industries of the model to enable us to utilise the data. It is assumed that the changes in productivity for sectors within each of the nine aggregate industries are the same.

It is desirable to gather as much information as possible but the availability of official statistics and the inconsistencies in statistical reports have impaired our ability to collect all the changes in observable variables.

Table 2 Sectoral percentage changes, 1985–1992

Sector	Domestic output	Exports (Volume)	Imports (Volume)	Employment	Price of exports
1 Palay	8.26		−98.78	4.69	
2 Corn	8.11		−90.68	6.29	
3 Coconut/copra in farms	−29.33	31.60	0.00	−53.95	
4 Sugarcane	13.56		0.00	11.72	
5 Banana	−21.21	8.05	0.00	−34.33	
6 Other crops incl. agric. services	23.44	34.44	170.07	22.14	
7 Livestock	61.73	−100.00	429.08	83.33	
8 Poultry	80.16	0.00	669.15	138.08	
9 Fish and fishery products	19.51	123.06	610.76	12.84	
10 Logs and other forest products	−38.53	−38.21	47.98	−66.06	
11 Copper	−28.77	12.39		−27.29	
12 Gold and other precious metals	−16.53	63.32		−3.73	
13 Chromium ores	−59.71	34.28	17.08	−56.18	
14 Nickel	−43.06	16.00		−61.11	
15 Other metallics	−47.04	30.04	230.83	−57.22	
16 Sand, stone and gravel	57.66	0.00	106.69	144.32	
17 Other non-metallic minerals	34.93	104.77	0.00	82.71	
18 Food manufactures	4.10	35.57	131.40	-22.87	47.23
19 Beverage products	13.78	35.57	139.85	−15.37	
20 Tobacco manufactures	−3.58	11.67	79.77	−29.54	
21 Textiles and textile goods	3.08	210.26	250.02	−20.10	42.77
22 Wearing apparel and footwear	99.09	152.38	179.46	105.16	57.12
23 Wood, cork and cane products	27.10	−19.19	106.98	8.87	
24 Furntrs and fxtrs, primarily of wood	28.51	86.41	106.98	12.14	
25 Paper and paper products	60.17	100.00	144.08	62.28	
26 Publishing and printing services	76.73	128.00	348.27	80.95	
27 Leather and leather products	6.14	58.38	56.60	−15.51	
28 Rubber products	35.88	0.00	68.96	21.36	
29 Chem. and chem. prod. except petroleum. and coal	15.32	88.05	109.38	−8.36	
30 Products of petroleum and coal	78.38	190.00	275.65	141.01	
31 Non-metallic mineral products	70.04	40.50	106.98	86.33	
32 Basic metal products	−1.85	−46.27	208.43	−37.97	
33 Fabricated metal products	34.04	39.47	313.04	18.84	
34 Machinery except electrical	59.40	185.82	116.27	55.03	
35 Electrical machinery	89.89	125.79	285.49	103.15	
36 Transport equipment	109.53	115.82	134.89	137.65	
37 Miscellaneous manufactures	56.80	146.31	127.72	53.44	
38 Construction	19.90	74.41	106.98	40.32	
39 Electricity and gas	28.65			27.23	
40 Water services	20.80			18.66	
41 Land transport	23.86	74.41	468.31	29.15	47.70
42 Water transport services	20.31	74.41	336.38	20.67	47.70
43 Air transport services	26.07	74.41	278.23	27.23	47.70
44 Storage and services incidental to transport	10.85	74.41	279.70	9.83	47.70
45 Communication	43.31	74.41	290.76	57.56	47.70
46 Trade	47.59	74.41		25.74	47.70

Table 2 *Continued*

Sector	Domestic output	Exports (Volume)	Imports (Volume)	Employment	Price of exports
47 Banking services	84.03	74.41	126.50	55.30	47.70
48 Non-bank services	55.21	74.41		33.07	47.70
49 Insurance services	36.26	74.41	312.20	4.37	47.70
50 Real estate services	63.08	74.41	565.04	45.93	47.70
51 Ownership of dwelling	22.68			0.00	
52 Government services	34.05			27.82	
53 Private education services	21.16	74.41	474.33	11.32	
54 Private health services	38.72	74.41	452.09	31.66	
55 Private business services	27.24	74.41	298.21	−7.06	
56 Recreational services	44.13	74.41	157.45	40.59	47.70
57 Private personal services	26.07	74.41	522.31	14.09	47.70
58 Restaurants and hotels	26.40	74.41	67.10	15.07	47.70
59 Other private services	14.41	74.41	490.94	1.99	

Sources: Computed from *Philippine Statistical Yearbook, UN International Trade Statistics* and *FAO Trade Yearbook*.

Table 3 Employment by major industry groups, 1985 to 1992 (1000 persons)

Major industry group	Third quarter 1985	Oct 92	Change (%)
Total	19,801	23,917	20.79
Agriculture, fishery and forestry	9,699	10,879	12.07
Mining and quarrying	128	143	11.72
Manufacturing	1,923	2,549	32.47
Electricity, gas and water	73	92	26.03
Construction	684	1,036	51.32
Wholesale and retail trade	2,612	3,286	25.74
Transportation, storage and communication	931	1,222	31.15
Financing, insurance, real estate and business services	342	452	32.16
Community, social and personal services	3,409	4,258	24.82

Source: *1993 Philippine Statistical Yearbook*.

Nevertheless, we presume that the data we were able to collect are sufficient to reflect the changes in the structure of the economy and to demonstrate IO updating by CGE simulation.

4. Updating the IO table[6]

The process by which an IO table such as that in figure 1 is updated using the simulation method may appear to be complex because of the size of the

[6] Database and IO table are used interchangeably in this article.

database and the model. A simple illustration of the procedure is therefore necessary. We start by restating this concept as in Dixon and McDonald (1993a).

It is convenient to present the model in a compact form:

$$A(Z^B)z = 0 \tag{1}$$

where A is an $m \times n$ matrix of coefficients whose components are functions of base period values (Z^B) of variables, and z is an $n \times 1$ vector of percentage changes in variables. The number of variables, n, is greater than m, the number of equations. The base period values (Z^B) are normally read from the model's IO database which, in this case, is the 1985 IO table. It is an initial solution to equation 1.

The A matrix contains costs and sales shares computed from the entries in the IO database. The vector z contains percentage changes in prices and quantities and other variables. An example of a component equation in equation 1 is:

$$x_c - \Sigma_i B_{ci} x_{ci} = 0 \tag{2}$$

where x_c is the percentage change in the demand for commodity c; x_{ci} is the percentage change in the demand for commodity c by user i; and B_{ci} is the share of the sale of commodity c to user i.

By specifying values for percentage changes in $n - m$ exogenous variables, the system can be solved for percentage changes in the remaining m endogenous variables according to:

$$A_1(Z^B)z_1 + A_2(Z^B)z_2 = 0 \text{ or} \tag{3a}$$

$$z_1 = -A_1^{-1}(Z^B)A_2(Z^B)z_2 \tag{3b}$$

where z_1 is the column vector of endogenous variables; z_2 is the column vector of exogenous variables; and A_1 and A_2 are submatrices of A formed from the m and $(n - m)$ columns corresponding to the endogenous and exogenous variables.

The shocks are the values to be used for z_2, the vector of exogenous variables. Solutions to equation 3a above are approximations to the solutions of the non-linear system of equations implied in the theory of the model. The solutions are valid when the shocks are small; otherwise linearisation errors occur. These errors are minimised by applying a multi-step simulation in which the exogenous shocks (the values assigned to z_2) are applied in a number of steps (see Dixon and McDonald 1993a; Harrison and Pearson 1994a; Horridge *et al.* 1993). The multi-step simulation can only be done by updating the values of Z^B. When this is updated, the A matrix also changes since it is a function of the former.

For example, suppose that we knew that the change in exports during the period 1985 to 1992 was 50 per cent and decided to apply a two-step simulation. The flows data that will be directly affected are $V4BAS_c$ in the TABLO notation of the model in the appendix. The components of $V4BAS$ are flows in Peso values of commodity c to the export market. They are products of prices and quantities. The updating formula is:[7]

$$V4BAS_c^{1992} = V4BAS_c^{1985} \times \{1 + [p4_c + x4_c]/100\} \quad (4)$$

where $V4BAS_c^{1992}$ and $V4BAS_c^{1985}$ are the updated and the original values of exports of commodity c, and $p4_c$ and $x4_c$ are the percentage changes in price and quantity of exports of commodity c. Prices and quantities are usually endogenous in simulations. In this case, we already know the value of $x4_c$ so that, instead of allowing the model to estimate its values, we feed into it the actual or historical change, that is 50 per cent for each component c. This is done by adopting a closure in which $x4_c$ is made exogenous and the actual changes in exports are introduced as ‘shocks’ as discussed in detail in the next section. With a two-step simulation, the shocks are broken into two pieces and in the first step, the original values of the database are the values before the first step and the updated values are the ones written on the database after the step. The updated data are used for the second step and another updated dataset is written at the end of the second step. In other words, for every step in a multi-step simulation, an updated database is written. In the two-step simulation where we put the known increase in export of commodity c, we start by using equation 3b to calculate the effects of a uniform 25 per cent increase in exports of commodity c. The solution would include the effect of this shock on other endogenous variables particularly prices and quantities. The flows data $V4BAS_{c,}$ and other components of Z^B, would be updated according to the price changes resulting from the shock and the 25 per cent actual increase in the quantity of exports according to updating equations as in equation 4 above. In other words, the whole flows database is updated in accordance with the movements in the endogenous variables by moving the entries in the IO table to reflect the situation after the 25 per cent increase in exports of commodity c. This updated IO table allows the evaluation of the A matrix (that is, the cost and sales shares as in equation 3). These new costs and sales shares are then used in the computation of the remaining increase in exports that is sufficient to make the total increase in exports equal to 50 per cent. We

[7] With GEMPACK’s TABLO program, there is no need to write this explicit update of $V4BAS$. TABLO uses some rules in updating database flows such that an update statement like equation 4 can be conveniently written as: Update (All, c, COM) $V4BAS(c) = p4(c) * x4(c)$. For details, see Gempack User Documentation GPD-1.

may break the 50 per cent shock into much smaller pieces by increasing the number of steps in the simulations to improve the accuracy of solution.

In the actual updating, we solved equation 1 in which the exogenous shocks consisted of known changes in variables in the period 1985 to 1992. Through the process discussed above, we moved the database from 1985 to 1992. The values of Z^B written at the end of the final step of a multi-step simulation represent the estimated 1992 IO table. Two types of simulations were employed, one being macroeconomic historical simulation and the other sectoral historical simulation.[8]

4.1 Macroeconomic historical simulations

Macroeconomic historical simulations require the inclusion in the database of the known macroeconomic changes such as actual changes in aggregate consumption (*x3tot*), investment (*x2tot_i*), exports (*x4tot*), imports (*x0cif_c*) and government consumption (*x5tot*) from 1985 to 1992 as in table 1. These aggregate variables are usually endogenous in the model or estimated from the respective changes in the expenditures on commodities in each of the five categories of final demand. Incorporating the changes on the above macroeconomic variables requires the adoption of a new closure or endogenous–exogenous split of the model where the said variables are made exogenous and shocked at their observed percentage changes. It also requires a similar number of variables to be endogenised for the model to have a solution. For this purpose, the following variables were endogenised:[9]

a1primgen — a general technological change or total factor productivity. This was endogenised so that the aggregate consumption can be exogenous and shocked at its observed level.

ff_accum — a general shifter for aggregate investment. This facilitated the exogenisation of aggregate investment.

twist_src_bar — a general twister for import. This is endogenous while the aggregate import is exogenous and shocked at its known percentage change.

f4q_general — a general shifter for exports. When this is endogenous, the percentage change in aggregate exports can be incorporated.

[8] These are historical in the sense that the values of variables are already known.

[9] The model is large. Space limitation prevented the inclusion of the full model which is available on request. The equations reported in the appendix are only those relevant to the discussions in the text.

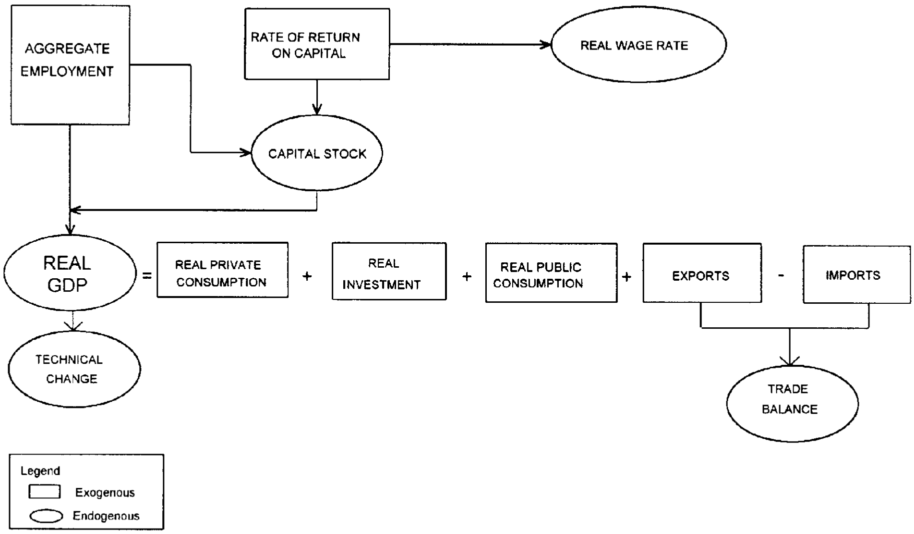

Figure 2 Diagrammatic representation of macroeconomic closure

f5tot2 — a shifter for aggregate 'other' demand. We endogenised this so that government consumption could be exogenised and shocked at its observed percentage change.

In addition to the above macroeconomic variables, we also introduced the following shocks:

- Employment (*employ_i*) = 20.79. This is the percentage change in aggregate employment in the Philippines during the period. Not taking this into consideration would result in scarcity of labour, leading to higher wages and the over-substitution of capital for labour.
- Number of households (q) = 17.54. This allowed for the changes in consumption to be measured in terms of per household basis.
- Consumer price index = 81.40. This allowed the actual change in aggregate consumer price to be imposed exogenously. Commodity price variations are allowed to vary subject to this aggregate percentage change. This shock made it possible for the updated database to be expressed in 1992 values.

The closure in this simulation is exhibited in figure 2. It worked as follows:[10]

[10] A closure is important in running models as it influences results and determines whether the equation system can be solved or not.

- On the expenditure side, the aggregate consumption, investment, government, exports and imports were fixed to their actual changes from 1985 to 1992. The gross domestic product (GDP) should therefore be endogenous as it is implied by its components. Although we also know the change in GDP, exogenising it will make the model over-determined. Fixing the aggregate final demands to the known changes means that their commodity components are allowed to vary independently subject to the exogenous aggregate demand.
- With fixed exports and imports, the balance of trade must be endogenous.
- On the income side, fixing the economy-wide rate of return (*r1cap_i*) allowed the aggregate capital stock (*x1cap_i*) to be endogenously determined. This determines the real wage rate via the factor price frontier. Aggregate employment, fixed at observed level, also helps to determine the capital stock via the production function. The industry changes in capital stocks were allowed to vary in accordance with the changes in their respective rates of return which are endogenous.
- These known aggregate variables from the income side were sufficient to set the value of the GDP. However, GDP is also implied in the expenditure side. It is an accounting requirement that the GDP estimates from income and expenditure sides are equal. The overall technical change variable *a1primgen*, which is endogenous, reconciles the GDP from income and expenditure sides.

In incorporating the macroeconomic changes using the above closure and shocks to exogenous variables, a new IO table is created post-simulation. This new table is consistent with the observed or actual percentage changes in the macroeconomic variables. It now reflects the macroeconomic structure of the economy for 1992. The next step was to ensure that the sectoral estimates generated by the model during macroeconomic historical simulations were consistent with the observed or known sectoral changes. Comparing the simulated and the observed sectoral percentage changes, we found that for some variables, there were inconsistencies. The main reason is that taste changes, technology changes and import twists were not uniform across commodities and industries. To deal with this problem, we need to incorporate the observed sectoral changes through sectoral historical simulation instead of allowing the model to estimate them. In this kind of simulation, changes in sectoral variables must add up to the known changes in macroeconomic variables (for example, the weighted sum of the known changes in commodity imports must equal the known aggregate imports). Hence, the macroeconomic historical simulation was only a starting point. It served two purposes: (a) to test the ability of the model to reproduce the known macroeconomic variables; and (b) to test our methodology before going into more detailed historical simulations.

4.2 Sectoral historical simulations

The purpose of sectoral historical simulations is to incorporate a more detailed data set into the database, particularly sectoral data. We used such a method to incorporate the observed percentage changes on imports ($x0imp_c$), exports ($x4_c$), commodity output ($x0dom_c$), employment ($employ_i$) and some export prices ($p4_c$), for which data were available. We introduced the variables step by step rather than simultaneously so that we might be able to trace any problem if it arose during the simulation. First, we worked on import volumes followed by export volumes. Then we added industry output. Finally, we included employment changes followed by export prices in the database. In the final simulation, all the above-mentioned variables were incorporated simultaneously and shocked with their percentage changes.

Import volumes are usually endogenous. To exogenise them requires a variable with a similar number of components to be endogenised in order to solve the model. We added a commodity twist variable ($twist\_src_c$) to the model to enable us to exogenise the import volume variable. This variable was introduced into the Monash model by Dixon and McDonald (1993a). It affects users of domestic and imported goods so that this variable appears in all equations of intermediate input demands, demand for capital creation, and household demand. For example, the demand for intermediate input ($x1$) of commodity c from source s by industry i (as shown in E_x1 in the appendix) is expressed as:

$$x1_{csi} - a1_{csi} = x1_{ci\_s} - \sigma 1COM_c(p1_{csi} + a1_{csi} - p1_{ci\_s}) - (SRCDOM_s - S1DOM_{ci}) \times twist\_src_c \quad c \in COM, s \in SRC, i \in IND \tag{5}$$

where:

$$S1DOM_{ci} = V1PURDOM_{csi}/V1PUR_{ci\_s} \quad c \in COM, s = DOM, i \in IND$$

$$V1PUR_{csi} = V1BAS_{csi} + V1TAX_{csi} \quad c \in COM, s \in SRC, i \in IND \tag{6}$$

$$SRCDOM_s = 0 \text{ if } s = 2, 1 \text{ otherwise}$$

It is helpful to explain the nature of the twist.[11] We start by doing away with the *c* and *i* subscripts in equation 5 and we assume that:

$x1\_s = 0$, no change in the total requirement for $x1$ from both sources,
$p_s = 0$, no change in the prices of $x1$ from both sources, and
$a_s = 0$, no change in technology affecting $x1$ from both sources.

Then the ratio of domestic to imported good in percentage change is:

$$
\begin{aligned}
x1_1 - x1_2 &= -(SRCDOM_1 - S1DOM)twist \\
&\quad + (SRCDOM_2 - S1DOM)twist \quad SRCDOM_2 = 0 \text{ by assumption} \\
&= -\ (SRCDOM - S1DOM)twist - (S1DOM)twist \\
&= (-S1IMP - S1DOM)twist, \text{since } 1 - S1DOM = S1IMP \\
&= -(S1IMP + S1DOM)twist \\
&= -twist
\end{aligned} \tag{7}
$$

where we simplify the notation by writing *twist* rather than *twist_src*.

Thus the difference between the percentage changes in domestic and imported commodities is equal to negative of twist variable. A value of 10 therefore of the twist variable imposes a reduction in the ratio between domestic and imported commodity or there is a twist in favour of imported good by 10 per cent. This percentage change in the ratio is cost-neutral as shown below.

Since there are no changes in prices, the percentage change in cost per unit of $x1\_s$ is:

$$c = S1DOM \times x1_1 + S1IMP \times x1_2 \tag{8}$$

Substituting values of $x1_1$ and $x1_2$ using the assumptions in equation 6 gives:

$$
\begin{aligned}
c &= -S1DOM(SRCDOM_1 - S1DOM)twist \\
&\quad - S1IMP(SRCDOM_2 - S1DOM)twist \\
&= -S1DOM(S1IMP)twist - S1IMP(-S1DOM)twist \\
&= [-S1DOM(S1IMP) + S1IMP(S1DOM)]twist \\
&= 0
\end{aligned} \tag{9}
$$

Thus a change in the twist represents a cost-neutral twist in preference between the domestic and imported commodity. It also allows the model to cope with changes in imports which are not explained by import price

[11] Thanks are due to Peter Dixon who patiently introduced and explained the meaning and impacts of the twist variable.

changes. With $twist\_src_c$ endogenous, the percentage changes in imports can be set exogenously at their observed values.

In incorporating the percentage changes in imports, the aggregate import variable ($x0cif\_c$) is implied by the components of the sectoral imports. Thus, it has to be endogenous. This is done by making the aggregate twist variable ($twist\_src\_bar$) exogenous. The respective changes in import volumes must add up to the known aggregate import volume. If the computed and known changes in the aggregate import volume are not identical because of data inconsistencies,[12] we change the closure and activate the import volume adjusting equation ($E\_x0impObs$ in the appendix). In this adjustment equation, $x0cif\_c$ becomes exogenous and shocked with its observed value. A scalar variable ($fx0imp$) adjusted the values of observed components of imports to hit the known aggregate. This process yields estimates of the twist variable shown in table 6.

To incorporate the observed percentage changes in commodity output ($x0dom_c$), we added a uniform taste/technical change variable ac_c. This variable is linked to the commodity demand for production, capital creation and consumption via the equations $E1\_ac$, $E2\_ac$ and $E3\_ac$ shown in the appendix. These equations define the technical change in production, capital creation and taste to be uniform, that is $ac_c = a1_c = a2_c = ffx3_c$. They allow us to include the changes in commodity outputs in the IO table by exogenising $x0dom_c$ and endogenising the uniform technical/taste change shifter ac. The observed changes in commodity outputs are introduced as shocks to the respective components of the variable $x0dom_c$. This simultaneously determines values of ac_c as in table 6.

The observed changes in export volume by commodity were incorporated into the model as shocks to the respective components of the export volume variable ($x4_c$). This was done by endogenising the export demand shifters. The aggregate export volume is implied from those exogenous changes, so it must be made endogenous while the aggregate twist variable becomes endogenous. In the case where the computed aggregate change in export volume did not add up to the observed change, we added an export adjusting equation (E_x4Obs) to hit the historical value of export. This is made possible by maintaining the aggregate export volume as exogenous and endogenising a scalar variable ($ff4q$). This scalar variable scales the observed

[12] It is often expected that, when observed commodity imports are imposed, their share-weighted sum would equal the observed historical change in aggregate imports. When this does not hold, there is inconsistency in the data, which is often the case when data are taken from different sources. The introduction of the adjustment equation rectifies this problem. This approach was similarly applied to exports.

exports by commodity up or down such that its weighted sum is equal to the exogenous aggregate export volume.

Known export prices were introduced as shocks to the respective components of the export price vector variable. This was made possible by endogenising the usual exogenous export tax variable instead of the normally endogenous export prices.[13]

There are nine industry groupings in which employment by industry is reported in Philippine statistical publications. Our model, however, requires employment changes in all the 59 industries. To utilise the information on the nine industry groupings (table 3) we made an assumption that labour productivity in a particular industry group is the same in all industries that belong to that group. This assumption is implemented in the model by mapping between the nine industry groups and the 59 industries in the model. With this mapping in place, we allow in equation E_f_lab9 in the appendix the equalisation of labour productivity for all industries that belong to the same nine major industry groups. Thus, in incorporating the observed percentage changes in nine industry employment $employ9_l$, we endogenise the nine-industry labour productivity variable $a1lab9_l$ and exogenise the shifter f_lab9_i while the all-industry labour productivity variable $a1lab_{i\_o}$ is endogenous. This equates $a1lab9_l$ with $a1labi\_o$. This closure gives estimates of labour productivity $a1labi\_o$ in each of the 59 industries with values being the same for each industry that belongs in one of the nine industry groupings. For example, labour productivities in the agricultural sector are the same as shown in table 6. Labour productivity varied at the nine industry grouping.

The final step is a simulation where all the known percentage changes in sectoral variables such as exports, imports, outputs and employment are incorporated simultaneously into the database. Unobservable variables such as technological change, export demand shift, twist variable, and labour productivity are made endogenous. In this final simulation, a new database is created at the end of the multi-step simulation through the update statements in the TABLO file of the model. Because the changes introduced into the database represent the sectoral and macroeconomic changes from 1985 to 1992, the new database reflects both the macroeconomic and sectoral structure of the economy for 1992.

5. New database for the Philippines

A by-product of historical simulations is a new database suitable for the

[13] An alternative to this procedure is a method, implemented by Horridge *et al.* (1995) in the IDCGEM model of South Africa, that allows the exogenisation of exports without polluting the export tax vectors.

Table 4 Summary of updated data (million Pesos)

Sector	Labour	Capital	Land	Indirect Tax	Investment	Consumption	Gov/ Invent	Export	Import	Sales	Output
1	19,851	12,549	7,664	1,098	–	153	(342)	1	0	51,203	51,203
2	8,800	4,435	3,126	(785)	–	2,177	–	13	205	19,788	19,788
3	3,423	1,994	693	160	–	113	(59)	645	–	6,778	6,778
4	3,722	2,327	580	330	–	179	–	–	–	9,103	9,103
5	2,095	1,086	94	360	–	1,574	–	2,483	–	4,783	4,783
6	29,560	28,951	1,984	3,301	15,010	39,843	(63)	4,179	14,369	78,895	78,895
7	10,914	12,744	–	905	3,699	5,628	118	1	193	45,915	45,915
8	6,927	17,413	–	856	6,485	12,761	24	4	425	38,137	38,137
9	20,610	26,139	–	2,420	–	54,535	–	5,192	68	68,838	68,838
10	1,947	1,294	–	685	1,218	247	1,046	418	266	7,777	7,777
11	1,231	989	–	748	–	–	89	2,364	–	5,858	5,858
12	3,371	2,811	–	663	–	57	1,644	5,102	–	9,908	9,908
13	108	25	–	45	–	–	(157)	406	87	262	262
14	91	64	–	9	–	–	243	796	–	1,515	1,515
15	45	25	–	41	–	–	70	9	142	275	275
16	954	1,430	–	84	–	50	(359)	157	121	4,190	4,190
17	1,272	3,120	–	1	–	639	223	8	40,010	6,521	6,521
18	26,625	35,771	–	8,973	–	170,711	570	27,289	18,272	237,384	237,384
19	1,544	4,120	–	3,046	–	21,693	(38)	208	652	21,532	21,532
20	1,566	1,517	–	3,111	–	15,832	116	84	293	16,312	16,312
21	3,139	2,718	–	1,273	991	6,042	(598)	7,950	25,226	18,825	18,825
22	9,693	7,146	–	903	–	19,906	(143)	30,016	11,019	38,534	38,534
23	2,053	2,197	–	172	–	89	(391)	780	107	5,306	5,306
24	1,513	1,206	–	68	4,191	1,782	10	3,091	21	9,125	9,125
25	1,528	3,150	–	496	–	1,209	(853)	1,551	6,059	15,346	15,346
26	2,204	2,342	–	289	358	2,593	(91)	140	1,238	10,840	10,840
27	122	130	–	16	–	907	(16)	72	2,216	538	538
28	1,511	1,670	–	607	–	5,877	(203)	298	3,733	9,457	9,457
29	6,007	8,699	–	4,099	–	23,637	(278)	5,498	34,373	48,744	48,744
30	1,869	23,650	–	30,983	–	21,863	(1,305)	3,551	13,913	84,745	84,745

31	2,342	6,065	–	342	842	1,273	(2,507)	1,088	1,112	20,374	20,374
32	1,505	3,896	–	1,007	–	302	(369)	7,314	14,540	29,888	29,888
33	2,074	2,483	–	525	4,073	1,900	(290)	206	7,476	13,608	13,608
34	1,449	1,614	–	248	20,065	200	(287)	1,350	16,916	6,946	6,946
35	9,016	10,915	–	4,455	27,660	15,657	1,157	72,755	86,691	82,601	82,601
36	1,949	2,469	–	312	8,604	3,009	(320)	1,301	8,053	12,083	12,083
37	2,276	2,399	–	560	2,978	1,925	(34)	8,469	5,968	8,920	8,920
38	36,055	21,049	–	4,424	114,867	507	–	6,214	859	122,760	122,760
39	5,163	19,351	–	(496)	–	13,919	–	–	–	52,592	52,592
40	782	1,249	–	13	–	1,374	–	–	–	2,920	2,920
41	19,618	17,531	–	3,082	2,987	68,683	–	12,200	11,527	82,425	82,424
42	3,278	4,031	–	572	731	4,522	–	8,759	322	14,902	14,902
43	772	1,925	–	188	–	7,123	–	12,026	3,506	16,888	16,888
44	4,288	3,411	–	586	702	2,617	–	8,175	2,917	10,937	10,937
45	2,671	12,136	–	558	–	6,031	–	4,499	1,907	17,382	17,382
46	64,541	147,624	–	12,773	17,012	145,196	–	34,867	(0)	299,108	299,108
47	13,209	7,663	–	5,501	–	8,997	–	16,105	12,960	36,947	36,947
48	2,277	4,486	–	680	–	2,698	–	9,570	–	11,602	11,602
49	3,846	4,065	–	652	–	6,588	–	735	2,000	13,504	13,504
50	4,697	9,092	–	2,329	–	16,144	–	5,631	1,307	41,098	41,098
51	–	38,842	–	–	–	44,134	–	–	–	44,134	44,134
52	57,729	1,051	–	6	–	80	91,468	–	–	92,330	92,330
53	5,478	2,231	–	241	–	13,517	–	166	119	14,082	14,082
54	4,585	5,405	–	245	–	16,450	–	454	380	17,549	17,549
55	3,721	3,993	–	784	–	2,992	–	3,265	5,132	17,480	17,480
56	5,641	9,031	–	1,942	–	10,009	–	11,893	5,753	18,916	18,916
57	8,304	8,137	–	874	–	18,922	–	2,383	3,708	29,591	29,591
58	5,770	4,749	–	1,229	–	21,453	–	29,384	24,118	32,667	32,667
59	1,610	854	–	52	–	3,007	–	592	117	4,408	4,408
Total	448,940	569,462	14,141	108,638	232,473	849,324	88,074	361,707	390,396	2,045,076	2,045,076

Note: Sector equivalents are shown in table 2.

Table 5 Summary of original data (million Pesos)

Sector	Labour	Capital	Land	Indirect Tax	Investment	Consumption	Gov/ Invent	Export	Import	Sales	Output
1	10,731	8,118	4,335	627	2,596	76	(208)	0	0	29,237	29,237
2	4,706	2,814	1,730	241	900	1,299	0	8	700	11,237	11,237
3	3,586	5,169	2,189	275	1,653	201	(70)	565	0	11,679	11,679
4	1,909	1,371	295	176	439	83	0	0	0	4,849	4,849
5	1,625	1,413	122	335	452	1,702	0	1,756	0	4,446	4,446
6	14,098	15,030	876	681	4,806	17,297	(30)	1,904	4,134	38,337	38,337
7	3,819	3,943	0	313	1,261	1,839	64	4	30	17,029	17,029
8	1,989	3,936	0	217	1,258	3,555	11	2	47	11,559	11,559
9	10,409	15,017	(0)	1,261	4,802	28,832	0	1,647	8	36,299	36,299
10	2,604	7,356	0	1,021	2,352	914	1,180	787	128	13,858	13,858
11	876	1,658	0	638	530	0	58	1,411	0	4,992	4,992
12	1,923	2,826	0	496	904	45	1,058	2,196	0	7,417	7,417
13	107	110	0	31	35	0	(101)	207	51	340	340
14	101	496	0	10	159	0	173	498	0	1,702	1,702
15	47	132	0	10	42	0	51	5	34	339	339
16	272	390	0	28	125	12	(146)	65	44	1,251	1,251
17	448	1,230	0	29	393	280	107	2	26,809	2,541	2,541
18	18,199	31,276	0	2,805	10,001	104,736	379	14,117	6,021	153,315	153,315
19	973	3,111	0	1,751	995	12,913	(26)	110	208	13,252	13,252
20	1,158	1,539	0	2,118	492	10,316	79	52	120	11,378	11,378
21	2,098	2,278	0	259	728	2,722	(380)	1,965	5,761	11,847	11,847
22	3,095	1,790	0	187	572	8,014	(79)	8,017	3,076	12,944	12,944
23	1,091	1,240	0	194	397	366	(727)	1,939	39	8,232	8,232
24	770	630	0	37	202	1,422	7	1,309	7	5,309	5,309
25	582	1,032	0	137	330	456	(521)	541	1,905	6,467	6,467
26	771	670	0	50	214	726	(44)	37	226	3,474	3,474
27	78	96	0	7	31	555	(12)	37	1,022	417	417
28	724	788	0	213	252	2,416	(119)	174	1,614	4,350	4,350
29	3,574	5,931	0	1,204	1,896	10,844	(187)	2,171	12,356	29,121	29,121
30	516	4,780	0	10,877	1,528	8,679	(965)	1,010	2,981	37,475	37,475
31	800	1,673	0	125	535	341	(1,174)	401	404	6,584	6,584

32	1,228	4,788	0	260	1,531	164	(322)	10,754	3,719	25,342	25,342
33	1,013	1,208	0	96	386	574	(161)	89	1,470	6,009	6,009
34	571	556	0	78	178	77	(160)	329	5,912	2,843	2,843
35	2,896	2,753	0	581	880	3,158	1,148	16,869	18,147	21,687	21,687
36	555	517	0	98	165	868	(152)	354	2,619	3,620	3,620
37	905	822	0	110	263	994	(21)	2,448	1,994	3,762	3,762
38	15,609	10,353	0	2,092	3,310	233	0	2,212	312	58,165	58,165
39	2,406	9,804	0	(224)	3,135	5,936	0	0	0	23,756	23,756
40	391	721	0	7	231	695	0	0	0	1,538	1,538
41	9,070	8,766	0	1,277	2,803	28,977	0	4,273	1,691	37,489	37,489
42	1,590	2,197	0	280	702	2,848	0	3,248	60	7,406	7,406
43	354	939	0	76	300	3,602	0	4,363	747	7,891	7,891
44	2,246	2,145	0	262	686	1,544	0	3,112	619	5,963	5,963
45	1,046	4,624	0	186	1,478	2,056	0	1,400	394	6,117	6,117
46	30,409	60,459	0	5,423	19,332	58,459	0	12,890	(0)	127,002	127,002
47	5,282	2,428	0	1,975	776	3,236	0	5,980	4,351	13,245	13,245
48	1,021	1,687	0	280	539	1,545	0	3,502	0	4,778	4,778
49	2,107	2,089	0	295	668	3,043	0	301	394	6,777	6,777
50	1,945	3,018	0	768	965	5,020	0	1,828	166	13,812	13,812
51	0	26,530	0	0	8,483	29,882	0	0	0	29,882	29,882
52	26,961	491	0	3	157	42	41,778	0	0	42,320	42,320
53	2,830	1,241	0	128	397	7,129	0	65	17	7,508	7,508
54	2,063	2,384	0	118	762	7,942	0	182	57	8,588	8,588
55	2,229	2,388	0	372	764	1,477	0	1,377	1,043	10,083	10,083
56	2,403	3,634	0	714	1,162	4,179	0	4,274	1,726	7,929	7,929
57	4,182	4,326	0	400	1,383	8,612	0	931	500	14,809	14,809
58	2,895	2,513	0	426	804	12,468	0	11,968	10,524	17,593	17,593
59	891	536	0	27	171	1,565	0	321	17	2,399	2,399
Total	218,779	291,760	9,546	42,461	93,290	416,961	40,490	136,010	124,206	1,019,590	1,019,590

Note: Sector equivalents are shown in table 2.

model presented earlier. This new database reflects the structure of the economy in 1992 rather than the base year since the observed variables imposed on the model are changes during the period 1985 to 1992. The creation of this new database was made possible by the incorporation of update statements in the TABLO file of the model allowing the database illustrated in figure 1 to change in accordance with the changes in the variables. The structure of the database is the same as the old IO table. Their properties, such as equality between sales and costs and GDP from income and expenditure sides, are preserved. Only the levels changed. A summary of the updated data is reported in table 4. The original data are displayed in table 5 to facilitate comparison.

5.1 A balanced database

An important question that may be asked is whether the database remained balanced after updating. The answer is definitely yes, provided that the updating is made correctly. To illustrate this observation, let us consider an example by Harrison and Pearson (1994c) illustrated below.

Suppose that Z refers to a variable in levels, z to percentage change in Z, z^* to the fractional change, and Z^* to the updated value of Z. From this we can infer that:

$$z^* = z/100, \text{ and} \tag{10}$$

$$Z^* = Z(1 + z/100) = Z(1 + z^*) \tag{11}$$

We apply these definitions to a case where the quantity demanded is equal to the quantity supplied, that is:

$$\Sigma_s Q_{cs} = \Sigma_t Y_{jt} \tag{12}$$

where $Q_j = P_j \times X_j$ and $Y_t = W_t \times N_t$ are flows in dollar values which usually constitute the database. The percentage and fractional changes in Q_j and Y_t are:

$$q_j = p_j + x_j \text{ and so } q_j^* = p_j^* + x_j^*, \tag{13}$$

Similarly:

$$y_t^* = w_t^* + n_t^* \tag{14}$$

The updated values are:

$$Q_j^* = Q_j(1 + p_j^* + x_j^*), \tag{15}$$

and

$$Y_t^* = Y_t(1 + w_t^* + n_t^*). \tag{16}$$

Table 6 Estimates of unobservable variables

Sector	Labour productivity	Technical and taste change	Foreign demand shift	Import/ domestic twist
1 Palay	−9.68	3.66	13.23	−99.97
2 Corn	−9.68	−11.81	85.27	−99.89
3 Coconut/copra in farms	−9.68	−35.08	−96.66	x
4 Sugarcane	−9.68	7.87	x	x
5 Banana	−9.68	−46.56	−40.14	x
6 Other crops incl. agric. services	−9.68	12.89	211.98	440.08
7 Livestock	−9.68	33.12	81.75	199.44
8 Poultry	−9.68	39.42	706.43	206.11
9 Fish and fishery products	−9.68	−12.92	510.47	498.65
10 Logs and other forest products	−9.68	−49.51	−99.28	423.04
11 Copper	−63.45	−40.44	112.24	x
12 Gold and other precious metals	−63.45	−58.96	225.37	x
13 Chromium ores	−63.45	−81.69	171.75	532.33
14 Nickel	−63.45	−76.39	−14.70	x
15 Other metallics	−63.45	−30.49	13.33	523.26
16 Sand, stone and gravel	−63.45	20.37	400.87	−23.37
17 Other non-metallic minerals	−63.45	−43.30	190.00	−80.59
18 Food manufactures	7.97	−17.74	39.32	151.69
19 Beverage products	7.97	−10.23	48.47	124.55
20 Tobacco manufactures	7.97	−21.24	27.35	76.93
21 Textiles and textile goods	7.97	11.69	148.91	406.66
22 Wearing apparel and footwear	7.97	12.03	242.51	163.52
23 Wood, cork and cane products	7.97	3.35	−98.89	758.49
24 Furntrs and fxtrs, primarily of wood	7.97	−31.34	11.39	113.53
25 Paper and paper products	7.97	20.43	551.57	91.38
26 Publishing and printing services	7.97	39.49	634.22	166.74
27 Leather and leather products	7.97	−8.54	−66.06	67.34
28 Rubber products	7.97	6.97	357.68	64.94
29 Chem. and chem. prod. except petroleum and coal	7.97	12.20	113.32	193.68
30 Products of petroleum and coal	7.97	62.09	185.17	203.10
31 Non-metallic mineral products	7.97	24.93	533.12	−20.07
32 Basic metal products	7.97	34.76	−98.46	245.96
33 Fabricated metal products	7.97	42.57	450.78	183.90
34 Machinery except electrical	7.97	15.67	560.54	27.90
35 Electrical machinery	7.97	103.59	597.12	50.80
36 Transport equipment	7.97	37.61	405.63	−42.07
37 Miscellaneous manufactures	7.97	−13.91	610.06	900.22
38 Construction	−32.26	−32.20	340.01	86.30
39 Electricity and gas	−15.22	−10.64	x	x
40 Water services	−15.22	−13.50	x	x
41 Land transport	−15.74	−9.70	81.74	417.63
42 Water transport services	−15.74	−45.76	89.30	404.72
43 Air transport services	−15.74	−20.51	84.73	442.55
44 Storage and services incidental to transport	−15.74	−29.99	89.30	624.72
45 Communication	−15.74	6.96	80.25	238.27
46 Trade	22.04	1.48	80.25	x
47 Banking services	23.55	36.63	81.74	15.47

Table 6 *Continued*

Sector	Labour productivity	Technical and taste change	Foreign demand shift	Import/ domestic twist
48 Non-bank services	23.55	−44.06	81.74	x
49 Insurance services	23.55	7.84	80.25	373.33
50 Real estate services	23.55	13.03	81.74	347.58
51 Ownership of dwelling	x	9.50	x	x
52 Government services	0.28	−26.97	22.73	x
53 Private education services	0.28	−19.04	191.22	399.41
54 Private health services	0.28	−3.59	184.30	337.11
55 Private business services	23.55	5.44	115.55	342.43
56 Recreational services	0.28	6.78	81.74	161.09
57 Private personal services	0.28	−0.52	81.74	453.38
58 Restaurants and hotels	0.28	−18.30	81.74	352.69
59 Other private services	0.28	−9.63	117.57	474.01

Note: x = Not applicable due to zero values for employment, import or export.

Because equation 15 holds, its linearised form must be a consequence of one or more of the linearised equations of the model. Thus the simulation results have the property that:

$$\Sigma_s(P_{cs} \times X_{cs}/C)(p_{cs} + x_{cs}) = \Sigma_t(W_{jt} \times N_{jt}/C)(w_{jt} + n_{jt}) \tag{17}$$

where C is the total of either side of equation 11 above. It follows that:

$$\begin{aligned} \Sigma_s Q^*_{cs} &= \Sigma_s Q_{cs}(1 + p^*_{cs} + x^*_{cs}) \\ &= \Sigma_s Q_{cs} + \Sigma_s Q_{cs}(p^*_{cs} + x^*_{cs}) \\ &= \Sigma_t Y_{jt} + \Sigma_t Y_{jt}(w^*_{jt} + n^*_{jt}) \\ &= \Sigma_t Y^*_{jt} \end{aligned} \tag{18}$$

Hence, the updated data are balanced and they will remain so in the n-step simulations. This is seen in the updated data reported in table 4 where for all commodities, domestic sales are equal to domestic output and GDP from income is equal to the GDP from expenditure side.

6. Conclusion

In this article, we demonstrated the updating of an IO table of the Philippines by simulation. One of the advantages of using the CGE model in the updating process is that the properties and compatibility of the updated IO table with the specifications of the model are preserved. It is also a convenient process of updating when an existing CGE model and its associated database are already available.

The methodology employed enables modellers to routinely update the IO tables whenever the latest economic statistics are made available. However, due to the rarely complete economic statistics, the methodology offers only a proxy for the real IO tables. In our case, we only managed to collect information on changes in output, imports, exports, employment and some prices. Most of these variables are concerned with the demand side of the economy. We were unable to obtain detailed information on the supply side such as industry employment, capital stock, and land utilisation.

The updated table which now reflects the latest structure of the economy is suited for sectoral policy analysis, particularly for the agricultural sector which is vulnerable to numerous factors such as weather conditions, pests and diseases and the globalisation of trade. The updated database provides, additionally, a good basis for forecasting using a CGE model.

There are other opportunities that may arise from this methodology which we did not consider in this article. The procedure generates estimates of unobservable variables which provide information about the productivity changes, technical and taste changes and shifts in export demand. These unobservable variables can be used to explain the pattern of structural change in the Philippines from 1985 to 1992. For example, macroeconomic and sectoral changes can be decomposed into impacts of productivity changes, technological and taste changes, shifts in export demand and other variables. Such methods of studying structural change may be found in Buetre (1996) for the case of the Philippines and in Dixon and McDonald (1993b) and Parmenter *et al.* (1990) for the case of Australia.

Appendix
Relevant equations and variables in historical simulations

A. Equations

```
Equation E_ac_c
Sum(i,IND, Sum(c,COM,(V1PUR_S(c,i)+V2PUR_S(c,i)) * {ac(c) - ac_c})) = 0 ;

Equation E1_ac # Uniform Input using Tech Changes #
(All,c,COM)(All,s,SRC)(All,i,IND) a1(c,s,i) = ac(c) + fa1(c,s,i);

Equation E2_ac # Uniform Input using Tech Changes #
(All,c,COM)(All,s,SRC)(All,i,IND) a2(c,s,i) = ac(c) + fa2(c,s,i);

Equation E3_ac # Uniform Taste Changes #
(All,c,COM) ffx3_s(c) = ac(c) + fa3(c);

Equation E_x0impObs # Exogenous imports #
(All,c,COM) x0imp(c) = x0impObs(c) + fx0imp;

Equation E_x4Obs # Exogenous imports #
(All,c,TRADEXP) x4(c) = x4Obs(c) + ff4q;

Equation E_employ9 # Employment in 9 wide groups #
(All,l,LAB9) Sum(i,IND:IND_TO_LAB9(i) EQ ORD9(l), {TINY+V1LAB_O(i)} *
{ employ9(l) - x1lab_o(i)} ) = 0;
```

```
Equation E_f_lab9
# labour productivity shift, uniform within each of 9 ind groups #
(All,i,IND) Sum(l,LAB9:IND_TO_LAB9(i) EQ ORD9(l), { a1lab_o(i) - a1lab9(l)} )
= f_lab9(i);

Equation E1_cneutral # Allows Cost Neutral ac Shift #
(All,i,IND) Sum(c,COM,(V1PUR_S(c,i)/V1TOT(i))*ac(c)) = -a1tot(i) + fac1(i);

Equation E_x0dom # Total output of domestic commodities #
(all,c,COM) MAKE_I(c)*x0dom(c) = Sum(i,IND, MAKE(c,i)*q1(c,i));

Equation E_p0_B # Demand equals supply for commodities #
(All,c,COM) SALES(c)*x0dom(c) = Sum(i,IND,V1BAS(c,"dom",i)*x1(c,"dom",i)
+ V2BAS(c,"dom",i)*x2(c,"dom",i)) + V3BAS(c,"dom")*x3(c,"dom")
+ [ V4BAS(c)+TINY]*x4(c) + V5BAS(c,"dom")*x5(c,"dom");

Equation E_x1prim # Demands for primary factor composite #
(All,i,IND) x1prim(i) - { (a1prim(i) + a1primgen) + a1tot(i)} = x1tot(i);

Equation E_p1tot # Zero pure profits in production #
(All,i,IND)V1TOT(i)*{ p1tot(i)-a1tot(i)} = Sum(c,COM, V1PUR_S(c,i)
*{ p1_s(c,i) + a1_s(c,i)} ) + V1PRIM(i)*{ p1prim(i) + (a1prim(i) + a1primgen)} +
V1OCT(i) *{ p1oct(i) + a1oct(i)} ;

Equation E_x2tot # investment/capital accumulation #
(All,i,IND) x1cap(i) = K_TERM(i)*delFudge + M_term(i)*R_T(i)*x2tot(i) +
f_accum(i) + ff_accum;

Equation E_f5tot # Overall "Other" demands shift #
f5tot = x3tot + f5tot2;

Equation E_twist_src
#Allows import/domestic twists to be determined by agg. import forecast #
(All,c,COM) twist_src(c) = twist_src_bar + ftwist_src(c);

Equation E_x4_A # Traditional export demand functions #
(All,c,TRADEXP) x4(c) - f4q(c) = EXP_ELAST(c)*[ p4(c) - phi - f4p(c)] +
f4q_general;

Equation E_r1cap # capital growth rates related to rates of return #
(All,i,IND)(r1cap(i) - r1cap_i) = BETA_R(i)*[ x1cap(i) - x1cap_i] + f1ret(i);

E_employ_i # aggregate employment,wage bill weights #
V1LAB_IO*employ_i= Sum(i,IND,V1LAB_O(i)*employ(i));

Equation E_x1 # Source-Specific Commodity Demands #
(All,c,COM)(All,s,SRC)(All,i,IND)
x1(c,s,i)-a1(c,s,i) = x1_s(c,i) - SIGMA1(c)*{ p1(c,s,i)+a1(c,s,i) - p1_s(c,i)}
- { SOURCEDOM(s) - S1(c,"dom",i) }*twist_src(c);

Equation E_x2 # Source-Specific Commodity Demands #
(All,c,COM)(All,s,SRC)(All,i,IND)
x2(c,s,i)-a2(c,s,i) - x2_s(c,i) = - SIGMA2(c)*{ p2(c,s,i)+a2(c,s,i) -
p2_s(c,i)} - { SOURCEDOM(s) - S2(c,"dom",i)}*twist_src(c);

Equation E_x3 # Source-Specific Commodity Demands #
(All,c,COM)(All,s,SRC)x3(c,s)-a3(c,s) = x3_s(c) - SIGMA3(c)*{ p3(c,s)+a3(c,s)
- p3_s(c) }
-{ SOURCEDOM(s) - S3(c,"dom") }*twist_src(c);

Equation E_x3_s # Total Household demand for composite commodities #
(All,c,COM) x3_s(c) = B3LUX(c)*x3lux(c) +[ 1-B3LUX(c)]*x3sub(c)+ ffx3_s(c);
```

B. Variables

```
a1primgen     # All-industry all-factor augmenting technical change #;
employ_i      # Aggregate Employment- Wage Bill Weights #;
f4q_general   # General export shifter #;
f5tot         # Overall Shift Term For "Other" Demands #;
f5tot2        # Ratio between f5tot and x3tot #;
ff_accum      # General capital Accumulation Shifter #;
ff4q          # Scaling variable for Exports, traditional #;
fx0imp        # Scaling variable for Imports #;
phi           # Exchange Rate, Peso/$world #;
r1cap_i       # Average Rate of Return #;
twist_src_bar # Common twist #;
x1cap_i       # Aggregate Capital Stock, Rental Weights #;
x3tot         # Real Household Consumption #;
(All,c,COM) ac(c)          # Uniform Taste/Tech Shifter #;
(All,c,COM) f4p(c)         # Price (upward) Shift in Export Demand
(All,c,COM) fa3(c)         # Household Shift #;
(All,c,COM) ffx3_s(c)      # Taste Shift Variables #;
(All,c,COM) p3_s(c)        # Effective price of composite, Household #;
(All,c,COM) p4(c)          # Exports, Peso #;
(All,c,COM) x0dom(c)       # Total Supplies of Domestic Goods #;
(All,c,COM) x0imp(c)       # Total Supplies of Imported Goods #;
(All,c,COM) x0impObs(c)    # Observed imports #;
(All,c,COM) x3_s(c)        # Composite demand, Household #;
(All,c,COM) x3lux(c)       # Household - Supernumerary Demands #;
(All,c,COM) x3sub(c)       # Household - Subsistence Demands #;
(All,c,COM) x4(c)          # Export #;
(All,c,COM) ftwist_src(c) # Twist shift - see 'shift twist' #;
(All,c,COM) twist_src(c)   # Source composition twister by commodity #;
(All,c,TRADEXP)f4q(c)      # Quantity (right) Shift in Export Demands #;
(All,c,TRADEXP)x4Obs(c)    # Observed exports, traditional #;
(All,i,IND) a1lab_o(i)     # Labour Augmenting Technical Change #;
(All,i,IND) a1oct(i)       # Other Costs Augmenting Technical Change #;
(All,i,IND) a1prim(i)      # All Factor Augmenting Technical Change #;
(All,i,IND) a1tot(i)       # All Input Augmenting Technical Change #;
(All,i,IND) employ(i)      # Employment by Industry #;
(All,i,IND) f_accum(i)     # Capital Accumulation Shifter #;
(All,i,IND) f_lab9(i)      # labour productivity shift, uniform within each of 9
                             ind groups #;
(All,i,IND) f1ret(i)       # Rate of Return Shifter #;
(All,i,IND) fac1(i)        # Cost-Neutral "ac" Shifter Intermediate #
(All,i,IND) p1oct(i)       # Other Costs #;
(All,i,IND) p1prim(i)      # Effective Price of Primary Factor Composite #;
(All,i,IND) p1tot(i)       # Average Input/Output Price #;
(All,i,IND) r1cap(i)       # Current Rates of Return on Fixed Capital #;
(All,i,IND) x1cap(i)       # Current Capital Stock #;
(All,i,IND) x1lab_o(i)     # Effective Labour Input #;
(All,i,IND) x1prim(i)      # Primary Factor Composite #;
(All,i,IND) x1tot(i)       # Activity Level or Value-Added #;
(All,i,IND) x2tot(i)       # Investment by Using Industry #;
(All,l,LAB9) a1lab9(l)     # labour productivity shift, uniform within each of 9
                             ind groups #;
(All,l,LAB9) employ9(l)    # Employment in 9 wide groups #;
(Change)delFudge # "Fudge Factor": set to Unity for dynamic simulation #;
```

```
(All,c,COM)(All,i,IND) a1_s(c,i) # Tech Change, Intermediate composite #;
(All,c,COM)(All,i,IND) p1_s(c,i) # Effective price of composite,
                                  Intermediate #;
(All,c,COM)(All,i,IND) p2_s(c,i) # Effective price of composite, Investment #;
(All,c,COM)(All,i,IND) q1(c,i)   # Output of commodity c by industry i #;
(All,c,COM)(All,i,IND) x1_s(c,i) # Composite demand, Intermediate #;
(All,c,COM)(All,i,IND) x2_s(c,i) # Composite demand, Investment #;
(All,c,COM)(All,s,SRC) a3(c,s)   # Taste change #;
(All,c,COM)(All,s,SRC) p3(c,s)   # Purchaser price, Household #;
(All,c,COM)(All,s,SRC) x3(c,s)   # Basic demand, Household #;
(All,c,COM)(All,s,SRC)(All,i,IND) a1(c,s,i)  # Tech change, Intermediate #;
(All,c,COM)(All,s,SRC)(All,i,IND) a2(c,s,i)  # Tech change, Investment #;
(All,c,COM)(All,s,SRC)(All,i,IND) fa1(c,s,i) # Intermediate Shift #;
(All,c,COM)(All,s,SRC)(All,i,IND) fa2(c,s,i) # Investment Shift #;
(All,c,COM)(All,s,SRC)(All,i,IND) p1(c,s,i) # Purchaser price, Intermediate #;
(All,c,COM)(All,s,SRC)(All,i,IND) p2(c,s,i)  # Purchaser price, Investment #;
(All,c,COM)(All,s,SRC)(All,i,IND) x1(c,s,i)  # Basic demand, Intermediate #
(All,c,COM)(All,s,SRC)(All,i,IND) x2(c,s,i)  # Basic demand, Investment #;
```

C. Coefficients

```
V1LAB_IO                    # total payments to labour #;
(All,c,COM) B3LUX(c)        # supernumerary expenditure commodity c/total
                             expenditure commodity c #;
(All,c,COM) EXP_ELAST(c) # Export Demand Elasticities #;
(All,c,COM) SALES(c)        # Total sales of domestic commodity c #;
(All,c,COM) SIGMA1(c)       # Armington elasticities: Intermediate #;
(All,c,COM) SIGMA2(c)       # Armington elasticities: Investment #;
(All,c,COM) SIGMA3(c)       # Armington elasticities: Households #;
(All,c,COM) V4BAS(c)        # Export       #;
(All,c,COM) V4PUR(c)        # Export       #;
(all,i,IND) BETA_R(i)       # Elasticity of required ROR #;
(All,i,IND) V1OCT(i)        # Other Costs #;
(All,i,IND) K_TERM(i)       # delFudge coefficient #;
(All,i,IND) M_term(i)       # useful constant #;
(All,i,IND) R_T(i)          # investment/capital ratio #;
(All,i,IND) V1LAB_O(i)      # total labour bill in industry i #;
(All,i,IND) V1PRIM(i)       # total factor input to industry i#;
(All,i,IND) V1TOT(i)        # total cost in each industry #;
(All,s,SRC) SOURCEDOM(s) # Equals 1 if s = "dom", else 0 #;
(All,s,SRC) SOURCEIMP(s) # Equals 1 if s = "imp", else 0 #;
(Integer)(All,l,LAB9) ORD9(l) # natural numbers 1 to 9 #;
(Inteter)(All,I,IND) IND_TO_LAB9(i) # element of LAB9 containing industry i #;
(All,c,COM)(All,i,IND) MAKE(c,i) # production of com c by industry i #;
(All,c,COM)(All,s,SRC) S3(c,s)     # Source share, household;
(All,c,COM)(All,s,SRC) V3BAS(c,s) # Households   #;
(All,c,COM)(All,s,SRC) V3PUR(c,s) # Households   #;
(All,c,COM)(All,s,SRC) V5BAS(c,s) # Other Demand #;
(All,c,COM)(All,s,SRC)(All,i,IND) S1(c,s,i) # Source share, intermediate #;
(All,c,COM)(All,s,SRC)(All,i,IND) S2(c,s,i) # Source share, investment #;
(All,c,COM)(All,s,SRC)(All,i,IND) V1BAS(c,s,i) # Intermediate #;
(All,c,COM)(All,s,SRC)(All,i,IND) V1PUR(c,s,i) # Intermediate #;
(All,c,COM)(All,s,SRC)(All,i,IND) V2BAS(c,s,i) # Investment   #;
(All,c,COM)(All,s,SRC)(All,i,IND) V2PUR(c,s,i) # Investment   #
```

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