QUANTITY AND PRICE EFFECTS IN AN ANALYSIS OF WORLD TRADE BASED ON AN ACCOUNTING MATRIX*

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This paper describes the construction of an accounting matrix for the world economy in 1977, cast along similar lines to SNA National Accounts, but one in which trade flows replace inter-industry flows as intermediate demand. The matrix distinguishes ten regions. Institutional accounts are presented for three of these, the European Community, North America and Japan. This matrix is used to provide the basis of a linear model in which average propensities to import and consume are replaced by estimated marginal propensities. Use is made of standard estimates of the income effects of terms of trade changes in order to distinguish substitution from income effects in the model, and a means is suggested for separating the full as well as the impact effects of a terms of trade change into income and substitution effects. The estimated import equations are used to derive estimates of regional growth rates compatible with external balance in each region. Multiplier matrices are calculated from the model showing regional interdependence of the world economy reflecting the pattern of trade which is identified in the marginal propensities to import.

The effects of various aid policies are calculated using the model. It is shown that the cost of aid to any region is radically altered by taking into account the feedback effects of changes in demand. A policy of tied aid pursued by EEC, North America and Japan can actually lead to an improvement in Japan's balance of payments position. Finally the effects of movements in relative prices are illustrated by means of two examples.

1. INTRODUCTION

Linear models of the world economy have now a long tradition going back to Metzler [12]. They remain valuable for the simplicity and clarity they offer, which tends to be lacking in non-linear models, and provide a suitable framework for expressing concisely the effects of exogeneous changes on aggregates of interest.

This paper describes a model based on a world accounting matrix and extending the analysis of Pyatt and Round [14.15] to a situation where prices, although remaining exogeneous, may vary. In particular the effects of various aid policies are estimated and the treatment of price changes means it is possible to identify the income and substitution effects of movements in the terms of trade and thus make a direct comparison with transfer payments; the extension of a conventional national (or regional) social accounting matrix to an international framework enables, for example, the assessment of increased aid to take place under various assumptions about the associated budgetary stance taken in the developed world. Extending the analysis by Goodwin [5] of Thorbecke and Field's [18] linear trade model one can, in an international framework, highlight the hazards of domestic deflation as a route to budgetary balance in addition to seeing its consequences if used to achieve external balance.

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2. A World Accounting Matrix

The basis of this linear model of the world economy is a set of accounts derived from the United Nations System of National Accounts and cast in matrix form. The full model identifies the following ten regions:

1. EEC (excluding Greece)
2. North America
3. Japan
4. Other Europe
5. Australia, New Zealand and the Republic of South Africa
6. Middle East
7. Latin America
8. Other Africa
9. Other Asia
10. Communist States (considered exogenous).

Institutional accounts for the following sectors

1. Personal
2. Industrial and Commercial Companies
3. Financial Companies
4. Government
5. Rest of the World

are identified for the first three regions while for regions 4 to 9 only a consolidated national income account is shown. Full details of the accounts and the way in which the accounting matrix is derived are presented in Appendix 1. However a consolidated world accounting matrix is given in Table 1 below, with the endogeneous regions aggregated into three groups of three and the institutional sectors consolidated into just two. Its major difference from a national accounting matrix is that trade flows appear as intermediate rather than final demand. Transfers which cannot be allocated on a bilateral basis are shown in row 23 while row 33 covers the accounting discrepancies which are not usually separately identified.

3. The Linear Model

Pyatt and Round showed how an accounting matrix can be used as a basis for a linear model. If the accounts are split into endogenous and exogenous accounts and it is assumed that the expenditure shares implicit in each column of the matrix represent average propensities to spend, the economy can be represented as a set of linear equations of the form

$$y = Ay + x$$

where A = matrix of average propensities derived from the accounting matrix, y = vector of endogenous account totals and x = vector of exogenous receipts by each endogenous account.

Where there is separate information on marginal shares the model may be improved by respecifying as

$$y = My + x + c$$

TABLE 1

WORLD ACCOUNTING MATRIX 1977, MILLION U.S.$

			1	2	3	4	5	6	7	8	9	10	11	12
1	Production	Region 1	0	0	0	128,801	25,273	351,576	126,917	115,514	0	0	0	0
2		Region 2	0	0	0	61,192	12,122	123,588	37,520	32,706	0	0	0	0
3		Region 3	0	0	0	35,671	9,090	116,780	16,150	37,316	0	0	0	0
4	Services Trade		137,666	56,734	31,980	0	0	0	0	0	0	0	0	0
5	Goods Trade	Comm. Bloc	21,212	15,235	10,983	0	0	0	0	0	0	0	0	0
6		Region 1	351,576	126,917	115,514	0	0	0	0	0	0	0	0	0
7		Region 2	123,588	37,520	32,706	0	0	0	0	0	0	0	0	0
8		Region 3	116,780	16,150	37,316	0	0	0	0	0	0	0	0	0
9	Region 1	Private	0	0	0	0	0	0	0	0	2,501	0	2,556,020	1,370,314
10	EEC	Government	0	0	0	0	0	0	0	0	0	2,063	0	45,976
11	N. America	Empl. Inc.	2,554,593	0	0	0	0	0	0	0	0	0	0	0
12	Japan	Surplus	1,416,290	0	0	0	0	0	0	0	0	0	0	0
13		Ind. Taxes	390,327	0	0	0	0	0	0	0	0	0	0	0
14		Dir. Taxes	0	0	0	0	0	0	0	0	554,592	0	0	0
15		Other Transfers	0	0	0	0	0	0	0	0	1,511,193	707,796	0	0
16		Consumption	0	0	0	0	0	0	0	0	2,659,627	744,843	0	0
17	Region 2	Regional Income	0	890,256	0	0	0	0	0	0	168	1,513	0	0
18	Oth. Eur.	Gov. Consumption	0	0	0	0	0	0	0	0	0	0	0	0
19	A-NZ-RSA M.E.	Pvt. Consumption	0	0	0	0	0	0	0	0	0	0	0	0
20	Region 3	Regional Income	0	0	903,611	0	0	0	0	0	1,117	11,126	0	0
21	L. America	Gov. Consumption	0	0	0	0	0	0	0	0	0	0	0	0
22	Afr. Asia	Pvt. Consumption	0	0	0	0	0	0	0	0	0	0	0	0
23	International Transfers		0	0	0	0	0	0	0	0	0	0	−1,427	0
24	Saving	Region 1 Pvt.	0	0	0	0	0	0	0	0	898,278	0	0	0
25		Gov.	0	0	0	0	0	0	0	0	0	54,667	0	0
26		Region 2	0	0	0	0	0	0	0	0	0	0	0	0
27		Region 3	0	0	0	0	0	0	0	0	0	0	0	0
28	Investment	Region 1	0	0	0	0	0	0	0	0	0	0	0	0
29		Region 2	0	0	0	0	0	0	0	0	0	0	0	0
30		Region 3	0	0	0	0	0	0	0	0	0	0	0	0
31	Net Acquisition of Financial Assets		0	0	0	0	0	0	0	0	0	0	0	0
32	Goods Balance		0	0	0	0	0	0	0	0	0	0	0	0
33	Unallocated		0	0	0	0	0	0	0	0	0	0	0	0
34	Total		5,112,032	1,142,812	1,132,110	225,664	46,485	591,944	180,587	185,536	5,627,536	1,522,008	2,554,593	1,416,290

TABLE 1 (*continued*)

			13	14	15	16	17	18	19	20	21	22	23	24
1	Production	Region 1	0	0	0	3,404,470	0	0	0	0	0	0	0	0
2		Region 2	0	0	0	0	0	160,874	481,213	0	0	0	0	0
3		Region 3	0	0	0	0	0	0	0	0	109,576	597,718	0	0
4	Services Trade		0	0	0	0	0	0	0	0	0	0	0	0
5	Goods Trade	Comm. Bloc	0	0	0	0	0	0	0	0	0	0	0	0
6		Region 1	0	0	0	0	0	0	0	0	0	0	0	0
7		Region 2	0	0	0	0	0	0	0	0	0	0	0	0
8		Region 3	0	0	0	0	0	0	0	0	0	0	0	0
9	Region 1	Private	0	0	1,698,698	0	15	0	0	0	0	0	0	0
10	EEC	Government	390,578	554,966	528,426	0	0	0	0	0	0	0	0	0
11	N. America	Empl. Inc.	0	0	0	0	0	0	0	0	0	0	0	0
12	Japan	Surplus	0	0	0	0	0	0	0	0	0	0	0	0
13		Ind. Taxes	0	0	0	0	0	0	0	0	0	0	0	0
14		Dir. Taxes	0	0	0	0	0	0	0	0	0	0	377	0
15		Other Transfers	0	0	0	0	0	0	0	0	0	0	73,974	0
16		Consumption	0	0	0	0	0	0	0	0	0	0	0	0
17	Region 2	Regional Income	0	0	0	0	1,418	0	0	163	0	0	17,061	0
18	Oth. Eur.	Gov. Consumption	0	0	0	0	160,874	0	0	0	0	0	0	0
19	A–NZ–RSA M.E.	Pvt. Consumption	0	0	0	0	481,213	0	0	0	0	0	0	0
20	Region 3	Regional Income	0	0	0	0	5,704	0	0	468	0	0	5,281	0
21	L. America	Gov. Consumption	0	0	0	0	0	0	0	109,576	0	0	0	0
22	Afr. Asia	Pvt. Consumption	0	0	0	0	0	0	0	597,718	0	0	0	0
23	International Transfers		−251	0	65,839	0	20,111	0	0	26,110	0	0	0	0
24	Saving	Region 1 Pvt.	0	0	0	0	0	0	0	0	0	0	0	0
25		Gov.	0	0	0	0	0	0	0	0	0	0	0	0
26		Region 2	0	0	0	0	241,246	0	0	0	0	0	0	0
27		Region 3	0	0	0	0	0	0	0	193,332	0	0	0	0
28	Investment	Region 1	0	0	0	0	0	0	0	0	0	0	0	825,868
29		Region 2	0	0	0	0	0	0	0	0	0	0	0	0
30		Region 3	0	0	0	0	0	0	0	0	0	0	0	0
31	Net Acquisition of Financial Assets		0	0	0	0	0	0	0	0	0	0	0	72,410
32	Goods Balance		0	0	0	0	0	0	0	0	0	0	0	0
33	Unallocated		0	0	0	0	0	0	0	0	0	0	0	0
34	Total		390,327	554,966	2,292,963	3,404,470	910,581	160,874	481,213	927,367	109,576	597,718	96,693	898,278

TABLE 1 (*continued*)

			25	26	27	28	29	30	31	32	33	34
1	Production	Region 1	0	0	0	959,462	0	0	0	0	19	5,112,032
2		Region 2	0	0	0	0	233,600	0	0	0	−3	1,142,812
3		Region 3	0	0	0	0	0	209,814	0	0	−5	1,132,110
4	Services Trade		0	0	0	0	0	0	0	0	−716	225,664
5	Goods Trade	Comm. Bloc	0	0	0	0	0	0	0	−945	0	46,485
6		Region 1	0	0	0	0	0	0	0	−2,063	0	591,944
7		Region 2	0	0	0	0	0	0	0	−13,227	0	180,587
8		Region 3	0	0	0	0	0	0	0	15,290	0	185,536
9	Region 1	Private	0	0	0	0	0	0	0	0	−12	5,627,536
10	EEC	Government	0	0	0	0	0	0	0	0	−1	1,522,008
11	N. America	Empl. Inc.	0	0	0	0	0	0	0	0	0	2,554,593
12	Japan	Surplus	0	0	0	0	0	0	0	0	0	1,416,290
13		Ind. Taxes	0	0	0	0	0	0	0	0	0	390,327
14		Dir. Taxes	0	0	0	0	0	0	0	0	−3	554,966
15		Other Transfers	0	0	0	0	0	0	0	0	0	2,292,963
16		Consumption	0	0	0	0	0	0	0	0	0	3,404,470
17	Region 2	Regional Income	0	0	0	0	0	0	0	0	2	910,581
18	Oth. Eur.	Gov. Consumption	0	0	0	0	0	0	0	0	0	160,874
19	A-NZ-RSA M.E.	Pvt. Consumption	0	0	0	0	0	0	0	0	0	481,213
20.	Region 3	Regional Income	0	0	0	0	0	0	0	0	0	927,367
21	L. America	Gov. Consumption	0	0	0	0	0	0	0	0	0	109,576
22	Afr. Asia	Pvt. Consumption	0	0	0	0	0	0	0	0	0	597,718
23	International Transfers											
24	Saving	Region 1 Pvt.	0	0	0	0	0	0	0	0	0	898,278
25		Gov.	0	0	0	0	0	0	0	0	0	54,667
26		Region 2	0	0	0	0	0	0	0	0	0	241,246
27		Region 3	0	0	0	0	0	0	0	0	0	193,332
28	Investment	Region 1	133,595	0	0	0	0	0	0	0	−1	959,462
29		Region 2	0	233,600	0	0	0	0	0	0	0	233,600
30		Region 3	0	0	209,814	0	0	0	0	0	0	209,814
31	Net Acquisition of Financial Assets		−78,928	7,646	−16,482	0	0	0	0	0	15,354	0
32	Goods Balance		0	0	0	0	0	0	0	0	0	0
33	Unallocated		0	0	0	0	0	0	0	945	0	0
34	Total		54,667	241,246	193,332	959,462	233,600	209,814	0	0	0	0

where y_0, x_0 are the base values of y and x, $M = A$ with marginal propensities substituted for average propensities where possible and c = vector of constants associated with marginal propensities $= y_0 - Mx_0$.

Thus far the model is fixed-price, but the matrix based model can be extended to accommodate both the income and substitution effects of price changes. Gutmann [6] and Hibbert [7] surveys methods of measuring the income effect of terms of trade changes. The adjustment proposed by Geary [4] derives the income transfer of a terms of trade change as

$$(E+M)\frac{(p_e - p_m)}{(p_e + p_m)}$$

where E = export volume, M = import volume, p_e = price index of exports and p_m = price index of imports and ensures that gains over the whole world sum to zero and the gain is independent of the regional aggregation. Further linearity in quantities is maintained.

Thus import equations of the type

$$M_{ij} = m_{ij}Y_j + n_{ij}P_{ij}Y_j + c_{ij}$$

can be estimated where Y_j = real national income of region j (allowing for terms of trade effects), P_{ij} = price of exports of region i relative to those of region j and M_{ij} = import volume from region i by region j.

In this equation $m_{ij} + n_{ij}$ is a volume marginal propensity to import and n_{ij} represents the substitution effects of relative price changes. Point elasticities can be derived. No cross substitution effects are identified. For convenience subsequent estimation proceeds with Y_j representing final demand adjusted for terms of trade effects rather than real income. This maintains the analogy with an input–output system more closely.

Import equations of this type together with simple marginal propensities to consume can be incorporated to yield a model in which the volume, income and substitution effects are separately identified using the expression for the terms of trade gain given above and expressing import and export volumes in terms of regional real income as

$$y = M_1 y + M_2 y + M_3 y + x + c + \Delta c$$

where M_1 = matrix of volume propensities to spend,[1] M_2 = matrix of income effects, M_3 = matrix of substitution effects, Δc = effect of terms of trade changes on constant terms and y = vector of endogenous account totals.

Full details of this derivation are presented in Appendix 2. The solution to the equation is given as

$$y = (I - M_1 - M_2 - M_3)^{-1}(x + c + \Delta c).$$

If the relative price changes are small so that second order effects can be neglected and a marginal change to x is considered, the solution can be expressed

[1]This incorporates marginal propensities to import and consume and otherwise uses the average propensities derived from the accounting matrix.

as

$$\Delta y = N_1\Delta x + N_1\Delta c + \Delta N_2 N_1(x+c) + \Delta N_3 N_1(x+c)$$

where $N_1 = (I - M_1)^{-1}$, $N_2 = N_1 M_2$ and $N_3 = N_1 M_3$ where $\Delta N_2 N_1(x+c)$ represents additions and subtractions to y due to substitution effects and $N_1\Delta c + N_2 N_1(x+c)$ those due to the income effects of price changes.

Financial balances are derived from the multipliers. The accumulation of financial assets derived from a unit exogenous receipt is 1—the sum of endogenous payments (Goodwin [5]) for those accounts which are endogenous to the system. Since Government accounts of the three major regions are exogenous the effect on Government income is given by the sum of the leakages from the endogenous accounts to the Government sectors, and this represents a financial accumulation. The financial savings of each region are expressed as the sums of the savings of each sector within the region concerned. This yields the balance of payments surplus on the current account.

Algebraically, for the endogeneous accounts, a financial saving multiplier is given as $(I - i\hat{A})(I - \hat{A})^{-1}$ where the model is expressed compactly as $y = Ay + x$ and $i\hat{A}$ represents diagonalisation of the column sums.

For the Government accounts the financial saving multiplier is $B(I - A)^{-1}$ where B represents the leakages from the endogeneous accounts to the Government accounts.

When prices are varied (and exogenous demand is not) the variation in y is given as

$$(\Delta N_2 + \Delta N_3) N_1(x + c + \Delta c)$$

and the variations in financial balances are again $(I - i\hat{A})(\Delta N_2 + \Delta N_3) N_1(x + c + \Delta c)$ for the endogenous accounts and $B(\Delta N_2 + \Delta n_3) N_1(x + c + \Delta c)$ for the Government accounts. These balances are in real terms. As Geary [4] shows the specification of the income effect implies external trade balance deflation from money prices by $(p_i + p_j)/2$ for each pair of trading partners.

4. Trade and Consumption Propensities

The propensities to import are estimated in Table 2 using data for the period 1963 to 1978. Trade and price data are provided in the United Nations Yearbook of International Trade Statistics [22] and the components of regional final demand in the Yearbooks of National Accounts Statistics [23], although adjustments are needed to take account of different EEC composition before 1973. The income effects of changes in the terms of trade are calculated using Geary's formula applied to the flows derived from the trade matrices—it is not possible to take account of variations in the relative price of service trade.

In view of the small number of observations it does not seem practical to estimate equations with lags and this may to some extent lead to an underestimation of the substitution effects of price changes. The estimated import equation is

$$M_{ijt} = m_{ij} Y_{jt} + n_{ij} P_{ijt} Y_{jt} + c_{ij}$$

M_{ijt} = constant price imports by region j from region i in year t, Y_{jt} = terms of

TABLE 2

PROPENSITIES TO IMPORT

		Importing regions								
	A. Quantity effects	EEC	North America	Japan	Other Europe	A–NZ–RSA	Middle East	Latin America	Africa	Asia
Exporting regions	EEC	0.15490 (36.38)	0.02751 (4.20)	0.01860 (7.99)	0.12018 (34.10)	0.05010 (2.88)	0.07592 (8.45)	0.02685 (5.69)	0.10986 (15.36)	0.02245 (13.94)
	North America	0.01820 (7.79)	0.03696 (15.72)	0.02779 (3.78)	0.01397 (6.17)	0.02622 (4.26)	0.03277 (13.45)	0.04679 (15.3)	0.02159 (14.56)	0.02106 (8.26)
	Japan	0.00814 (10.31)	0.02116 (4.34)		0.01558 (6.29)	0.04994 (9.52)	0.02997 (8.12)	0.02336 (12.56)	0.02917 (8.56)	0.06480 (14.71)
	Other Europe	0.03859 (7.16)	0.00579 (3.91)	0.00431 (5.74)	0.03487 (9.96)	0.01314 (4.02)	0.01363 (8.26)	0.00663 (8.54)	0.02207 (21.18)	0.00510 (9.10)
	A–NZ–RSA	0.00161 (2.10)	0.00231 (5.34)	0.00805 (15.17)	0.00260 (5.45)	0.00866 (9.22)	0.00300 (12.46)	0.00010 (0.22)	0.00217 (1.18)	0.01080 (6.10)
	Middle East	0.02282 (4.59)	0.00751 (4.54)	0.02700 (7.36)	0.01943 (24.79)	0.00816 (2.05)	0.00554 (1.39)	0.02461 (7.02)	0.00514 (0.83)	0.03604 (5.95)
	Latin America	0.00588 (4.13)	0.00994 (7.58)	0.00425 (2.54)	0.00748 (3.73)	−0.00100 (0.75)	0.00304 (8.08)	0.01917 (8.60)	0.00692 (4.37)	0.00187 (1.93)
	Africa	0.00496 (1.00)	0.01032 (4.15)	0.00280 (1.83)	0.00881 (3.5)	−0.00466 (1.57)	−0.00056 (1.51)	0.01278 (3.31)	−0.00100 (0.54)	−0.00160 (1.54)
	Asia	0.01128 (4.81)	0.01975 (4.98)	0.02469 (8.77)	0.00587 (3.89)	0.01777 (4.72)	0.01549 (6.32)	0.00708 (28.08)	0.00961 (6.61)	0.04490 (16.81)

(*t*-ratios shown in brackets).

TABLE 2 (*continued*)

	B. Price effects	Importing regions: EEC	North America	Japan	Other Europe	A–NZ–RSA	Middle East	Latin America	Africa	Asia
Exporting regions	EEC		−0.00838 (1.61)	−0.01355 (5.78)		−0.02141 (1.52)		−0.00762 (1.95)		−0.00099 (1.06)
	North America	−0.00369 (1.48)		−0.01002 (1.30)	−0.00464 (1.67)	−0.00616 (1.18)	−0.00386 (2.14)	−0.00964 (2.40)	−0.00806 (3.53)	−0.00447 (3.72)
	Japan		−0.00252 (0.65)		−0.00526 (1.92)	−0.01099 (2.52)	−0.00060 (0.34)	−0.00770 (4.69)	−0.00464 (1.07)	
	Other Europe	−0.01225 (2.61)	−0.00160 (1.37)	−0.00248 (3.49)		−0.00518 (2.13)				−0.00015 (0.37)
	A–NZ–RSA	−0.00064 (0.87)	−0.00026 (0.70)		−0.00055 (0.99)		−0.00040 (2.25)	−0.00024 (0.43)	−0.00215 (2.07)	−0.00043 (0.52)
	Middle East					−0.00080 (0.53)			−0.00392 (0.94)	−0.00148 (0.42)
	Latin America	−0.00536 (5.10)		−0.00307 (2.06)	−0.00381 (2.31)	−0.00063 (0.70)	−0.00078 (1.71)			
	Africa			−0.00130 (1.19)	−0.00205 (1.72)	−0.00033 (0.21)		−0.00119 (0.38)		
	Asia	−0.00246 (1.84)	−0.00270 (1.00)		−0.00119 (1.35)		−0.00002 (0.02)	−0.00231 (1.45)	−0.00045 (0.18)	

(*t*-ratios shown in brackets). Coefficients with a positive sign are restricted to zero.

TABLE 2 (*continued*)

	C. Constant	Importing regions: EEC	North America	Japan	Other Europe	A–NZ–RSA	Middle East	Latin America	Africa	Asia
Exporting regions	EEC	−126,038 (17.78)	−17,259 (2.77)	−219 (1.52)	−16,290 (9.49)	2,395 (2.22)	−5,283 (2.39)	3,963 (2.62)	−4,768 (3.58)	1,790 (1.99)
	North America	1,750 (1.36)	−31,581 (6.93)	384 (0.37)	2,035 (3.31)	658 (1.69)	−804 (0.79)	3,753 (3.24)	1,057 (1.78)	6,095 (4.61)
	Japan	−8,531 (6.42)	−22,851 (5.50)		−2,607 (5.48)	−3,843 (14.04)	−2,909 (2.39)	−1,205 (2.11)	−992 (0.92)	−7,688 (5.82)
	Other Europe	−15,746 (8.57)	−3,656 (2.66)	−293 (3.59)	−5,708 (3.31)	−378 (1.77)	−874 (2.14)	333 (1.22)	−1,318 (6.89)	−80 (0.24)
	A–NZ–RSA	3,589 (4.15)	−1,622 (3.44)	−907 (3.04)	−421 (2.23)	−472 (3.19)	−78 (0.72)	477 (2.51)	923 (1.78)	−1,115 (1.16)
	Middle East	−8,596 (1.03)	−8,477 (0.63)	−1,371 (9.93)	−3,790 (2.18)	1,182 (3.69)	3,485 (3.69)	−4,359 (3.66)	1,449 (3.57)	−3,374 (1.91)
	Latin America	9,573 (8.15)	1,430 (0.57)	1,331 (2.64)	1,159 (2.75)	468 (3.94)	−3 (0.02)	3,262 (4.27)	−447 (1.43)	3 (0.01)
	Africa	12,645 (1.48)	−12,194 (2.44)	220 (0.34)	−567 (0.55)	1,117 (3.20)	428 (4.89)	−2,344 (5.24)	2,543 (7.47)	1,179 (3.76)
	Asia	−6,158 (1.81)	−21,743 (4.00)	−4,913 (3.02)	−980 (1.68)	−1,216 (2.04)	−1,244 (1.58)	−512 (1.24)	−352 (0.80)	−3,377 (4.35)

(*t*-ratios shown in brackets).

TABLE 2 (*continued*)

D. R^2 1st order autocorrelation (t-ratio)		Importing regions								
		EEC	North America	Japan	Other Europe	A–NZ–RSA	Middle East	Latin America	Africa	Asia
Exporting regions	EEC	0.999 0.22 (0.9)	0.995 0.67 (3.6)	0.994 −0.35 (1.5)	0.999 −0.07 (0.3)	0.994 0.12 (0.5)	0.991 0.76 (4.7)	0.997 0.74 (4.3)	0.997 0.42 (1.8)	0.998 −0.12 (0.5)
	North America	0.999 −0.19 (0.8)	0.999 0.69 (3.8)	0.991 0.16 (0.6)	0.998 0.14 (0.6)	0.994 −0.21 (0.9)	0.985 0.23 (1.0)	0.998 −0.14 (0.6)	0.990 −0.05 (0.2)	0.997 −0.03 (0.1)
	Japan	0.995 0.72 (4.2)	0.990 0.35 (1.5)		0.985 −0.08 (0.3)	0.994 −0.25 (1.1)	0.983 0.70 (3.9)	0.996 0.68 (3.7)	0.983 0.35 (1.5)	0.998 0.63 (3.3)
	Other Europe	0.999 −0.11 (0.4)	0.997 0.72 (4.2)	0.989 −0.07 (0.3)	0.998 0.78 (5.0)	0.992 0.12 (0.5)	0.990 0.77 (4.8)	0.998 0.74 (4.4)	0.995 −0.01 (0.0)	0.992 −0.05 (0.2)
	A–NZ–RSA	0.995 0.39 (1.7)	0.991 0.21 (0.9)	0.992 0.09 (0.4)	0.978 0.26 (1.1)	0.996 0.50 (2.3)	0.980 0.17 (0.7)	0.943 0.15 (0.6)	0.979 0.84 (6.3)	0.989 0.47 (2.1)
	Middle East	0.993 0.68 (3.7)	0.981 0.83 (5.9)	0.996 0.75 (4.6)	0.997 −0.26 (1.1)	0.997 0.72 (4.2)	0.981 0.63 (3.3)	0.952 0.26 (1.1)	0.977 0.24 (1.0)	0.995 0.82 (5.7)
	Latin America	0.997 −0.14 (0.6)	0.996 0.14 (0.6)	0.990 0.68 (3.7)	0.996 0.21 (0.9)	0.967 0.07 (0.3)	0.968 0.31 (1.3)	0.998 0.5 (2.3)	0.980 0.81 (5.5)	0.913 0.50 (2.3)
	Africa	0.993 0.88 (7.6)	0.980 0.89 (7.9)	0.968 0.78 (5.1)	0.994 0.81 (5.5)	0.954 0.65 (3.4)	0.985 0.57 (2.8)	0.987 0.49 (2.2)	0.984 0.22 (0.9)	0.969 0.65 (3.4)
	Asia	0.993 0.88 (7.6)	0.992 0.84 (6.3)	0.990 0.64 (3.3)	0.990 0.88 (7.6)	0.990 0.78 (5.1)	0.986 0.87 (7.0)	0.982 0.79 (5.2)	0.988 0.36 (1.5)	0.995 0.02 (0.1)

(*Footnotes to Table* 2)

Price elasticities at 1977 incomes and 1977 prices $E_{ij}=b_{ij}/(a_{ij}+b_{ij}+c_{ij}/Y_{77j})$. Substitution effects only

	1	2	3	4	5	6	7	8	9
1 European Community	0.0	−0.7710	−2.8642	0.0	−0.4849	0.0	−0.2585	0.0	−0.0364
2 North America	−0.2363	0.0	−0.5467	−0.3386	−0.2534	−01488	−0.2058	−0.4300	−0.1242
3 Japan	0.0	−0.3271	0.0	−1.1150	−0.7777	−0.0323	−0.6138	−0.2363	0.0
4 Other Europe	−0.7464	−0.6557	−1.7678	0.0	−0.9386	0.0	0.0	0.0	−0.4398
5 A–NZ–RSA	−0.1980	−0.2041	0.0	−0.4802	0.0	−0.1731	−0.2196	−0.4702	−0.0631
6 Middle East	0.0	0.0	0.0	0.0	−0.0534	0.0	0.0	−0.4685	−0.0060
7 Latin America	−0.8175	0.0	−0.9839	−0.6184	−0.4524	−0.3468	0.0	0.0	0.0
8 Other Africa	0.0	0.0	−0.7140	−0.3699	−0.1484	0.0	−0.2151	0.0	0.0
9 Other Asia	−0.4983	−0.4064	0.0	−0.0215	0.0	−0.0018	−0.6702	−0.0606	0.0

Activity elasticities $E_{ij}=(a_{ij}+b_{ij})/(a_{ij}+b_{ij}+c_{ij}/Y_{77j})$

	1	2	3	4	5	6	7	8	9
1 European Community	2.0537	1.7600	1.0675	1.4110	0.6497	1.3470	0.6525	1.2723	0.7901
2 North America	0.9293	1.6919	0.9695	0.6809	0.8252	1.1148	0.7929	0.7219	0.4608
3 Japan	2.9485	2.4198	0.0	2.1876	2.7564	1.5791	1.2483	1.2491	1.6074
4 Other Europe	1.6050	1.7171	1.3045	1.5427	1.4423	1.3113	0.8851	1.4175	1.0757
5 A–NZ–RSA	0.3000	1.6095	1.1965	1.7900	1.5432	1.1250	−0.1281	0.0044	1.5208
6 Middle East	1.3115	2.1751	1.0799	1.7217	0.4909	0.3004	1.8444	0.1458	1.4274
7 Latin America	0.0793	0.9356	0.3782	0.5957	−1.1706	1.0049	0.6945	1.4675	0.9949
8 Other Africa	0.3835	2.3017	0.8239	1.2199	−2.2439	0.2611	2.0953	−0.0866	−0.7424
9 Other Asia	1.7865	2.5665	1.4086	1.0380	1.7919	1.4239	1.3840	1.2338	1.3150

trade adjusted real final demand of region j in year t, P_{ijt} = price of exports of region i relative to those of region j and in order to take account of "omitted variables" a first order auto correlation procedure is used. Again it is not possible to look for higher order lags in the error process.

The matrix of quantity effects cannot be interpreted as a matrix of fixed-price marginal propensities to import, for the equations are estimated in 1977 volume terms. Under these circumstances the relative prices are all 1 and therefore a matrix of fixed-price marginal propensities is derived by adding the two together. A negative constant in the third table indicates, of course, an "activity" elasticity greater than one while a positive one shows an elasticity of less than one. As with all linear models the elasticity approaches 1 as the influence of the constant term becomes small. Asymptotic price elasticities may also be derived but those calculated at the base of the model are likely to be of greater economic relevance. Although of course these quantity and price effects are unlikely to be as "reliable" as those estimated for individual countries and products or using quarterly data and investigating appropriate lag structures, they nevertheless conform to generally held views. The quantity effects reflect, to a large extent, geography. Other Europe and Other Africa are hinterlands of the EEC while the United States dominates Latin America and Japan sells to Other Asia. However after adjusting for its smaller size (dividing import propensities by the exporter's GDP), Japan becomes the most important marginal metropolitan supplier to the last five regions. There are fewer wrong signs and larger price effects found on imports from the developed regions. Imports from the Middle East (which are mainly oil) are, as one would expect, almost independent of prices (since the effects of price changes on income have already been taken into account). Although some high asymptotic price elasticities are implied, they are much lower close to the price base.

Four negative quantity variables are found. Although one could argue that there are grounds for excluding them *a priori* because one would normally expect trade to be positively correlated with income, these coefficients (which are not significantly different from zero at any usual level) all relate to flows between regions which are underdeveloped or primary producers and it is quite possible that as output grows domestic production is substituted for imports leading to a negative marginal propensity to import, an ultra anti-trade bias.

The income and price elasticities are presented for values in 1977, when all prices are 1. The actual price elasticities are substantially lower than those presented by Thorbecke and Field, and tend to be at the low end of the ranges presented by Stern, Francis and Schumacher [16]. However it must be remembered that they are compensated rather than total price elasticities: this will tend to reduce the estimated magnitude. The income elasticities too tend to be lower than those produced by Thorbecke and Field but are generally closer to the range provided by Houthakker and Magee [8] for individual countries. A striking but not unexpected feature is the high income elasticity of demand for imports from Japan and the low income elasticity of demand for imports by Japan.

Equally striking are the low elasticities for imports from North America, representing the fact that, although this region has grown more slowly than the rest of the world over the estimation period, it has nevertheless been prone to balance of payments crises. The generally lower elasticities for trade with and

among the developing regions summarise the pattern of the expansion of trade which has been biased towards intra-industry trade between developed countries (Barker [2]) and has departed from the classical pattern of comparative advantage. Taken together the elasticities can be used to derive growth rates for each region relative to a standard such that the trade balance of each region remains constant. If $\hat{Y}$ = vector of growth rates, ε = elasticity matrix, M = trade matrix in 1977, i = vector of 1's, then

$$(\varepsilon * M) \cdot \hat{Y} = \text{Growth in exports}$$

(where $*$ denotes that each element of the matrices is multiplied together)

$$\text{DIAG}\,(i'(\varepsilon * M))\,\hat{Y} = \text{Growth in imports}$$

(where DIAG indicates that the vector forms the leading diagonal of an otherwise zero matrix).

For trade balance

$$(\varepsilon * M - \text{DIAG}\,(i'(\varepsilon * M))) \cdot \hat{Y} = 0.$$

Putting $\hat{Y}_1 = 1$ and solving we find the following results.

	Relative growth rate (trade balance)	Actual relative growth rate (1963–78)
EEC	1	1
North America	0.5	0.8
Japan	1.7	2.1
Other Europe	0.9	1.1
A–NZ–RSA	1.1	1.2
Middle East	1.6	2.2
Latin America	0.5	1.6
Other Africa	0.6	1.4
Other Asia	1.4	1.3

These results show a general equilibrium solution rather than the partial results derived by looking at each country separately. Latin America is constrained not only because it faces a low elasticity of demand for its exports (the Prebisch hypothesis) but also because its major market is North America, which faces a low elasticity of demand for its exports and cannot therefore grow rapidly. These elasticities are point elasticities and therefore not strictly comparable with the second column and moreover they are calculated on the assumption of constant relative prices. Nevertheless the massive indebtedness of several Latin American countries can be regarded as the counterpart of their rapid historic growth, and the same comment can be made about Africa, although the discrepancy is less marked.

The propensities to consume are estimated from OECD statistics for the three major regions. Data are available for Japan, U.S.A. and Canada while the relation between consumption and personal disposable income for France, Germany, Italy, the Netherlands and the United Kingdom added together is taken to be representative of the EEC since data are not available for the other countries.

For the countries comprising these groups the consumers' expenditure deflator adjusted to a 1977 base is used to deflate personal disposable income. Personal disposable income and consumers' expenditure are then aggregated into figures for the three regions using 1977 exchange rates, and simple marginal propensities to consume are estimated by fitting the equation, again assuming first order auto-correlation,

$$c_{it} = a_i + bz_{it}$$

where c_{it} = consumers' expenditure in 1977 prices for year t in region i and z_{it} = personal disposable income deflated for year t in region i.

Since this yields a propensity to consume from disposable income rather than total income the estimates b_j are divided by the average propensity to consume in 1977 in each region and the resulting ratio is multiplied by the average propensity to consume from total personal income. It is therefore implicitly assumed that obligatory payments by the personal sector are a constant fraction of total personal income. The most striking feature of the estimates is the low marginal propensity to consume for Japan.

Since sectoral accounts are not disaggregated for the other regions propensities to consume can only be estimated relating consumption to GDP (adjusted for terms of trade effects). The UN National Accounts Statistics provide time series of consumption while adjusted GDP is calculated as described earlier. While a low consumption propensity in the Middle East is to be expected the low figure for Africa is striking and reflects a bias towards investment and government spending; this may reflect the fact that the region is at a relatively early stage of development. The estimate for region 5 shows a bias towards consumption in the growth process. Of course the propensities for the last six regions are low compared to the first three because they are estimated from adjusted GDP and not from personal income.

These consumption and import propensities are used to replace the relevant average propensities of the accounting matrix; the income and substitution effects of trade price changes are also incorporated so as to yield an empirical model of the world economy with the structure described in section 3.

5. The Multipliers

The model has 63 endogenous accounts and therefore the full fixed-price multipliers are represented by a 63×63 matrix showing the effect of \$1 of the income paid to any account on all the accounts. However of particular interest are the multipliers showing the effects on GDP (adjusted for terms of trade movements) of expansions in demand in the developed regions, and of transfer payments increasing the income of the underdeveloped regions. In the price-varying case the effects generated by an increase in the price of exports of regions 7, 8 and 9 and the effects of an increase in the price of exports from region 6 are also considered.

Table 4 shows the effects of \$1 extra of demand in each region on the GDP (in 1977 prices) of each region.

TABLE 3

CONSUMPTION PROPENSITIES

	Estimated from PDI			Estimated from terms of trade adjusted GDP					
	EEC	North America	Japan	Other Europe	A–NZ–RSA	Middle East	Latin America	Africa	Asia
b	0.819	0.925	0.669	0.592	0.619	0.333	0.600	0.422	0.672
	(82.3)	(44.2)	(36.9)	(26.6)	(40.6)	(34.8)	(25.1)	(13.2)	(68.1)
a	23,593	1,654	32,137	258	−4,957	12,680	26,827	37,167	10,886
	(2.56)	(0.1)	(4.17)	(0.03)	(2.5)	(7.4)	(3.9)	(7.9)	(4.7)
ρ	0.38	0.51	0.52	0.68	0.5	0.15	0.75	0.72	0.21
	(1.63)	(2.4)	(2.25)	(3.7)	(2.2)	(0.6)	(4.5)	(4.1)	(0.9)
R^2	0.997	0.988	0.982	0.970	0.987	0.988	0.957	0.915	0.996

Note: Estimation period—Regions 1–2, 1962–78, Region 3, 1965–78, Regions 4–9, 1963–78.

TABLE 4

THE EFFECT OF $1 OF EXOGENOUS DEMAND ON GDP/NATIONAL INCOME OF EACH REGION

	1	2	3	4	5	6	7	8	9
1 European Community	1.5256	0.1166	0.0675	0.4151	0.2083	0.2470	0.1484	0.3160	0.1651
2 North America	0.1047	1.8160	0.0898	0.0991	0.1614	0.1377	0.1946	0.0916	0.1369
3 Japan	0.0521	0.0840	1.5687	0.0618	0.1624	0.0924	0.0790	0.0820	0.2576
4 Other Europe	0.1084	0.0374	0.0256	1.4464	0.0786	0.0741	0.0572	0.0908	0.0525
5 A–NZ–RSA	0.0181	0.0181	0.0334	0.0225	1.7051	0.0247	0.0135	0.0138	0.0574
6 Middle East	0.0643	0.0330	0.0603	0.0658	0.0515	1.0270	0.0751	0.0283	0.1096
7 Latin America	0.0191	0.0461	0.0140	0.0310	0.0227	0.0289	1.7231	0.0327	0.0260
8 Other Africa	0.0209	0.0310	0.0087	0.0291	0.0155	0.0262	0.0391	1.1473	0.0071
9 Other Asia	0.0529	0.0789	0.0896	0.0477	0.1038	0.0691	0.0451	0.0486	1.7711

A comparison of these multipliers with those found by other researchers is complicated by the fact that regional groupings differ. Thorbecke and Field find a diagonal multiplier of 2.55 for U.S.A., 3.12 for the old EEC, 3.45 for the rest of Europe and only 1.18 for Japan. The OECD model produces diagonal multipliers much closer to those found here. For the United States the multiplier is 1.47, for EEC 1.77 and Japan 1.26; the OECD figures will tend to ignore feedback from the non-OECD world which will bias them downwards, and the presence of lags in the OECD model may again tend to lead to lower short-term multipliers than those derived from the model presented here.

The multipliers reflect the geographical pattern seen in the import propensities. This arises from the fact that most of the off-diagonal elements are generated by trade flows, transfer payments being much less important. There are large leakages from underdeveloped to metropolitan regions. The size of the leakages from regions 5 and 6 to region 1 probably reflects historical as much as geographical links. The low diagonal multipliers for regions 6 and 9 reflect their high propensity to save while Japan's propensity to save out of personal income is offset by lower taxes than in regions 1 and 2.

It is also possible to calculate the effects on Government income of the first three regions of an exogenous change in demand, as shown in Table 5.

Thus $1 of extra demand in the EEC raises Government income by 45¢ and thus, if this demand is Government consumption, would add 55¢ to the budget deficit. This table can be used to calculate the budgetary effects of expansion.

Finally the effects on the financial saving of each region are explored in Table 6.

The difference between "national" borrowing and national saving in each region must be met from abroad and therefore, for example, since $1 of spending in the EEC generates 77¢ of savings, a rise of $1 in government consumption or investment will lead to an increase of 23¢ in the external deficit of the region. The fact that the diagonal elements are larger for the three metropolitan regions than the others reflects the self-reinforcing nature of expansion here. Japan generates a high level of saving as a result of its low propensity to consume while the six non-metropolitan regions face larger trade leakages than the metropolitan ones. The off-diagonal elements show for example that $1 of government consumption in the Middle East adds 13¢ to saving in the EEC and thus to its external surplus. If all regions were endogenous each column of the savings matrix would sum to 1 because borrowing (to pay for government consumption or investment) must equal saving for the world as a whole. In this example each column sums to less than 1, discrepancy being the saving accruing to the communist states.

6. An Application of the Fixed-Price Multipliers— Aid Policies Under Financial Constraints

Aid policies considered as transfers from regions 1, 2 and 3 to the underdeveloped regions 7, 8 and 9 will have effects which depend on the reactions of the donor regions to the financial implications of giving aid. Thus if aid is given within the context of a Government budget constraint the effect will be more

TABLE 5

THE EFFECT OF $1 OF EXOGENOUS DEMAND ON GOVERNMENT INCOME IN EACH REGION

	1	2	3	4	5	6	7	8	9
1 European Community	0.4535	0.0361	0.0212	0.1257	0.0680	0.0772	0.0498	0.1025	0.0537
2 North America	0.0308	0.4930	0.0257	0.0297	0.0504	0.0409	0.0581	0.0280	0.0414
3 Japan	0.0106	0.0167	0.3065	0.0126	0.0329	0.0187	0.0164	0.0167	0.0510

TABLE 6

THE EFFECT OF $1 OF EXOGENOUS DEMAND ON NATIONAL SAVING IN EACH REGION

	1	2	3	4	5	6	7	8	9
1 European Community	0.7690	0.0613	0.0361	0.2133	0.1162	0.1310	0.0849	0.1711	0.0912
2 North America	0.0494	0.7840	0.0411	0.0478	0.0812	0.0656	0.0933	0.0448	0.0666
3 Japan	0.0278	0.0440	0.8110	0.0330	0.0863	0.0490	0.0427	0.0436	0.1346
4 Other Europe	0.0425	0.0147	0.0100	0.5668	0.0308	0.0291	0.0224	0.0356	0.0206
5 A–NZ–RSA	0.0061	0.0061	0.0113	0.0076	0.5780	0.0084	0.0046	0.0047	0.0195
6 Middle East	0.0399	0.0205	0.0374	0.0408	0.0319	0.6372	0.0466	0.0175	0.0680
6 Latin America	0.0071	0.0171	0.0052	0.0115	0.0084	0.0107	0.6380	0.0121	0.0096
8 Other africa	0.0113	0.0167	0.0047	0.0157	0.0084	0.0141	0.0211	0.6187	0.0038
9 Other Asia	0.0163	0.0243	0.0276	0.0147	0.0319	0.0213	0.0139	0.0150	0.5449

contractionary than if there is no such constraint. Further the deflation will be augmented if the governments of the aid-giving regions take into account the effects of a cut in domestic government spending on their revenues and thus cut further, driving the deflation through a multiplier process. Equally the developed regions may consider themselves facing an external constraint and thus cut domestic government spending in order to restore external balance. Just as under the internal constraint, the deflation will be multiplied by interactions in the system and large cuts in spending will be needed to restore balance. Under either of these cases of financial restraint untied aid may prove to be a source of depression for the world economy, and tied aid which, in this aggregate model if matched by cuts in domestic government spending has no effects on the financial variables, may be better both from the point of view of the donors and, because there is no deflationary pressure on the world economy, for the recipients.

In the context of the Brandt Report [3] it is helpful to look at the effects of a transfer of 1 percent of GDP (in 1977) from the major developed regions to regions 7, 8 and 9. If this flow is split in the same proportions as flows of all overseas development aid in 1977 [20] the following transfer is implied:

	U.S. $m (1977 prices)
EEC	−15,859
North America	−20,893
Japan	−6,860
Other Europe	0
A–NZ–RSA	0
Middle East	0
Latin America	5,610
Other Africa	24,408
Other Asia	13,594

In the most optimistic case where the aid flows are not offset by deflation there is, on the assumption that all aid contributes to an increase in exogenous demand, an expansion of GDP in each region given as $M_1 a_r$ where

$$a_r = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 5{,}610 \\ 24{,}408 \\ 13{,}594 \end{pmatrix}$$

and M_1 is the first multiplier matrix in the previous section (Table 4).

The effects on the current balance of each region are given as $a_s + M_3 a_r$ where

$$a_s = \begin{pmatrix} -15{,}859 \\ -20{,}893 \\ -6{,}860 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

and M_3 is the third multiplier matrix.

The consequences for the government budget are derived as the cost of the aid less the government income generated as the result of a higher level of activity in the world economy, given as $a_s^* + M_2 a_r$ where a_s^* represents the first three elements of a_s only and M_2 is the second multiplier matrix of the previous section.

In the second and third cases where government spending is cut either with reference to an external or an internal target, the change in exogenous demand in the developed regions must first be calculated before it is possible to determine the implications for world output or for the other financial balances.

In order to determine the cut in spending needed to ensure that financial balance is maintained it is helpful to consider just the first three rows of M_3, which can be written as $(s_1\ s_2\ s_3)$ where s_1, s_2, s_3 are blocks of three successive columns.

If government spending in each of the first three regions is changed by g then the increase in borrowing by these regions is $g - a_s^*$, and the increase in national savings is $s_1 g + s_3 a_r^*$ where a_r^* represents the last three elements of a_r. For there to be no net effect the two are equal and therefore

$$g - a_s^* = s_1 g + s_3 a_r^* \quad \text{or} \quad g = [I - s_1]^{-1}[s_3 a_r^* + a_s^*].$$

The similarity to the standard multiplier is clear. $[I - s_1]^{-1}$ represents the extent to which the initial deflation is multiplied as a result of the fact that all three regions are trying to restore balance in an interdependent system where one country's deficit is another's surplus, or where a cut in demand in one region reduces government revenue through taxation in another region.

The deflation multipliers calculated for the cases where deflation is pursued with respect to both in internal and external balance are shown in Table 7.

These multipliers imply that, for example, for the EEC to achieve a reduction of \$1 in public borrowing, government spending must be cut by \$1.84 there, and by 11¢ in North America and 3¢ in Japan if those two regions are merely to maintain their budgetary stance. The interactions are much stronger if deflation is pursued with respect to an external target.

For the EEC to achieve a reduction of \$1 in its external deficit and for North America and Japan to do no more than hold steady requires a cut of \$4.83 in state spending in the EEC and cuts of \$1.30 and \$1.01 in each of the other regions

TABLE 7

A. THE CUT IN GOVERNMENT SPENDING NEEDED TO ACHIEVE A REDUCTION OF $1 IN GOVERNMENT BORROWING

	1	2	3
1 European Community	1.8386	0.1327	0.0610
2 North America	0.1133	1.9830	0.0769
3 Japan	0.0309	0.0497	1.4447

B. THE CUT IN EXOGENOUS DEMAND NEEDED TO ACHIEVE A REDUCTION OF $1 IN NATIONAL BORROWING

	1	2	3
1 European Community	4.8316	1.6304	1.2779
2 North America	1.2967	5.2810	1.3960
3 Japan	1.0130	1.4680	5.8026

respectively, assuming that the other regions of the world do not respond but are willing to see their surpluses reduced.

After calculating g from the above equation the full effects on regions' GDP are given as

$$M_1 \begin{pmatrix} g \\ 0 \\ 0 \\ 0 \\ a_r^* \end{pmatrix}$$

and the effects on the financial balances are calculated as the change in saving less the change in borrowing, giving

$$\begin{pmatrix} g + a_s^* \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} - M_3 \begin{pmatrix} g \\ 0 \\ 0 \\ 0 \\ a_r^* \end{pmatrix}$$

for the external balance and

$$g + a_s^* - M_2 \begin{pmatrix} g \\ 0 \\ 0 \\ 0 \\ a_r^* \end{pmatrix}$$

for the internal balance.

TABLE 8

THE EFFECTS OF UNITED AID UNDER FINANCIAL CONSTRAINTS

	No Constraint			Government Deficit Fixed			External Deficit Fixed		
	GDP	External Surplus	Govt. Surplus	GDP	External Surplus	Govt. Surplus	GDP	External Surplus	Govt. Surplus
Million 1977 U.S.$									
1 European Community	10,790	−9,967	−12,347	−33,610	−6,855	−0	−133,030	0	27,546
2 North America	5,189	−18,371	−19,321	−71,260	−11,354	0	−217,864	0	34,995
3 Japan	5,945	−3,725	−5,667	−13,710	−4,402	−0	−100,099	0	32,230
4 Other Europe	3,251	1,274	0	−1,272	−498	0	−11,543	−4,523	0
5 A–NZ–RSA	1,194	405	0	−314	−107	0	−4,350	−1,475	0
6 Middle East	2,601	1,614	0	−945	−586	0	−10,063	−6,244	0
7 Latin America	10,818	4,006	0	8,345	3,090	0	3,106	1,150	0
8 Other Africa	28,319	15,273	0	26,455	14,267	0	22,501	12,135	0
9 Other Asia	25,516	7,850	0	20,137	6,195	0	6,781	2,086	0
Percent of GDP/ National Income									
1 European Community	0.6804	−0.6285	−0.7786	−2.1193	−0.4322	−0.0000	−8.3883	0.0000	1.7369
2 North America	0.2484	−0.8793	−0.9248	−3.4107	−0.5434	0.0	−10.4276	0.0000	1.6749
3 Japan	0.8667	−0.5430	−0.8260	−1.9985	−0.6416	−0.0000	−14.5917	0.0000	4.6982
4 Other Europe	0.6872	0.2693	0.0	−0.2688	−0.1053	0.0	−2.4399	−0.9561	0.0
5 A–NZ–RSA	0.7674	0.2601	0.0	−0.2020	−0.0685	0.0	−2.7959	−0.9477	0.0
6 Middle East									
7 Latin America	0.9230	0.5727	0.0	−0.3352	−0.2080	0.0	−3.5709	−2.2157	0.0
8 Other Africa	2.7619	1.0227	0.0	2.1305	0.7889	0.0	0.7929	0.2936	0.0
9 Other Asia	13.1961	7.1169	0.0	12.3274	6.6483	0.0	10.4851	5.6547	0.0
	7.9463	2.4446	0.0	6.2711	1.9292	0.0	2.1118	0.6497	0.0

The consequences of aid policy for the level of GDP in each region and for budget and external balance under each of three cases where first, no attention is paid to financial targets, secondly government spending is cut with reference to a budget target, and thirdly government spending is cut with reference to an external target, are given in Table 8.

Looking for a moment at the burden on the donor nations, if there is no financial constraint, North America derives very much less benefit from "international Keynesianism" than do the other metropolitan regions and the effect on both its external and internal deficits is much larger. In an atmosphere of deflation to pay for the aid world output actually falls. The severity of the fall in output when external balance is sought reflects the magnitude of the elements of the third multiplier, M_3, defined above.

These effects can helpfully be compared with a tied aid case in which the developed regions give the same amount of aid but tied to their own exports. Obviously the effect on GDP in the donor regions is much larger than in the untied case. However while GDP is relevant for some measures of welfare (indicating likely movements in employment for example) it is also useful to look at the effect on disposable output, defined as GDP less the transfer made or plus the transfer received. For regions 4 to 9 the effect on disposable national income rather than disposable output is shown (i.e. including any very small induced financial rather than physical transfers).

It is seen from Table 9 that the financial disturbance induced by tied aid is much smaller than that induced by untied aid and the benefits for the donor

TABLE 9

THE EFFECTS OF TIED AID WITHOUT A FINANCIAL CONSTRAINT

	Total Change in				
	GDP/ Nat. Inc.	+Transfer	Disposable Output	National Saving	Government Saving
Million U.S.$ 1977					
1 European Community	27,095	−15,859	11,236	−2,488	−7,768
2 North America	40,219	−20,893	19,326	−3,449	−9,928
3 Japan	13,343	−6,860	6,983	63	−4,240
4 Other Europe	2,677	0	2,677	1,049	
5 A–NZ–RSA	894	0	894	303	
6 Middle East	2,122	0	2,122	1,317	
7 Latin America	1,362	5,610	6,972	504	
8 Other Africa	1,040	24,408	25,448	561	
9 Other Asia	3,104	13,594	16,698	955	
Percent of GDP/ National Income					
1 European Community	1.7085	−1.0	0.7085	−0.1346	−0.4898
2 North America	1.9250	−1.0	0.9250	−0.1651	−0.4752
3 Japan	1.9450	−1.0	0.9450	0.0092	−0.6181
4 Other Europe	0.5658	0	0.5668	0.2217	
5 A–NZ–RSA	0.5747	0	0.5747	0.1948	
6 Middle East	0.7531	0	0.7531	0.4673	
7 Latin America	0.3477	1.433	1.7799	0.1288	
8 Other Africa	0.4845	11.3788	11.8553	0.2613	
9 Other Asia	0.9665	4.2328	5.1993	0.2973	

regions are more uniform. However the government surpluses of the three donor regions are affected much less by tying than either of the other variables. If the external constraint is considered important a tied aid programme could be over four times as large as an untied one before any donor regions face the same burden. While these comparisons do not, of course, take account of the loss of choice resulting from aid tying, it is unlikely that the use-value of tied aid is only a quarter that of untied aid.

However while tied aid has less uneven effects than untied aid it must nevertheless be noted that Japan's external position actually improves as a result of giving aid while its internal position suffers more than that of EEC or North America. Thus even if it were agreed that aid policy should be determined with respect to an overall measure of burden rather than some ex ante target (e.g. 1 percent GDP), and even if that measure is, in keeping with the current atmosphere, monetary, it would probably be impossible to decide on a pattern of donation which is generally regarded as equitable.

7. Variations in Relative Prices

This section briefly illustrates the effects of variation in relative export prices on the level of GDP or national income after adjustment for changes in the terms of trade. The analysis is once again full rather than partial since the initial effects on each region are multiplied throughout the world economy as a result of the trade and transfer interactions and the decomposition of section 4 is used to distinguish income and substitution effects. A substitution effect against Other Asia will also have repercussions for Japan which will lose some of its export markets. Although the first round income effects sum to zero as a consequence of the specification of the income effect, there is no reason why total income effects should sum to zero and there is equally no restriction on the substitution effects. Both effects can transfer demand from a region with a high propensity to save to one with a low propensity to save or vice versa.

These points can be illustrated by comparing the effects of a 50 percent increase in the relative price of exports of the last three regions with a 50 percent increase in the price of exports by the Middle East. In the first example the income effects benefit the underdeveloped regions and the substitution effects swing against them. However as a result of loss of exports to the underdeveloped regions which is not fully compensated by exports to the developed regions the Middle East also suffers from induced substitution against it. The fact that the Middle East suffers from substitution does not imply it must gain from the redistribution of income expressed as the income effect. The two effects will have rather different first-round magnitudes. Overall it is seen that a positive net income effect is slightly outweighed by a negative net substitution effect and world output is reduced.

An increase in the price of Middle East exports has rather different effects. The concentration of income in a region with a low propensity to spend has, through the multiplier, a depressing effect on the world as a whole. The national income of Africa scarcely suffers because the Middle East has a high propensity to give aid to Africa. Since the price elasticity of demand for Middle East exports

TABLE 10

INCOME AND SUBSTITUTION EFFECTS ON ADJUSTED GDP/NATIONAL INCOME OF A 50 PERCENT INCREASE IN EXPORT PRICES

A. By Latin America, Other Africa, and Other Asia

Million U.S.$ 1977	Income Effect	Substitution Effect
1 European Community	−16,405	14,079
2 North America	−41,039	9,365
3 Japan	−11,315	3,620
4 Other Europe	−4,301	3,940
5 A–NZ–RSA	−1,809	424
6 Middle East	−3,950	−247
7 Latin America	28,916	−21,548
8 Other Africa	19,153	−3,891
9 Other Asia	35,387	−12,345

B. By the Middle East

Million U.S.$ 1977	Income Effect	Substitution Effect
1 European Community	−16,477	−44
2 North America	−8,941	778
3 Japan	−8,580	118
4 Other Europe	−4,401	−9
5 A–NZ–RSA	−830	231
6 Middle East	29,906	−1,509
7 Latin America	−4,181	165
8 Other Africa	−5	761
9 Other Asia	−6,367	75

is low the substitution effects are much smaller than in the previous example. However it is notable that both European regions suffer substitution losses as a consequence of falling exports to the Middle East which are not made up elsewhere.

Appendix 1. Constructing the World Accounting Matrix

1. *Data Problems*

The full accounting matrix, of which a consolidated form is presented in section 2, identifies the following accounts:

Production—for 9 regions
Service Trade
Goods Trade—for 9 regions and communist bloc

Personal Sector Industrial and Commercial Companies Financial Companies General Government	Sectors	for the first 3 regions indicated in section 2
Wages Other Factor Income Indirect Taxes	Factor Incomes	
Direct Taxes Property Income Other Transfers	Transfers	
Consumption Investment	Final Demand	

Net Acquisitions of Financial Assets

National Income Property Income Other Transfers Government Consumption Investment Private Consumption Net Acquisition of Financial Assets	Summary accounts for the next 6 regions indicated in section 2

International Flows of Property Income
Other International Transfers
Goods Trade Balance
Unallocated and Residual

Although national accounts for individual countries are produced on a consistent basis or with clearly identified residuals, the construction of an international accounting matrix poses problems, especially in the income-outlay and capital accounts. A consolidated production account can be derived from the UN Regional National Accounts [23] but this is not consistent with published trade and financial data. Although some transfers can be identified a large component remains unallocated. Flows of property income to and from regions

are probably unreliably estimated. Finally the failure of the world balance of payments to sum to zero is widely noted [1], [13].

In constructing the matrix a variety of data sources were used which cannot be expected to be consistent. Adjustment procedures (see for example Stone [17], Van der Ploeg [19]) are therefore used to ensure that the extra information provided by the accounting constraints is in fact made use of. This procedure must be expected to increase the accuracy of the accounts. Adjustment techniques are used at several different stages in the construction of the matrix in order to reduce the magnitude of the problem compared with adjusting a complete matrix at once.

2. *The Adjustment Technique*

Suppose there is a vector of observations x with variance V and it is known that they should satisfy the linear restrictions $Ax = b$. It is reasonable to seek adjustments to x which minimise the quadratic loss function $(x - x^*)V^{-1}(x - x^*)$ subject to the constraint $Ax^* = b$ where x^* is the vector of adjusted observations.

This is of course a LaGrangian problem:

$$\text{minimise} \quad L = (x - x^*)V^{-1}(x - x^*) + \lambda(b - Ax)$$

$$V^{-1}(x - x^*) = A'\lambda$$

$$x^* = x + VA'\lambda$$

$$b = Ax + AVA'\lambda$$

$$\lambda = (AVA')^{-1}(b - Ax)$$

$$x^* = X + VA'^{1}(AVA'^{1})^{-1}(b - Ax)$$

$$= x + VA'(AVA')^{-1}(b - Ax).$$

3. *The Construction of Accounts for the Three Major Regions and the Fourth Region*

In the cases both of the EEC and North America institutional data obtained, together with those for Japan, from OECD National Accounts [21] are not available for all the component countries. In order to create balanced accounts for the whole region, first a vector x of observations for those countries for which data exists is constructed. This does not necessarily satisfy the accounting constraints because the accounts include residual and unallocated items. These observations are scaled by the ratio GDP in region/GDP in reporting countries in order to yield an initial estimate for the region as a whole. This initial estimate is adjusted using the techniques above not only so that the accounting constraints are satisfied but also so that the entries in the consolidated production accounts are those derived by summing the consolidated accounts of each country (converted to U.S.$) over the whole region. Thus in the adjusted accounts institutional receipts equal institutional payments, transfers paid equal transfers received and the components of each type of factor income or final demand sum to the total of that type of factor income or final demand shown in the consolidated accounts.

In carrying out the adjustment process V is unknown. It is assumed equal to the unit matrix which has the effect of putting a greater proportional adjustment burden on the smaller items which are probably rather poorly determined. The same technique is used for Japan but obviously no scaling is involved; the adjustment merely removes the residual error. Table A1 illustrates the procedure for the EEC.

Consolidated accounts for the fourth region are derived from OECD National Accounts.

4. *The Trade Flows*

Goods trade flows are derived from UN Trade Statistics [22] suitably aggregated. Since these show unallocated exports and imports the unallocated trade is spread over the matrix by constraining row and column sums to add to the total (including unallocated) and assuming that the variance of each observation is proportional to its square. Service trade flows are, for the three major developed regions, the balance of imports or exports respectively. Initial estimates of service trade flows for the other regions are derived from the UNCTAD Yearbook.

5. *Production Accounts for the Other Regions*

Consolidated accounts for these regions are derived from UN National Accounts [23]. This provides an estimate for GDP in 1977, together with estimates showing the percentage composition of final demand in 1975 and changes in the volume of each component between 1975 and 1977. From these it is possible to derive initial estimates for the components of domestic final demand. Because a different source of information on trade flows is used, the two will not be consistent.

6. *International Transfers and Accumulation of Financial Assets*

Data on transfers and flows of property income are rather poor. From the OECD Aid Statistics [20] it is possible to identify aid flows (including soft loans which comprise 35 percent of such flows). Aggregate flows of property income are derived from the regional accounts or the UNCTAD Yearbook [24] and the same sources are used for unallocated transfer flows and initial estimates of the net acquisition of financial assets (after adjustment for soft loans).

7. *Adjusting the Production and Income-Outlay Accounts for the Other Regions*

The estimates of transfers and financial accumulation have to be adjusted together with the regional production accounts in order to make both consistent. In doing this no variation is allowed in estimates of goods trade or identified transfers. Because communist states are excluded from the analysis it is not possible to impose adding up restrictions on either the net acquisition of financial assets or the unallocated transfer payments. Nor does the OECD study of the World Current Account discrepancy [13] give enough information to made a full allocation possible. Unadjusted and adjusted accounts are given in Table A2.

TABLE A1

THE DERIVATION OF BALANCED ACCOUNTS FOR THE EEC

1. Balanced Accounts Summed for France, Germany, Italy, Netherlands and the United Kingdom, Million U.S.$ 1977

	Receipts					Payments				
	Households	Industrial and Commercial Companies	Financial Companies	Government	Rest of the World	Households	Industrial and Commercial Companies	Financial Companies	Government	Rest of the World
Wages	817,733				477					
Surplus	143,606	194,135	−27,526	373						
Indirect Taxes				183,560	2,369					
Imports					374,059					
Property Income	159,496	27,378	170,374	19,320	25,307	11,841	204,639	120,605	38,183	26,181
Direct Taxes				172,701		141,563	26,205	6,775	210	64
Other Transfers	285,807	18,136	17,004	238,779	28,027	257,766	18,918	16,096	280,635	12,429
Capital Transfers	−3,145	20,580	−874	−10,196	940	22	108		7,171	4
Net Acquisition of Financial Assets						106,992	−70,498	8,135	−44,298	−2,500
Consumption						851,703			258,577	
Investment						55,189	200,312	11,354	48,547	
Exports										392,591
Depreciation	24,676	117,253	3,993	11,153						
Subsidies									29,128	2,175
Residual						3,097	−2,202	6	−2,463	235
Total	1,428,173	377,482	162,971	615,690	431,179	1,428,173	377,482	162,971	615,690	431,179

The components of GDP are not shown in a separate column in this unbalanced table. These estimates are scaled by the ratio $GDP_{EEC}/(GDP_F+GDP_D+GDP_I+GDP_{NL}+GDP_{UK})$, and balanced against estimates of factor income and final demand in the whole EEC to yield the table on the next page.

TABLE A1 (cont.)

2. Balanced Accounts for the EEC 1977, Million U.S.$ 1977

	Receipts						Payments					
	Households	Industrial and Commercial Companies	Financial Companies	Government	Rest of the World	Factor Incomes	Households	Industrial and Commercial Companies	Financial Companies	Government	Rest of the World	Final Demand
Wages	899,546				−999	898,547						
Surplus	158,721	214,758	−29,156	1,902		346,225						
Indirect Taxes				202,504	2,084	204,588						
Imports					445,354	445,354						
Property Income	174,981	30,209	187,214	21,523	27,676		13,393	224,880	132,701	41,698	28,931	
Direct Taxes				190,777			155,393	28,081	6,928		377	
Other Transfers	313,850	20,045	18,590	262,803	29,862		283,776	20,694	17,802	308,262	14,617	
Capital Transfers	−3,618	22,949	−849	−10,713	319		185	−204		7,388	718	
Net Acquisition of Financial Assets							118,280	−77,343	9,320	−48,711	−1,547	
Consumption							937,403			288,104		1,225,507
Investment							61,058	220,130	12,592	53,099		346,879
Exports											458,865	458,865
Depreciation	26,012	128,278	3,545	11,801		169,636						
Subsidies										30,758	2,335	33,093
Total	1,569,492	416,239	179,344	680,597	504,296	2,064,350	1,569,488	416,238	179,343	680,598	504,296	2,064,344

For presentational purposes imports are included with factor incomes and indirect taxes are shown gross of subsidies. Small rounding errors remain.

TABLE A2

THE DERIVATION OF BALANCED ACCOUNTS FOR AUSTRALIA, NEW ZEALAND, AND THE REPUBLIC OF SOUTH AFRICA AND THE DEVELOPING REGIONS

Million U.S.$ 1977

Region	Consumption	Investment	Government Consumption	Goods Balance	Services Exports	GDP	Services Imports	Property Income Received	Allocated Transfers	Property Income Paid	Unallocated Transfers	Net Acquisition of Financial Assets
1. Unbalanced Accounts for A–NZ–RSA and the Developing Regions												
5	91,891	36,474	24,800	−1,154	16,767	154,796	10,333	728	−1,112	3,881	0	−3,068
6	103,899	76,264	57,408	43,841	8,289	270,300	25,479	8,525	−1,685	7,987	0	27,907
7	255,492	89,425	43,743	−10,237	16,307	386,973	12,432	2,370	2,030	11,366	0	−12,528
8	120,876	53,358	33,486	−6,509	8,880	202,800	3,139	1,083	10,470	3,447	0	−3,720
9	219,257	66,567	32,190	−527	10,408	313,902	10,457	1,775	5,344	7,024	0	98
2. Balanced Accounts for A–NZ–RSA and the Developing Regions												
5	90,307	36,224	24,685	−1,154	15,568	154,841	10,788	674	−1,112	5,416	120	−2,108
6	106,927	77,896	58,333	43,841	8,317	270,095	25,218	8,745	−1,685	7,794	−658	25,548
7	259,392	89,903	43,857	−10,237	16,366	386,884	12,398	2,393	2,030	10,844	−472	−13,162
8	122,378	53,651	33,601	−6,509	8,829	202,758	9,193	1,061	10,470	3,668	−4,454	−3,463
9	216,020	66,269	32,120	−527	10,476	313,968	10,389	1,829	5,344	6,172	−463	98

Appendix 2. Income and Substitution Effects in a Linear Model

The full exposition of the incorporation of the effects of relative price changes, summarised in section 3, is described here.

The import equation is

$$M_{ij} = m_{ij} Y_j + n_{ij} P_{ij} Y_j + c_j$$

M_{ij} = import volume by region j from region i

Y_j = final demand in region j adjusted for terms of trade effects

or

$$M_{ij} = (m_{ij} + n_{ij} P_{ij}) Y_j + c_j$$

P_i = price of exports of region i

$$P_{ij} = P_i / P_j$$

The propensity to import $m_{ij} + n_{ij} P_{ij} = \mu_{ij}$ may be more helpfully expressed as

$$\mu_{ij} = (m_{ij} + n_{ij}) + n_{ij}(P_{ij} - 1)$$

since $m_{ij} + n_{ij}$ represent the non-price effects.

Marginal exports of region j to region i are given as $\mu_{ij} Y_j$ while marginal imports are $\mu_{ji} Y_i$. The terms of trade gain to region i on its marginal trade with region j is therefore

$$\frac{P_i - P_j}{P_i + P_j} (\mu_{ij} Y_j + \mu_{ji} Y_i).$$

The symmetry of this with the loss of region j is clear. The full system of marginal gains and losses can be expressed as the sum of two matrices μ^* and v^*, relating to exports and imports separately, where

$$\mu^*_{ij} = \frac{P_i - P_j}{P_i + P_j} \mu_{ij}, \qquad \mu^*_{ij} = 0 \quad \text{if } i, j > 9$$

$$v^*_{ij} = \sum_j \frac{P_j - P_i}{P_j + P_i} \mu_{ij}, \qquad v^*_{ij} = 0 \quad \text{if } j \neq i \text{ or } i, j > 9.$$

Gains and losses also occur as a result of the trade flows implied by the constant term as

$$\Delta c_i = \sum_j \frac{P_j - P_i}{P_j + P_i} (c_{ij} + c_{ji}).$$

This yields as a full system in matrix form

$$y = (M + N)y + (\mu^* + v^*)y + N(P - \hat{1})y + x + c + \Delta c$$

where $\hat{1}$ is a matrix with each element 1.

This is expressed in the text as

$$y = M_1 y + M_2 y + M_3 y + x + c + \Delta c.$$

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