KEY SECTOR IDENTIFICATION WHEN THERE ARE MULTIPLE OBJECTIVES*

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1. Introduction

It is by now a commonplace of several years standing that the multiple aims and ambitions of developing countries cannot be subsumed into the single operational target of growth of G.D.P. While the nature of the various trade-offs between G.D.P. and other objectives are not fully understood, it is clear that such trade-offs are numerous and that there is a resulting need for economic policy to give them explicit attention instead of relying on some implicit correlation with thw G.D.P. variable 1/. Unfortunately, while this is well recognised in theory, existing macro economic data in developing countries is rarely designed in such a way as to permit any serious quantitative investigation of what this might mean in any particular country situation 2/. The purpose of this paper is to provide a modest contribution to remedying this situation by illustrating numerically how the expansion of different sectors of an economy can have different consequences for the various possible objectives of that economy.

The illustrations are all based on a condensed version of a social accounting data system for Sri Lanka for 1970 which was constructed explicitly to vast light on objectives of development such as fuller employment, greater equality of income distribution and so on 3/. The approach to analysis (or

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1/ Many of these trade-offs exist because of market imperfections or economies of scale. For example in a two factor model, and beginning with an equilibrium situation, there would be no difference in the marginal productivities of labour between sectors provided that factor markets were perfect and no sector operated under conditions of increasing returns. In such circumstances, there would be no output:employment trade-off. However, even if economies did conform to the neo-classical assumptions, some welfare trade-offs would still remain e.g. between rural and urban incomes, between high and low incomes, and thus governments might still need to intervene to secure welfare maximisation.

2/ We are not the first to raise this point and, in particular, it has been raised in a critique of the World Employment Programme by Erik Thorbecke. See International Labour Office (1973).

3/ This data system is described in detail in F.G.Pyatt, A.R.Roe and others, Social Accounting for Development Planning, Cambridge University Press, forthcoming.

modelling), which is the most straightforward given this system is one based heavily on a series of fixed coefficient assumptions and it is this approach which is used throughout this paper. However, we do not set out with the philosophy that coefficients are in practice constant over time, nor with the view that such an approach will yield results which are "correct" in some absolute sense. Rather, the enquiry which this paper reports upon has two principle purposes. The first is to explore the orders of magnitude of the differences between sectors in terms of their impact on various objectives. If these are sufficiently large, the relative importance of different sectors in relation to particular objectives may remain unchanged over time even though certain coefficients alter. The second purpose is to see how resilient or otherwise the results about the relative importance of the various sectors are to changes in the precise form of model which is used to assess the effects of their expansion. It is obviously important to know whether the incorporation of greater richness and complexity into a model, has any substantial implications for the conclusions about the role of particular sectors which emerge.

No attempt is made in this present paper to consider the implications of the weighting together of different objectives, the choice of appropriate weights and so on. This is a matter which will be discussed subsequently.

2. The direct effects of sectoral expansion

The condensed social accounting system which underlies the analysis of this paper is set down in Table 1. This differs from the full data system

referred to earlier [4/] in two principle ways. First, production activities have been aggregated into twelve categories from the original forty-eight, and the distinction between households in terms of income size has been suppressed leaving only a distinction based on location [4a/]. Secondly, the present system shows a direct link between production activities and institutional income recipients (e.g. the rows labelled household income at the interesection with the columns labelled production activites), whereas the original system also showed an intermediate stage whereby incomes were paid to particular factors of production and thence to institutional sectors such as households, government and so on. These simplifications are introduced only to economise on the space needed to present our results and the analysis has been repeated to generate comparable results to those presented here for the more complex system.

Given the fixed coefficient assumption, Table 1 readily yields information about, what we shall call, the direct effects of sector expansion. This is done by dividing the entry in each column by the corresponding column total (i.e. total supplies as shown in the penultimate row of Table 1.) The results of this simple calculation give the direct effects of a one unit expansion of gross output in each activity on the output of each of the other activities, assuming an equal supply response and constant prices, on household incomes of various types, on government revenues, on imports and on employment. The results are shown in Table 2.

Perhaps the most interesting result to be thrown up by Table 2 concerns

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4/ See Pyatt, Roe and others, op.cit.

4a/ Some results using the full disaggregation of the data are presented in Roe and Tyler (1976).

Table 1. Semi-aggregated Social Accounting Matrix for Sri Lanka, 1970 (R.m.)

RECEIPTS \ EXPENDITURES		PRODUCTION ACTIVITIES												TOTAL INTER DEMAND	HOUSEHOLD DEMAND				CORPORATIONS (PUBLIC & PRIVATE)	Capital A/c.	Rest of World	TOTAL DEMAND
		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.		Urban	Rural	Estate	Govt				
PRODUCTION ACTIVITIES	1. Tea												2	2	14	56	6	2		-55	839	864
	2. Rubber								8					8	0	0	0	0		25	341	374
	3. Coconut						274						6	253	52	207	30	4		29	2	577
	4. Paddy				70		1012			2	5			1084	0	0	0	0		49	0	1133
	5. Other Farming	11	1			95	31	2	62	2			39	248	350	988	138	16		0	106	1846
	6. Agricultural Processing					11	34		187	1			40	273	275	1065	138	26		90	152	2019
	7. Mining								2	3	74		1	80	2	6	1	0		0	19	108
	8. Traditional Industry	15				19	19		96	29	101	48	5	332	209	569	79	7		58	92	1346
	9. Modern Industry	82	24	9	35	50	24	9	36	329	136	128	31	894	132	335	33	59		17	72	1542
	10. Construction							1			160	10	47	218	0	0	0	92		1595	0	1905
	11. Trade & Transport	55	11	9	8	23	116	6	113	138	221	138	62	900	402	1078	142	89		154	210	2975
	12. Services	6	2	6	9	1	4			1	6	17	14	66	435	799	60	7		0	280	1647
Total Intermediate Inputs		169	38	24	122	199	1487	18	504	505	703	341	247	(4353)	1871	5103	627	302		1962	2113	16336
Household Income	Urban	42	40	123	-11.5	395	70	19	127	213	302	851	40	2581	38	0	0	614	- 236	0	6	3003
	Rural	89	143	181	1070	68	98	33	275	156	276	912	603	4515	0	56	0	892	1432	0	6	6901
	Estate	401	71	18	-0.5	13	8	1	2	3	7	18	41	582	0	0	6	16	100	0	6	791
Corporations (Private & Public)		65	66	207	-81	487	76	32	33	289	466	648	141	2418	-	-	-	294		0	-113	2599
Government Receipts		33	4	14	5	19	80	2	262	153	78	130	76	856	368	195	4	0	376	314	130	2241
Capital Account		0	0	0	0	0	0	0	0	0	0	0	0	0	519	807	11	42	833	0	425	2640
Rest of the World		75	12	10	29	53	199	3	143	223	73	75	128	1024	207	741	143	79	16	364	0	2573
TOTAL SUPPLIES		864	374	577	1133	1846	2019	108	1346	1542	1905	2975	1647	16336	3003	6901	791	2240	2599	2640	2573	
EMPLOYMENT (000)		607	191	52	719	288	81	21	266	78	116	464	228	3111								

TABLE 2 The direct impacts of a unit expansion of each production activity

Effect on \ Expanding Sector		TEA 1	RUBBER 2	COCONUT 3	PADDY 4	OTHER AGRIC. 5	AGRIC. PROCESSING 6	MINING 7	TRAD. INDUST. 8	MOD. INDUST. 9	CONSTRUCTION 10	TRADE & TRANSPORT 11	SERVICES 12
Production Activities	1	1.000											
	2		1.000										.00121
	3			1.000					.00594				
	4				1.06178		.12234						.00364
	5	.01273	.00267			1.05146	.50124			.00130			
	6					.00596	.01535	.01852	.04606	.00130	.00262		.02368
	7						1.01684		.13893	.00065			.02429
	8	.01736						1.000	.00149	.00195	.03885		.00061
	9	.09491	.06417	.01560	.03039	.01029	.00941		1.07132	.01881	.05302	.01613	.00304
	10					.02709	.01189	.08333	.02675	1.21336	.07139	.04303	.01882
	11	.06366	.02941	.01560	.00706			.00926			.08399	.00336	.02854
	12	.00694	.00535	.01040	.00794	.01246	.057 45	.05556	.08395	.08949	.11601	1.04639	.03764
						.00054	.00198			.00065	.00315	.00571	1.00850
Total Intermediate		1.1956	1.1016	1.04160	1.1072	1.1078	1.7365	1.16667	1.3744	1.32751	1.36903	1.11462	1.1516
HOUSEHOLD INCOMES													
Urban	14	.04861	.10695	.21317	-01015	.21398	.03467	.17593	.09435	.13813	.15853	.28605	.24894
Rural	15	.10301	.38235	.31369	.94440	.36840	.04854	.30556	.20394	.10117	.14488	.30655	.36612
Estate	16	.46412	.18984	.03120	-.00044	.00704	.00396	.00926	.00111	.00195	.00367	.00605	.02489
TOTAL	17	.61574	.67914	.55806	.93380	.58938	.08717	.49074	.29941	.24125	.30709	.59866	.64056
Incomes of other institutions	18	.06366	.17647	.35875	-.07149	.26381	.03764	.29630	.02452	.18742	.24462	.21782	.08561
Government	19	.03819	.01070	.02426	.00441	.01029	.03962	.01852	.19465	.09922	.04094	.04370	.04614
Capital Account	20	0	0	0	0	0	0	0	0	0	0	0	0
Imports	21	.08631	.03209	.01733	.02560	.027871	.09856	.02778	.10624	.14462	.03832	.02521	.0 7772
Labour (Men/100)	22	.70254	.51016	.08960	.63477	.15585	.04007	.19631	.19770	.05058	.06068	.15610	.13837

the wide variation between sectors as regards their direct impact on the various objectives and constraints which are identified. For example, from row 21, we see that the effects of a one rupee expansion of sectoral output on the import bill varies from 0.145 rupees for modern industry to 0.017 rupees for coconuts. Row 22 indicates that the impact of a Rs 1000 expansion of output on employment varies from 0.702 jobs in tea to 0.040 jobs in agricultural processing.

As a final example, row 15 shows that the impact on rural incomes of a one rupee expansion of activity varies from 0.944 rupees in the case of paddy to 0.101 rupees in the case of modern industry. While these results as presented imply a degree of accuracy which is almost certainly illusory, the wide variation in the impacts found between different sectors, suggests that our data permit us to learn a good deal about the relative importance of different sectors, judged from the viewpoint of the various objectives and constraints which are identified.

3. The indirect effects of sectoral expansion

Turning our attention to the possible indirect consequences of the expansion of any activity, let us begin by looking at the orders of magnitude of these effects relative to the direct effects already calculated. For this purpose we will concentrate on (a) those indirect effects which arise from the generation of intermediate demands by those sectors undergoing the original expansion (the "intermediate" effects) and (b) those indirect effects which arise from the generation of future consumption demand as a result of the stimulus

to household incomes (the "induced" effects). For the moment we will assume that there are no capital capacity constraints to any of the expansions which are considered; this assumption being relaxed in Section 4.

The "intermediate" effects are calculated in the familiar way using the identity

$$\underset{\sim}{A}\ \underset{\sim}{g} + \underset{\sim}{f} = \underset{\sim}{g} \qquad (1)$$

where $\underset{\sim}{A}$ = the coefficient form of the input-output part of the social accounting matrix

$\underset{\sim}{f}$ = a vector of final demands on outputs

$\underset{\sim}{g}$ = a vector of gross outputs

Solving (1), we have

$$\underset{\sim}{g} = \left[\underset{\sim}{I} - \underset{\sim}{A}\right]^{-1} \underset{\sim}{f} \qquad (2)$$

or, in difference form

$$\Delta\underset{\sim}{g} = \left[\underset{\sim}{I} - \underset{\sim}{A}\right]^{-1} \Delta\underset{\sim}{f} \qquad (3)$$

If $\Delta\underset{\sim}{f}$ is taken as a unit vector (implying a one unit expansion of

demand in each activity), [5/] then the direct plus "intermediate" effects of expansion on output levels can simply be read off from the columns of $[\underset{\sim}{I} - \underset{\sim}{A}]^{-1}$. The direct plus intermediate effects on other variables such as employment, imports, incomes, etc., can be calculated by again invoking the assumption of fixed coefficients. Thus we have:

$$\Delta\underset{\sim}{\eta} = \underset{\sim}{N}\,[\underset{\sim}{I} - \underset{\sim}{A}]^{-1}\,\Delta\underset{\sim}{f} \qquad (4)$$

where $N = \begin{bmatrix} n_{11} & n_{12} & \cdots & n_{1}12 \\ n_{21} & \cdots & \cdots & \vdots \\ \vdots & & & \vdots \\ n_{m1} & \cdots & \cdots & n_{m12} \end{bmatrix}$ = the matrix of coefficients shown in the bottom half of Table 2

So, for example, n_{11} is the part of the gross output of activity 1, which is paid out to urban households, n_{21} is the part paid out to rural households and so on. The number of rows in $\underset{\sim}{N}$ (namely, m) is equal to the number of variables other than output, the level of which we wish to assess. Thus, in our aggregated treatment as shown in Table 2, m is equal to nine.

The direct plus intermediate plus induced effects of the expansion

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5/ We have made no attempt to consider the nature and likelihood of occurrence of the initiating increase in exogenous demand in each sector. However, it is worth emphasising that sectors differ enormously in the proportion of final demand that derives from domestic expenditure rather than exports. For this reason, if for no other, the likelihood of exogenous demand increasing will vary as between sectors.

of any activity are calculated as follows:

Equation (1) is now re-written as:

$$\underset{\sim}{g} = \underset{\sim\sim}{A}\underset{\sim}{g} + \underset{\sim\sim}{C}\underset{\sim}{y} + \underset{\sim}{\bar{f}} \qquad (5)$$

where y = a vector showing the incomes of our (three) different household groups

$\underset{\sim}{\bar{f}}$ = a vector of final demand other than consumption demand

$$C = \begin{bmatrix} C_{11} \cdots\cdots\cdots\cdots\cdots C_{13} \\ C_{21} \cdots\cdots\cdots\cdots\cdots \\ \vdots \\ C_{12.1} \cdots\cdots\cdots\cdots\cdots C_{12.3} \end{bmatrix}$$

and shows the proportion of income of each of the three household categories spent on commodities from each of the twelve production activities

We also invoke the relationship

$$\underset{\sim}{y} = \underset{\sim\sim}{\bar{N}}\underset{\sim}{g} + \underset{\sim\sim}{e}\underset{\sim}{y} + \underset{\sim}{r} \qquad (6)$$

where $\bar{N}$ consists of those (three) rows of N which relate to household income.

$\hat{\underset{\sim}{e}}$ = a diagonalised vector showing the proportion of the income of each household category spent on domestic servants

$\underset{\sim}{r}$ a vector of exogeneous incomes of households (e.g. factor income from abroad or government transfers)

Bringing equations (5) and (6) together, we have

$$\left[\begin{array}{c} \underset{\sim}{g} \\ \hline \underset{\sim}{y} \end{array}\right] = \left[\begin{array}{c|c} \underset{\sim}{A} & \underset{\sim}{C} \\ \hline \bar{\underset{\sim}{N}} & \hat{\underset{\sim}{e}} \end{array}\right] \left[\begin{array}{c} \underset{\sim}{g} \\ \hline \underset{\sim}{y} \end{array}\right] + \left[\begin{array}{c} \bar{\underset{\sim}{f}} \\ \hline \underset{\sim}{r} \end{array}\right] \qquad (7)$$

which solves as:

$$\left[\begin{array}{c} \underset{\sim}{g} \\ \hline \underset{\sim}{y} \end{array}\right] = \left[\underset{\sim}{I} - \left[\begin{array}{c|c} \underset{\sim}{A} & \underset{\sim}{C} \\ \hline \bar{\underset{\sim}{N}} & \hat{\underset{\sim}{e}} \end{array}\right] \right]^{-1} \left[\begin{array}{c} \bar{\underset{\sim}{f}} \\ \hline \underset{\sim}{r} \end{array}\right] \qquad (8)$$

Finally, and analogously with the earlier treatment, we can re-write equation (8) in difference form, make $\Delta\bar{\underset{\sim}{f}}$ equal to the unit vector and then read off the direct plus intermediate plus induced effects from the columns of the inverse matrix shown in equation 8. Making Δr equal to the unit vector would permit a similar reading off of the effects of direct income creation in each of our household categories 6/. In the way our data is

6/ Round and Pyatt, in Chapter 4 of Pyatt, Roe et al., op.cit., have produced a much more elegant version of the Equation (8) expression, which explicitly shows the link between production activities and factors of production, and the link between factors of production and institutions. They also present an interesting decomposition of the matrix inverse.

arranged, direct income creation could encompass expansion of the government wage and salary bill as well as government transfer payments.

Using this approach, the two categories of indirect effects have been calculated and are as shown in Table 3.

The comparisons of Table 3 needs to be interpreted with care since the rows headed (i) and (iv) are measured in rupees (or thousandths of men) while rows headed (ii) and (iii) are ratios. Thus a large indirect effect as indicated by rows (ii) and (iii) may be compensated by a very small direct effect (row (i)). Row (iv) shows the results of expansion (direct + induced + intermediate effects) per unit of import expansion and is therefore the appropriate row to consider in a situation where import capacity is a binding constraint.

Looking first at total incomes in row 6, we can see that the relative importance of the "intermediate" effect of expansion varies as between sectors in the range from direct effect plus 4 percent to direct effect plus 750 percent. While several sectors are subject to intermediate effects which exceed the direct effects by 50 percent or more, agricultural processing stands out as the only sector where the intermediate effects dominate the direct. So while one conclusion is that the size of the intermediate effects for some sectors is not such as to justify the expenditure of resources on their quantification, this is not true of all of them. Certainly, there are at least four sectors in our schema where any investment

TABLE 3 A comparison of the direct, "intermediate" and "indirect" effects of sectoral expansion

Impact on / Expansion in		(1) Tea	(2) Rubber	(3) Coconut	(4) Paddy	(5) Other Farming	(6) Agric. Processing	(7) Mining	(8) Trad. Industry	(9) Modern Industry	(10) Construction	(11) Trade	(12) Services
1. Gross Output	(i)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(ii)	1.26	1.14	1.06	1.23	1.14	1.85	1.22	1.56	1.44	1.50	1.15	1.21
	(iii)	2.68	2.50	2.09	3.06	2.29	3.22	2.23	2.54	2.14	2.38	2.30	2.50
	(iv)	7.20	8.77	10.83	8.55	10.00	9.02	10.32	8.30	7.04	10.97	10.18	8.22
2. Value Added:	(i)	.680	.855	.917	.862	.853	.125	.787	.324	.429	.552	.817	.727
	(ii)	1.22	1.09	1.03	1.11	1.10	6.52	1.17	1.94	1.56	1.54	1.11	1.17
	(iii)	2.50	3.26	1.75	2.51	1.96	13.42	1.99	3.83	2.58	2.55	2.00	2.30
	(iv)	4.56	9.82	8.43	5.94	7.21	4.69	7.17	4.07	3.62	6.56	7.29	5.53
3. Urban Incomes:	(i)	.049	.107	.213	..	.213	.035	.176	.094	.138	.158	.286	.249
	(ii)	2.00	1.24	1.05	..	1.11	2.65	1.24	1.73	1.57	1.58	1.10	1.14
	(iii)	6.71	3.36	1.88	..	2.03	9.19	2.23	3.47	2.43	2.54	1.79	2.02
	(iv)	.88	1.26	2.07	.89	1.89	.89	1.82	1.07	1.10	1.85	2.27	1.65
4. Rural Incomes:	(i)	.103	.383	.314	.944	.368	.049	.306	.204	.101	.145	.307	.366
	(ii)	1.47	1.06	1.04	1.08	1.14	13.11	1.12	1.75	1.77	1.74	1.11	1.13
	(iii)	5.71	2.18	2.07	1.72	2.08	22.09	2.19	3.33	2.90	3.66	2.28	2.25
	(iv)	1.58	2.92	3.36	4.53	3.35	2.99	3.10	2.22	1.23	2.44	3.09	2.71
5. Estate Incomes:	(i)	.464	.190	.031	..	.007	.004	.009	.001	.002	.004	.006	.025
	(ii)	1.00	1.00	1.01	..	1.10	2.17	1.09	1.33	1.75	1.62	1.12	1.07
	(iii)	1.04	1.09	1.41	..	3.05	6.27	2.40	14.73	5.93	4.49	3.37	1.69
	(iv)	1.30	.73	.23	.06	.09	.07	.10	.05	.04	.07	.09	.14
6. Total Household Incomes:	(i)	.616	.679	.558	.934	.589	.087	.491	.299	.241	.307	.599	.641
	(ii)	1.17	1.07	1.04	1.09	1.11	8.50	1.18	1.81	1.66	1.66	1.10	1.14
	(iii)	2.27	2.06	1.96	2.10	2.08	16.24	2.21	3.42	3.07	3.09	2.06	2.14
	(iv)	3.76	4.91	5.66	5.49	5.35	3.97	5.01	3.34	2.44	4.37	5.44	4.51
7. Government Revenue:	(i)	.038	.011	.025	.004	.010	.040	.019	.195	.099	.041	.044	.046
	(ii)	1.56	2.02	1.15	2.30	1.79	1.43	1.85	1.17	1.39	1.89	1.29	1.22
	(iii)	5.05	15.24	6.22	44.87	15.14	5.03	8.44	1.75	2.29	4.63	4.60	4.58
	(iv)	.52	.57	.78	.55	.68	.56	.72	1.11	.75	.88	.89	.69
8. Imports:	(i)	.087	.032	.017	.026	.029	.099	.028	.106	.145	.038	.025	.077
	(ii)	1.28	1.44	1.26	1.35	1.35	1.29	1.70	1.36	1.33	1.89	1.52	1.16
	(iii)	4.29	8.87	11.15	13.99	7.99	3.62	7.77	2.88	2.10	5.66	8.97	3.92
	(iv)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9. Employment:	(i)	.702	.510	.090	.635	.156	.040	.196	.197	.051	.061	.156	.138
	(ii)	1.04	1.02	1.07	1.08	1.12	1.04	1.11	1.55	1.86	2.04	1.12	1.22
	(iii)	1.41	1.50	3.12	1.62	2.45	16.53	2.04	2.43	4.27	4.63	2.43	2.88
	(iv)	2.63	2.69	1.45	2.89	1.66	1.85	1.85	1.57	.71	1.30	1.68	1.31

NOTES:
(i) = Direct Effects of a one rupee of expansion in the sector identified at the head of the column. (Measured in rupees for all items other than Employment which is measured in thousandths of men.)

(ii) = The ratio of "Intermediate" + Direct Effects to Direct Effects.

(iii) = The ratio of "Intermediate" + "Induced" + Direct Effects to Direct Effects.

(iv) = Direct + "Intermediate" + "Induced" effects normalised against imports. (Measured in rupees for all other items than Employment which is measured in thousandths of men.)

allocation decision would be sorely misleading if it confined itself to direct effects.

Turning to the disaggregation of incomes as between our three household categories, it is interesting to observe how the separation of the estate sector from the rest of the economy shows up in very small "intermediate" effects (see row 5). In the two sectors in which estate labour is mostly employed (tea and rubber), and where the direct gains to estate incomes from expansion are greatest, the "intermediate" effects of such expansion are virtually non-existent. In all other sectors the direct effect of expansion on estate households is less than on other rural households (line 4), and the relative magnitudes of the "intermediate" effects for the two household groups nearly always magnifies this discrepancy (a modest exception being trade and transport). When we allow for "induced" effects, the situation is reversed a little since several of the multipliers shown in row (iii) for estate households are larger than the corresponding multipliers for rural households. However, this last result depends heavily on induced consumption of tea giving rise (through the fixed coefficient assumption), to equi-proportionate increases in all categories of income arising from tea production including profits and estate and household incomes. To the extent that profits took a disproportionate share of any increased production, the size of the induced effect on estate incomes would obviously be reduced.

Turning to the other variables identified in the table, (i.e. government revenue, imports and employment), we again see that the "intermediate" effects are generally of considerable significance. This is even

more true of the induced effects which are often extremely large as well as being highly variable as between sectors. While the wide variability does indicate the necessity of taking proper account of the induced effects in planning investment allocation, the magnitude of these effects also invites a query about the number of rounds of induced spending which our multipliers involve, and the probable total time lag between direct and total induced effects. Our explorations of this indicate that while only about two rounds of the multiplier process are necessary for convergence when induced effects are ignored, this is increased to about seven rounds when they are included. Thus the wide variability of induced effects as between sectors may not be of concern to an investment allocation which has only a short time horizon.

But, perhaps the most interesting results to emerge from the calculation of direct and indirect effects of sectoral expansion, concerns the potential conflicts between objectives which are revealed, and the manner in which these conflicts are altered by incorporating a wider range of indirect effects. This is brought out in Table 4 which compares the effects of expansion of eight of the nine variables identified in Table 3, by ranking these in order (gross output being the Table 3 variable which is omitted). The rankings are given separately for direct effects, direct plus intermediate effects, direct plus intermediate, plus induced effects 7/ and for the effects normalised on imports 8/.

7/ The largest effect is given the rank of 1 for all variables other than the imports which, because it is regarded as a constraint rather than an objective, is ranked in reverse order with the smallest effect having the first position.

8/ This normalisation obviously invokes the reasonable assumption that foreign exchange is a scarce resource. However, it does give rise to certain difficulties in interpreting our results since the export element in the exogneous demand shift which triggers our multiplier must obviously differ between sectors. For a sector such as tea, where export demand dominates, the exogenous demand expansion eases the foreign exchange constraint automatically and in a way that does not apply to sectors relying heavily on domestic demand. This difference is not taken into account in our comparisons but it could easily be allowed for by calculating units of objective generated per unit of net foreign exchange gained. Thus sectors adjudged likely to have only a small export element in additional exogenous demand would yield net imports and a negative coefficient. Sectors likely to have a high export element in additional demand would be likely to generate a positive coefficient.

It is immediately clear that there is no tidy consistency of results. The rankings vary widely as between different targets (and constraints), and even when we restrict ourselves to single targets, the rankings vary according to whether or not we take account of the various indirect effects. The major conflicts between targets which emerge are as follows:-

Tea: good from the point of view of estate incomes and employment, but poor from the viewpoint of urban and rural incomes and imports.

Rubber: good from the viewpoint of estate income and employment but bad from the viewpoint of government revenues and urban income.

Coconut: good from the viewpoint of imports and estate income but poor from the employment angle.

Paddy: good from the viewpoint of rural income, and employment but bad from most other angles; considerable ambiguity about the import effect which change significantly depending upon whether or not the induced effects are included.

Agricultural Processing: considerable ambiguity about its effects on rural incomes and employment; incorporation of intermediate and induced effects renders this much more favourable. Reasonably good from the viewpoint of employment.

Traditional and Modern Industry: good for government revenues but bad on most other counts.

TABLE 4. Ranking of Sector According to Size of Effect on Certain Targets and Constraints

	VALUE-ADDED				URBAN INCOME				RURAL INCOME				ESTATE INCOME				GOVERNMENT REVENUE				IMPORTS			EMPLOYMENT			
	(i)	(ii)	(iii)	(iv)	(i)	(ii)	(iii)	(iv)	(i)	(ii)	(iii)	(iv)	(i)	(ii)	(iii)	(iv)	(i)	(ii)	(iii)	(iv)	(i)	(ii)	(iii)	(i)	(ii)	(ii)	(iv)
Tea	8	9	3	10	10	10	10	12	10	12	10	11	1	1	1	1	7	4	7	12	9	9	12	1	1	2	3
Rubber	3	4	1	1	8	9	7	7	2	5	3	7	2	2	2	2	10	10	9	9	6	5	6	3	3	3	2
Coconut	1	2	8	2	4	5	5	2	5	9	9	2	3	3	3	3	8	9	12	4	1	1	1	9	11	11	9
Paddy	2	1	2	7	12	12	12	11	1	1	1	1	12	12	6	10	12	12	6	11	3	2	11	2	2	1	1
Other Agriculture	4	3	5	4	3	4	3	3	3	3	5	3	7	7	8	6	11	11	11	8	5	4	5	7	7	8	7
Agricultural Processing	12	10	4	9	11	11	11	10	12	2	2	6	8	6	5	9	6	6	5	10	10	10	10	12	4	4	4
Mining	6	5	9	5	5	6	6	5	7	7	8	4	5	5	7	5	9	8	10	6	4	6	2	5	6	6	5
Traditional Industry	11	12	11	11	9	8	9	9	8	6	7	10	11	11	11	11	1	1	1	1	11	11	9	4	5	5	8
Modern Industry	10	11	12	12	7	7	8	8	11	11	12	12	10	10	12	12	2	2	2	4	12	12	7	11	12	12	12
Construction	9	8	10	6	6	3	4	4	9	10	11	9	9	9	10	8	5	3	8	3	7	7	3	10	10	10	11
Trade & Transport	5	6	7	3	1	1	1	1	6	8	6	5	6	8	9	7	4	5	4	2	2	3	4	6	8	9	6
Services	7	7	6	8	2	2	2	6	4	4	4	8	4	4	4	4	3	7	3	7	8	8	8	8	9	7	10

(i) = Direct Effect
(ii) = Direct + Intermediate Effects
(iii) = Direct + Intermediate + Induced Effects.
(iv) = Direct + Intermediate + Induced Effects normalised against Imports.

Trade, and transport: good for urban incomes but rather poor for employment.

These examples of conflicts between objectives can be defined more concisely so as to yield some conclusions of rather more general interest. This can be done by calculating the coefficients of rank correlation between some of the objectives, concentrating for this purpose on the import constrained case indicated in columns (iv) of Table 4. For example, the rank correlation coefficient between value-added and urban incomes is somewhat higher than the corresponding coefficient between value-added and rural incomes (.69 as against .66) indicating a slight urban bias in a strategy geared to output. Far more significant is the fact that government revenues have a strong positive rank correlation with urban incomes (.59) but a weak negative correlation (-.21) with rural incomes. As a final example, there is a large negative rank correlation coefficient between urban income and employment (-.45) and a large positive coefficient linking rural incomes and employment (.40). In short, the results suggest that an output objective is slightly more favourable to urban than rural incomes, urban income is better than rural income creation from the point of view of boosting government revenue, but rural income creation is better than urban income if the aim is to raise employment.

What though of the distance between sectors in terms of their effects on particular objectives? As was noted in the introduction, the greater this distance, the more likely is it that a simple fixed coefficient

approach may have some analytical value even though coefficients are in practice known to vary. This question is answered in tentative form in the table below which shows two indicators of distance for each of three sets of effects shown in Table 3 (direct effects, direct + intermediate plus induced effects, and effects normalised against imports). The first, or maximum distance, is simply the biggest sectoral effect as expressed as a ratio of the smallest. The second, or average, distance is defined, for each objective, as:

$$\frac{1}{n-1} \sum_{i=1}^{n-1} \left(\frac{E_{(i+1)}}{E_i} \right)$$

, where E_i is the effect on the objective of expanding the i^{th} sector in the rank order.

Three conclusions emerge very clearly from Table 5. The first is that the maximum distances between sectors in relation to several objectives is very large and is unlikely to be eliminated by coefficient changes of plausible magnitudes. For example, it is highly improbable that modern industry which is currently the worse sector from the viewpoint of employment creation could be promoted to a prime position from this viewpoint on the basis of coefficient shifts which were in any way plausible. The second conclusion is that estate incomes is an objective where the economic distance between sectors, even on average, is extremely marked and where even dramatic coefficient changes are unlikely to alter the sector specific dependence of this objective. Finally, it is clear that the distance between sectors, and therefore the case for a sectoral element in moving towards objectives, diminishes somewhat as a richer menu of endogeneity is introduced into the analysis.

Table 5. Distance between sectors from the viewpoint of various objectives.

	Direct Effects		Direct+Intermediate+Induced Effects		Normalised Effects	
	Max.Distance	Average Distance	Max.Distance	Average Distance	Max.Distance	Average Distance
Value-Added	7.33	1.25	1.52	1.09	2.52	1.09
Urban Income	negative	1.25	1.56	1.04	2.59	1.09
Rural Income	19.27	1.37	4.10	1.52	3.68	1.13
Estates Income	464.00	2.17	40.40	1.47	32.60	1.46
Total Household Income	10.74	1.30	2.65	1.10	2.32	1.08
Government Revenue	48.75	1.47	1.72	1.08	2.14	1.07
Employment	17.55	1.35	4.75	1.16	4.03	1.16

However, Table 4, together with the above discussion, is adequate to indicate the complexity of the conflict between objectives which faces the planner. In practice, his task could be eased by the calculation of the slope of the trade-offs between different objectives and this is of course a relatively simple task given the detailed results which underlie the tables shown here. But, it could only be solved by the specification of some social welfare function which would permit a weighting together of the various objectives. If nothing else, our results clearly confirm that the planner normally cannot proceed in the pursuit of a single objective relying on the assumption that he will thereby be furthering other objectives as well.

4. Capacity constraints

The models discussed so far involve the implicit assumption that sectoral expansions are not constrained by any shortages of capital capacity. While this is currently a reasonable assumption for most sectors of the Sri Lankan economy, this would clearly cease to be true if any non-marginal increments to output were considered. Thus the following paragraphs illustrate some of the issues associated with the introduction of capital formation as an endogenous part of the analysis.

The standard approach to the incorporation of capacity constraints involves the use of an "investment accelerator" through which any increase in output generates a proportionate increase in investment. The difficulty

is that if the ratios of capital : output are assumed constant, and exceed unity then the output effects of any exogenous increase in demand will be extremely large since the number of rounds of secondary demand generation can easily approach infinity. This result is avoided if a large enough proportion of the induced demands leaks into imports or if the process is frozen after a specified number of rounds corresponding, in time, to decision making horizons. It would also be avoided if it were possible to distinguish those sectors where an accelrator machanism is likely to apply because of full capacity working, from other sectors.

In the absence of this first best procedure, an alternative "device" to avoid the problem of an infinite process is to assume rather arbitrarily, that sectors which produce capital goods have a capacity which exceeds any induced demands for capital while other sectors are initially at full capacity and so need new investment as soon as they face any increase in demand however small 9/. The system under this regime is easily solved since one can simply add the capital : output ratios of the sectors not producing capital goods (suitably disaggregated by the industries which supply the capital goods), to the appropriate rows (i.e. the rows representing the capital goods producing sectors), of the A matrix, and then invoke equations (3) or (8) above. The results of applying this procedure to our aggregate SAM are shown in summary form in Table 6. The rows labelled (a) in the table indicate the mutiples of the direct effect of expansion which are generated by a combination of the indirect effects discussed earlier and the accelrator effects. These numbers have little interest except that they indicate by their magnitude, and by comparison

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9/ Though insofar as one is thinking of the increase in exogenous demand which triggers out multiplier process as deriving from policy changes, then the increased exogenous demand on the capital goods sector may take the form of an increase in investment which the strict logic of our assumption indicates to be unnecessary.

BLE 6. Effects of sectoral expansion when capital is endogenous

	Tea	Rubber	Coconut	Paddy	Other Agric.	Agric. Proces.	Mining	Trad. Ind.	Mod. Ind.	Constr- uction.	Trade & Tran.	Services
	1	2	3	4	5	6	7	8	9	10	11	12
ıral comes	a 91.9 b .460 c 8	69.7 .449 10=	30.0 .468 5	9.9 .575 1	51.4 .485 2=	202.9 .485 2=	41.2 .458 9	51.5 .465 6=	106.5 .469 10=	48.5 .469 4	32.9 .465 6=	56.2 .444 12
ban comes	a 156.5 b .370 c 7=	200.8 .361 12	35.4 .376 5	- .409 1	26.1 .384 2	218.4 .370 7=	57.7 .369 9=	89.0 .371 6	64.1 .369 9=	36.2 .383 3	28.7 .379 4	67.4 .362 11
state comes	a 1.6 b .036 c 1	5.1 .016 2	9.7 .015 3=	- .015 3=	29.2 .014 5=	71.4 .014 5=	39.6 .013 10=	274.9 .014 5=	166.2 .013 10=	56.3 .014 5=	49.0 .014 5=	24.9 .013 10=
otal ousehold comes	a 28.9 b .866 c 4=	72.3 .826 11	30.9 .859 6	17.4 .999 1	21.7 .883 2	202.5 .869 3	47.1 .841 9	64.1 .850 8	82.7 .831 10	42.2 .866 4=	31.1 .858 7	59.3 .819 12
mports	a 70.8 b .299 c 10=	526.1 .284 1	334.5 .289 3	211.8 .334 12	155.0 .297 7	61.6 .299 10 =	283.8 .287 2	63.3 .298 8=	48.9 .295 6	116.5 .298 8=	251.4 .292 5	173.4 .291 4
mployment	a 8.3 b .282 c 2	29.0 .249 10	56.1 .250 8=	8.2 .321 1	24.3 .261 4	135.6 .267 3	35.0 .250 8=	29.4 .258 5	115.8 .244 11	62.8 .255 6	35.1 .253 7	80.3 .240 12
overnment	a 122.2 b .227 c 7	1220.4 .220 12	185.5 .223 8=	933.0 .253 1	322.5 .228 4=	116.7 ..228 4=	330.4 .222 11	27.3 .235 2	55.1 .228 4=	84.9 .232 3	110.6 .223 10	224.7 .224 8

with Table 3, that the applicability and interpretation of the results is changed dramatically by the endogenisation of investment within the model. Of slightly greater interest are the results shown in the rows labelled (b) in which the total effects shown in the rows labelled (a) are divided by the total increase in capital which is induced in generating these effects 10/. An examination of these effects and their rankings in the rows labelled (c) indicates the same conflict between the various objectives which was noted earlier, but suggests this to be of a slightly lower degree than was the case when investment effects were ignored (e.g. in Table 3). However, the main conclusion from Table 6 is that the model underlying it is qualitatively quite different from the earlier models in that it involves very many rounds of indirect effects and takes us into a time dimension which is certainly far in excess of the medium term one which is at issue in most economic planning. This is turn means that the incorporation of an investment multiplier in the manner discussed here may merely obscure the real issues which are involved in the identification of key sectors for normal planning purposes.

A somewhat more promising approach is the so-called Semi-Input output method proposed in Tinbergen 11/. This approach recognises that many of the demands which are induced at various stages of the multiplier processes just discussed, can be met by imported supplies, thus reducing the size of the

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10/ This normalisation carries with it the reasonable implication that capital is a scarce commodity.

11/ J.Tinberger (1967)

multipliers. The dichotomy in the previous model between capital goods producing and non capital goods producing sectors is replaced in the semi-input output method, by a dichotomy between sectors producing tradeable goods and those producing non-tradeable goods. Demands on the goods produced by tradeable goods sectors are assumed to be wholly imported while demands on the goods produced by non-tradeable goods sectors are assumed to be domestically produced thereby contributing to the various multipliers. The latter sectors are identified as those sectors unable to trade due to transportation costs or socio-economic, cultural or political impediments.

It should be stressed that this approach was originally developed to identify the 'key' sector that would be selected for expansion in a first best world where all internationally tradeable outputs and inputs can be bought and sold at constant prices in perfect world markets, and where capital is the only scarce factor of production. Within this framework, the aim is to find that single sector whose product the economy should specialise in producing for export, while importing, if possible, all requirements of other traded goods. In other words, the approach is designed to find the optimum specialisation of an economy in the context of free trade and perfectly price elastic markets. The conditions underlying this optimising approach are clearly not generally applicable to the circumstances of the Sri Lankan economy and therefore any proposed ranking of sectors which its use generates must be qualified by the separate question (which we do not consider in this paper), of the extent to which, and the terms on which, exportable surpluses might indeed be disposed of. Equally

on the import side, as well as implying no import constraint, the approach implies the maximal effect of expansion on imports and its value for practical investment alternatives decisions is therefore increased if we normalise the results on the import expansion in order to obtain a clear picture of the relative merits of expanding the different sectors 12/. These and other results of applying the semi input-output approach are shown in Table 7. The underlying algebra of the model is presented in the Appendix to the paper.

The top panel of Table 7 shows the impact of a one rupee expansion of the nine international (or tradeable goods) on various objectives and constraints of development, while the second panel shows the same results but in their more meaningful normalised form. If we compare the results in the top panel of Table 7 with those in Table 3, we find, not surprisingly given our assumptions, that the import effects in Table 7 are always greater than in Table 3, (for example, the product of the row (i) and row (iii) entries for imports in Table 3, never exceeds one whereas the smallest corresponding entry in Table 7 is 2.32). However, for all other effects, the consequences of incorporating induced investment using the semi input-output method is sometimes to increase these effects as compared with Table 3, and sometimes to reduce them. Thus, for example, the income effects of expanding Paddy production are lower using the semi input-output method than in the simpler application which included only intermediate and induced consumption effects. By way of contrast the income effects of expanding Rubber production are considerably larger under the semi input-output assumptions.

12/ Also see the footnote on page 14 for one difficulty associated with this normalisation.

Table 7. The effects of one rupee expansion of international sectors in a semi-input-output approach

Objective / International Sectors (constraints)	Tea	Rubber	Coconut	Paddy	Other Agri-Culture	Agri-cultural Processing	Mining	Traditional Industry	Modern Industry
i) Absolute Effects									
Value-Added (Rs)	3.019	9.567	4.096	1.991	2.269	2.156	5.108	2.700	3.524
Urban Income (Rs)	.4747	1.8300	.8431	.2144	.4852	.2762	.9969	.4451	.6548
Rural Income (Rs)	.5464	2.1351	.9607	1.1993	.6551	.2966	1.1407	.5654	.6284
Estate Income (Rs)	.4806	.2407	.0504	.0081	.0160	.0109	.0333	.0115	.0169
Total Household Income (Rs)	1.5018	4.2062	1.8544	1.4219	1.1564	.5837	2.1711	1.0221	1.3002
Government Revenue (Rs)	.1996	.6565	.2853	.1072	.1422	.1307	.3456	.3369	.3036
Imports (Rs)	3.6500	12.29	4.09	2.43	2.32	2.54	5.65	3.51	4.67
Employment (men-thousandths)	.9112	1.3190	.3885	.7533	.2898	.1559	.5804	.3655	.2953
(ii) Normalised Effects									
Value-Added (Rs)	.827(5)	.778(7)	1.002(1)	.819(6)	.978(2)	.849(4)	.904(3)	.769(8)	.755(9)
Urban Income (Rs)	.130(6)	.149(4)	.206(2)	.088(9)	.209(1)	.109(8)	.177(3)	.127(7)	.140(5)
Rural Income (Rs)	.150(7)	.174(5)	.235(3)	.494(1)	.282(2)	.117(9)	.202(4)	.161(6)	.135(8)
Estate Income (Rs)	.122(1)	.020(2)	.012(3)	.003(7)	.007(4)	.004(6)	.006(5)	.003(7)	.004(9)
Total Household Income (Rs)	.411(4)	.342(6)	.453(3)	.585(1)	.498(2)	.230(9)	.384(5)	.291(7)	.278(8)
Government Revenue (Rs)	.055(6)	.053(7)	.070(2)	.044(9)	.061(4)	.052(8)	.061(4)	.096(1)	.065(3)
Employment (men-thousandths)	.250(2)	.107(4)	.095(7)	.310(1)	.125(3)	.061(9)	.103(6)	.104(5)	.063(8)

The bottom panel of Table 7 shows both the normalised effects of expansion and (in brackets), the rankings of these effects. These results reveal many of the same conflicts between objectives as are present in Table 4. In particular, Paddy production occupies the prime position when the objective is rural income but last position when the objective becomes urban income. Tea and rubber are the most important sectors from the viewpoint of estate household incomes bur relatively low in the ranking from the viewpoint of rural incomes. Comparison of the first, second and third rows of the second panel of the table indicate that the correlation between value-added and rural income (the rank correlation coefficients are .55 and .43 respectively), which suggest as before a slight urban bias in an output objective. It is also the case that the correlation between urban incomes and government revenues is still very much higher than that between rural incomes and government revenues (rank correlation being .51 and -.04 respectively). As a final example, the conflict between urban and rural objectives can again be brought out by noting that the rank correlation coefficient between urban incomes and employment is -.10 whereas the corresponding correlation between rural incomes and employment is .600.

In short the information about certain broad conflicts in development policy is approximately the same under semi input-output assumptions as it was when we considered a rather simpler model earlier in the paper. For completeness, it is also useful to look again at the

distance between sectors using the semi-input-output results. This is done in Table 8 which uses the same definitions of distance as those employed in Table 5, and the normalised results from Table 7.

Table 8 Distance between sectors from the viewpoint of various objectives.

Objective	Max Distance	Average Distance
Value-Added	1.33	1.04
Urban Income	2.38	1.12
Rural Income	4.22	1.21
Estate Income	30.50	1.94
Total Household Income	2.54	1.13
Government Revenue	2.18	1.11
Employment	5.08	1.26

Comparing the Table 8 results with those in the last panel of Table 5 indicates that the average distance between sectors is increased for virtually all objectives when the semi input-output approach is used, and that the uniqueness of the estate income objective remains. It would still seem to be the case that there is enough "structure" in the economy to get useful information from a fixed coefficient approach even though coefficients can alter in practice.

5. Conclusions

While the conclusions of this paper must in the first instance be seen as specific to the circumstances of the Sri Lankan economy, and indeed to the aggregation of the data for that economy which has been chosen, they do provide information which would almost certainly be of relevance in other contexts.

The main conclusion is that sectors do vary considerably from the viewpoint of the effect of their expansion on particular objectives. Thus an initial quantification of these differences is of some policy value in its own right. Unfortunately, these differences are not positively correlated as between objectives so that several important trade-offs are suggested by the results. In particular, our results indicate that an output objective is far from being perfectly consonant with a household income objective but seems to be in greater conflict with a rural than an urban income objective. A government revenue objective is similarly more in conflict with a rural than an urban income objective, while an employment objective is in the opposite position.

A secondary result is that the precise conclusions which one reaches about the effects of expanding particular sectors on particular objectives is sensitive to a degree upon the richness of the endogeneity which is employed in reaching these conclusions. For example, we show that one cannot talk about "the" most employment intensive sector without specifying the range of indirect effects, if any, which are being employed to calculate this. On the other hand the time dimensions of ones policy

interest clearly increases as endogeneity is increased and this ambiguity will therefore be more apparent than real if one is only concerned with relatively short term issues. It is especially the case that the endogenisation of capital changes the nature of the issues being examined.

Finally, on the question of fixed coefficients it is clearly the case that many of our conclusions about sector rankings would change in the face of coefficient shifts. However, the calculations of distance between sectors which we present suggest that many of the relativities between sectors which we show, would prove robust even in the face of large coefficient changes. This is especially true as concerns the sectoral dependence of the estate income objective.

Appendix: The algebra of the semi input-output approach

In describing this method, we first need to note that the variables which it involves relate to changes between two time periods and not the absolute magnitudes as in normal Leontief-type inter-industry equations. The commodity balance equations in terms of changes can be written as follows for an economy having M production sectors.

$$\underset{\sim}{X}_M = \underset{\sim}{A}_{MM}\underset{\sim}{X}_M + \underset{\sim}{B}_M + \underset{\sim}{C}_M + \underset{\sim}{Z}_M \qquad (9)$$

where

$\underset{\sim}{X}_M$ = Changes in sectoral output (a column vector of order M x 1).

$\underset{\sim}{A}_{MM}$ = Matrix of technical coefficients of order M x M

(Note: $\underset{\sim}{A}$ being an aggregation of the Input-Output Transactions matrix and an import matrix).

$\underset{\sim}{B}_M$ = Change in net balance of trade or difference between exports and imports (a column vector of order M x 1).

$\underset{\sim}{C}_M$ = Change in consumption (a column vector of order M x 1).

$\underset{\sim}{Z}_M$ = Change in output devoted to capital formation (a column vector of order M x 1).

Consumption is assumed to be linearly related to changes in income for each of the three household groups (i.e. we assume separate linear Engel curves for urban, rural and estate households).

$$\underset{\sim}{C}_M = \underset{\sim}{c}_M\underset{\sim}{Yi}_M \qquad (10)$$

where $\underset{\sim}{c}_M$ is the matrix showing the marginal propensity to consume the M commodities, in each of the three household groups, and $\underset{\sim}{Y}$ is a matrix showing the change in income for each household corresponding to change in aggregate sectoral value-added defined as:

$$\underset{\sim}{Y} = \underset{\sim}{v'}_{M}\hat{\underset{\sim}{X}}_{M} \qquad (11)$$

where $\underset{\sim}{v'}_{M}$ is a matrix of value-added coefficients (i.e. each cell shows the value-added share of gross output in a particular sector, attributable to each household group). The change in capital formation output requirements is taken as the difference between absolute magnitudes of investment flows during the base year (0) and terminal year (1) of the planning period, as shown in (12) below.

$$\underset{\sim}{Z}_{M} = \underset{\sim}{Z}_{IM} - \underset{\sim}{Z}_{OM} \qquad (12)$$

Further, the changes in output envisaged during the plan period requires additional capital formation the magnitude of which can be derived through the capital matrix $\underset{\sim}{K}_{MM}$ thus:

$$\underset{\sim}{Z}_{IM} = \underset{\sim}{K}_{MM}\underset{\sim}{X}_{M} \qquad (13)$$

Then substituting equations (10), (11), (12) and (13) into (9), we obtain

$$\underset{\sim}{X}_{M} = \underset{\sim}{A}_{MM}\underset{\sim}{X}_{M} + \underset{\sim}{B}_{M} + \underset{\sim}{c}_{M}\underset{\sim}{v'}_{M}\hat{\underset{\sim}{X}}_{M}\underset{\sim}{i}_{M} + \underset{\sim}{K}_{MM}\underset{\sim}{X}_{M} - \underset{\sim}{Z}_{OM} \qquad (14)$$

At this point we have to take note of Tinbergen's objection to standard input-output procedures by dichotomising the country's economic structure into two parts. Sectors that can enter international trade by exporting excess supply or importing to meet excess demand are classified as 'trading' or 'international' sectors. Sectors which cannot trade due to transportation costs or socio-economic, political or cultural impediments

are classified as non-tradeable or national sectors. In the disaggregated Sri Lanka Input-Output Table for 1970 the sectors Construction (36), Electricity (37), Road Passenger Transport (38), Rail Transport (39), Trade and Other Transport (40a), (40b), (40c), Services (41a, 41b, 41c, 41d, 41e) we redefined as non-tradeable or national sectors. The remaining sectors were defined as tradeable or international sectors. In our aggregated system there are only three national sectors namely Construction, Trade and Transport and Services. The criterion for sector ranking then involves taking account only of those indirect effects emanating from the expansion of any tradeable sector which affects the non-tradeable sectors.

If we partition equation (14), according to the dichotomisation premise into T tradeable sectors and N non-tradeable sectors, we derive the following result:

$$\begin{bmatrix} \underset{\sim}{X}_T \\ \cdots \\ \underset{\sim}{X}_N \end{bmatrix} = \begin{bmatrix} \underset{\sim}{A}_{TT} & \vdots & \underset{\sim}{A}_{TN} \\ \cdots & \cdots & \cdots \\ \underset{\sim}{A}_{NT} & \vdots & \underset{\sim}{A}_{NN} \end{bmatrix} \begin{bmatrix} \underset{\sim}{X}_T \\ \cdots \\ \underset{\sim}{X}_N \end{bmatrix} + \begin{bmatrix} \underset{\sim}{B}_T \\ \cdots \\ \underset{\sim}{B}_N \end{bmatrix} + \begin{bmatrix} \underset{\sim}{c}_T \\ \cdots \\ \underset{\sim}{c}_N \end{bmatrix} \begin{bmatrix} \underset{\sim}{v}'_T & \underset{\sim}{v}'_N \end{bmatrix} \begin{bmatrix} \underset{\sim}{X}_T \\ \cdots \\ \underset{\sim}{X}_N \end{bmatrix}$$

$$+ \begin{bmatrix} \underset{\sim}{K}_{TT} & \vdots & \underset{\sim}{K}_{TN} \\ \cdots & \cdots & \cdots \\ \underset{\sim}{K}_{NT} & \vdots & \underset{\sim}{K}_{NN} \end{bmatrix} \begin{bmatrix} \underset{\sim}{X}_T \\ \cdots \\ \underset{\sim}{X}_N \end{bmatrix} - \begin{bmatrix} \underset{\sim}{Z}_{oT} \\ \cdots \\ \underset{\sim}{Z}_{oN} \end{bmatrix} \qquad (15)$$

Re-arranging this expression, leads to:

$$\begin{bmatrix} I_{TT} - A_{TT} - K_{TT} - c_T v_T' & \vdots & A_{TN} - K_{TN} - c_T v_N' \\ \cdots\cdots & \vdots & \cdots\cdots \\ A_{NT} \quad K_{NT} \quad c_N v_T' & \vdots & I_{NN} - A_{NN} - K_{NN} - c_N v_N' \end{bmatrix} \begin{bmatrix} X_T \\ \cdots \\ X_N \end{bmatrix} = - \begin{bmatrix} Z_{oT} \\ \cdots \\ Z_{oN} \end{bmatrix} + \begin{bmatrix} B_T \\ \cdots \\ B_N \end{bmatrix} \qquad (16)$$

The above system of M simultaneous equations has T + N = M + T unknowns. This leaves T degress of freedom to attain the objective of maximising value-added (or national income) by using the minimum possible investment budget. The T degrees of freedom are accounted for by specifying that only one tradeable sector is expanded at a time and then quantifying its repercussions on its complementary non-tradeable sectors.

By the assumptions of the semi-input-output model the non-tradeable sectors do not export or import and hence $B_N = 0$. Also if each international sector is assumed to expand by one unit successively X_T can be written as i_T (a unit vector of order T) and we obtain the repercussions on the national sectors, derived from (16) as,

$$(I_{NN} - A_{NN} - K_{NN} - c_N v_N')\, X_N = (A_{NT} + K_{NT} + c_T v_T')\, i_T - \bar{Z}_{ON} \qquad (17)$$

Substituting $D = A + K + cv'$ we get the following result from (18)

$$X_N = (I_{NN} - D_{NN})^{-1} D_{NT} i_T - (I_{NN} - D_{NN})^{-1} Z_{ON} \qquad (19)$$

This final expression shows that the expansion of output in the non-tradeable sectors depends upon two opposing effects represented by the two terms on the right hand side of (19). The first, and positive effect, arises from the assumed expansion of the tradeable sectors multiplied by a

matrix multiplier which in turn shows the intermediate and induced effects of this expansion on the national sectors. The second, and negative effect, represents the contribution to output of the investment in the base year (Z_{ON}), and this gives the fall in output this year were there no new investment induced by expansion of the tradeable sectors (i.e. this investment needs to be repeated in each subsequent year in order to sustain an output level equal to that in the previous year). The overall expression indicates the magnitude of the net output effects in national sectors arising from a one unit expansion of demand in each tradeable sector.

The effects of the expansion of tradeable sectors on objectives (and constraints) other than output can be calculated by adding the direct effects of this expansion on these other objectives (i.e. as shown in Table 2), to the effects of the indirect expansion of the national sectors on these objectives. The full range of effects for our aggregated system are shown in Table 7, excluding the effects of Z_{ON} (i.e. the non-renewal of the previous year's investment), which being constant does not affect the ranking of sectors.

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