QUANTIFICATION OF SECTORAL DEVELOPMENT PROSPECTS IN PAPUA NEW GUINEA USING TINBERGEN AND RASMUSSEN CRITERIA

N. D. KARUNARATNE

A. *Strategy of Development Planning in Papua New Guinea*

THE DEVELOPMENT strategy embodied in Somare's "eight aims"[1] is clearly a watershed in economic planning and development for Papua New Guinea (PNG) [6] [7]. In the preceding decade, planning objectives have been mainly concentrated on the maximization of GNP through foreign aid, private enterprise, and imported technology. The Five Year Development Programmes based on the World Bank Mission recommendations (1964) are typical of the orientation of early development strategy [8] [9]. A "mixed open economy" policy with active fostering of foreign private enterprise was an important part of that strategy. Under the "eight aims" and its aftermath there was a possibility of returning to a more "closed" door development strategy. The dangers of autarkic development policies to long-term growth in developing economies necessitates an increase in appropriate techniques for correct policymaking to achieve efficient growth. Shibboleths and slogans on the eve of political independence may cloud the need for efficient allocation of scarce resources and the importance of objective planning techniques for a country like PNG.

The cardinal theme of Somare's "eight aims" for PNG development is the promotion of Papua New Guinean control of its economy. Its objectives are equal distribution of benefits, decentralization of economic activity, fostering local enterprise, skills and indigenous technology. The overwhelming influence of expatriate enterprise on economic activity would be gradually whittled down by a policy of economic localization. Foreign private enterprise would still have a critical role to play in the development of the economy alongside indigenous private enterprise. The basic sectors of the economy or the "commanding heights" would come under the aegis of government or public sector control and enterprise. It would be correct to surmise that the new PNG strategy attempts to institutionalize control systems to develop the economy in private and public sectors. In other words, development will proceed according to a "mixed economy" pattern where public and private enterprise would coexist and reinforce each other to achieve a preferred set of planning goals.

The Tinbergen semi-input-output criterion proposed is appropriate for investment programing and sector and project cost-benefit appraisal for private enter-

[1] The "eight aims" were proposed by M. Somare, chief minister, and were first accepted in the House of Assembly in March 1974.

prise, where profit maximization is the primum mobile [14]. To appraise costs and benefits of sectors and projects for public enterprise, structural economic changes are of great importance. The proposed Rasmussen-Hirschman linkage criteria quantify cost-benefits of projects and sectors for public enterprise, taking structural changes and linkages of the economy into account [4] [11].

B. *Semi-Input-Output Criterion for Private Enterprise Appraisal in PNG*

The semi-input-output criterion is essentially a cost-benefit ratio which attempts to overcome the limitations of direct capital-output or cost-benefit ratios which have been widely used for sector and project appraisals in developing economies.[2] The direct capital-output ratios exclude indirect repercussions of investment in new development projects and thus distort their true opportunity cost to the economy. To overcome this limitation, Tinbergen suggested the dichotomization of the economy, as simulated by a static Leontief input-output model, into two broad categories: tradeable, "international sectors" and non-tradeable, "national sectors."

In appraising sectors according to the semi-input-output criterion, the international trading prospects as shown by the principle of Richardian comparative advantage are explicitly taken into account. Tradeable sectors in the economy can freely import and export according to comparative advantage. But non-tradeable sectors would be precluded from international trade due to prohibitive transport costs, deliberate economic policy (protection or tariffs), or socio-political factors. In any given economy, expansion of tradeable sectors would require intermediate inputs from these non-tradeable sectors. Therefore, capacity, or production, in non-tradeable sectors would have to expand if tradeable sector expansion is to occur. The evaluation of sectors or projects without considering the direct cost-benefits from tradeable sectors together with their indirect repercussions on non-tradeable sectors would give an erroneous evaluation of a sector's true cost-benefits. The semi-input-output criterion obviates such errors.

In sector programing and development experience of other mixed economies in developing countries, private enterprise has been allowed to establish "import-substituting" sectors or projects under protectionist barriers. The sectors or projects, although attractive to private enterprise for short-term profit-maximization goals, have proved detrimental to long-term economic growth. The lessons of import-substitution industrialization in Latin America and Asia prove that the neglect of international trading prospects particularly in sectoral investment programing have led to a critical economic impasse [5]. The semi-input-output criterion by explicit recognition of trading prospects in its cost-benefit appraisal of a sector eliminates the pitfalls of import-substituting industrialization under protectionist policies at sector and project level planning. In other words, the semi-input-output criterion would recommend import of a product if it is cheaper than one produced locally.

[2] The direct capital-output ratio gives the cost per unit of output or value added per annum. This ratio is defective in many respects as pointed out by W. B. Reddaway [12, Appendix C].

Another merit of the semi-input-output criterion is the emphasis it gives to employment creation and labor-intensive technology. The semi-input-output criterion has one objective function and one constraint, viz., maximization of national income subject to scarce capital resources. It is noteworthy that this criterion gives the same result as a linear programing formulation of the problem [2]. The semi-input criterion, implicitly, shadow prices labor at zero wage at sector level. Therefore, it gives a 100 per cent premium to employment generation in sector cost-benefit evaluation. Maximization of national income and employment are of paramount importance to development of PNG and the semi-input-output approach is ideally consistent with these planning objectives.

C. *An Algebraic Resume of the Semi-Input-Output Criterions for a Bi-Sector Economy*

An expose of the simplistic version of the semi-input-output criterion proposed for application in PNG planning is presented here in terms of a bi-sector economy. The proposed versions of the criterion are operational for planning applications in an economy like Papua New Guinea which has limited statistical data and expertise.

The tabular presentation gives Leontief input-output coefficients (a_{ij}), final demands (F_i), and outputs (X_i) for a two-sector economy. Sector 1 is tradeable and Sector 2 is non-tradeable in this simple model.

A SIMPLE BI-SECTOR ECONOMY

Sector	1	2	Final Demand	Gross Output
1. Tradeable	a_{11}	a_{12}	F_1	X_1
2. Non-tradeable	a_{21}	a_{22}	F_2	X_2
Capital coefficients	k_1	k_2		
Value-added coefficients	v_1	v_2		

The balance relations according to the static Leontief model are:

$$a_{11}X_1+a_{12}X_2+F_1=X_1\,. \tag{1}$$

$$a_{21}X_1+a_{22}X_2+F_2=X_2\,. \tag{2}$$

A unit expansion of output of tradeable sectors, through new projects (i.e., $X_1=1$), would have indirect repercussions on non-tradeable sectors. Ignoring the effects in final demand, for simplicity, indirect repercussions would be shown in the solution:

$$X_2=\left[\frac{a_{21}}{1-a_{22}}\right].$$

(Note that final demand effect $F_2/(1-a_{22})=0$, by assumption.)

The cost-benefit ratio takes into account the group of direct and indirect repercussions, which could be called the Tinbergen or semi-input-output criterion. In terms of the above notation, the semi-input criterion, after Tinbergen, could be defined as:

$$T=\frac{k_1+k_2X_2}{v_1+v_2X_2}\,.$$

($T\neq k_1/v_1$: the traditional capital-output ratio.)

D. *Recapitulation of the Semi-Input-Output Criterion in Matrix Algebra*

To recapitulate, in matrix algebra, the proposed semi-input-output criterion for sector appraisal, the Leontief balance relations for an n-sector economy is expressed as follows:

$$AX+F=X,$$

where A: Leontief technical coefficient matrix of dimension nxn; X: vector of gross sectoral outputs of dimension n; F: vector of final demand of dimension n.

Partitioning the above sectoral balance relations into tradeable sectors (T) and non-tradeable sectors (N) and indicating the relevant submatrices by subscripts:

$$\begin{bmatrix} A_{TT} & A_{TN} \\ A_{NT} & A_{NN} \end{bmatrix} \begin{bmatrix} X_T \\ X_N \end{bmatrix} + \begin{bmatrix} F_T \\ F_N \end{bmatrix} = \begin{bmatrix} X_T \\ X_N \end{bmatrix}.$$

On multiplication, this yields the following relations:

Tradeable sectors: $A_{TT}X_T+A_{TN}X_N+F_T=X_T\,.$

Non-tradeable sectors: $A_{NT}X_T+A_{NN}X_N+F_N=X_N\,.$

From the second set of relations the required solution is derived: namely, the repercussions on the national sectors of output expansion of tradeable sectors identified for development, i.e.,

$$\begin{aligned} X_N &= [I-A_{NN}]^{-1}[A_{NT}X_T+F_N]\,, \\ &= [I-A_{NN}]^{-1}A_{NT}I_T\,, \end{aligned}$$

where $X_T=I_T$ is an identity matrix, denoting unit expansion of tradeable sectors. Note that final demand effects are ignored for simplicity in this version for criterion, i.e., $F_N=\phi$ (null).

The Tinbergen or semi-input-output cost-benefit criterion for the evaluation of the j-th sector would be direct effects given by k_j and v_j and indirect repercussions by other items in the formula:

$$T_j=\frac{k_j+K'_N[I-A_{NN}]^{-1}A_{nj}}{v_j+V'_N[I-A_{NN}]^{-1}A_{nj}}\,,$$

where k_j: direct capital coefficient of j-th sector v_j: direct value-added coefficient of j-th sector; K'_N: row vector of non-tradeable sector capital coefficients; V'_N: row vector of non-tradeable sector value-added coefficients; $[I-A_{NN}]^{-1}$: inverse of non-tradeable sector input-output coefficient matrix; A_{nj}: column vector inputs from tradeable sector j to n non-tradeable sectors. ($T_j\neq k_j/v_j$: direct cost-benefit ratio.)

The calculations of the inverse of the non-tradeable sectors and the semi-input-output criterion T_j are shown in Tables IA and IB.

TABLE I

A. NON-TRADEABLE SECTORS OF PNG ECONOMY

	Non-Tradeable Sectors					Palm Oil
1. Building & construction	.0041	.0026	.0015	.0734	.0000	.0193
2. Transport & communication	.0247	.0446	.0589	.0821	.0000	.0319
3. Electricity	.0010	.0018	.0000	.0131	.0000	.0021
4. Services	.0064	.0070	.0030	.0275	.0000	.1638
5. Nonmarket production	.0000	.0000	.0000	.0000	.0000	.0000

B. SEMI-INPUT-OUTPUT MODEL SOLUTION FOR PNG ECONOMY

($1,000)

$$[I-A_{NN}]^{-1}X_p^n=\begin{pmatrix}1.0047 & .0033 & .0015 & .0761 & .0000\\ .0266 & 1.0475 & .0615 & .0913 & .0000\\ .0011 & .0020 & 1.0001 & .0137 & .0000\\ .0068 & .0076 & -.0026 & 1.0294 & .0000\\ .0000 & .0000 & .0000 & .0000 & 1.0000\end{pmatrix}\times\begin{pmatrix}.0196\\ .0319\\ .0021\\ .1638\\ .0000\end{pmatrix}=\begin{pmatrix}.0323\\ .0490\\ .0044\\ .1689\\ .0000\end{pmatrix}$$

$$\times(1526.16)=\begin{pmatrix}49.2950\\ 74.7818\\ 6.7151\\ 257.7684\\ .00\end{pmatrix}$$

(where X_p^n denotes palm oil project data for non-tradeable sectors).

E. *Application of the Semi-Input-Output Criterion for Sector Appraisal in PNG*

In order to apply the semi-input-output criterion for sector appraisal to PNG, Parker's 21×21 inter-industry transactions matrix (1970) was consolidated into 10×10 and rearranged suitably [10]. The following five sectors could be identified as tradeable or international sectors: (1) agriculture, (2) fishing, forestry, and mining, (3) manufacturing, (4) commerce, and (5) business expenses. The following five sectors can be identified as non-tradeable or national sectors: (6) building and construction, (7) transport and communication, (8) electricity, (9) services, and (10) nonmarket production. (See Table II.)

Out of a gross value output of $1,664.11 million in 1970, 34.2 per cent was accounted for by non-tradeable sector output in PNG.

Quantification of costs ideally requires sectoral capital-output ratios or a sectoral capital-output matrix. In the absence of such data for PNG, sectoral capital-output ratios were collated by reference to cross-country data on the assumption that sectoral technologies in developing economies exhibit close similarity. The benefits were quantified using value-added coefficients which were assumed to be a net output of total sectoral intermediate inputs and sectoral import coefficients. (See Table III.)

TABLE II

PAPUA NEW GUINEA INTER-INDUSTRY TRANSACTIONS (1970)

($ million: purchasers' value)

Selling Sectors \ Buying Sectors	1	2	3	4	5	6	7	8	9	10	Total Inter. Demand	Final Demand	Total Demand
1. Agriculture	1.53	.00	6.86	.00	.02	.00	.00	.00	.45	.00	8.86	68.58	77.44
2. Fishing, forestry, mining	.01	.00	3.24	.00	.01	.04	.00	.00	.07	.00	3.37	7.38	10.75
3. Manufacturing	5.67	.22	3.73	1.14	1.06	26.49	7.44	.01	4.72	.00	50.48	45.77	96.25
4. Commerce	3.52	.96	10.85	.51	.96	6.14	2.57	.34	.67	.00	26.52	31.74	58.26
5. Business expenses	1.16	.32	3.06	9.36	.00	5.49	1.71	.17	4.51	.00	25.78	2.43	28.21
6. Building & construction	.26	.00	.14	.45	.05	.47	.13	.01	12.79	.00	14.30	100.15	114.45
7. Transport & communication	2.97	.20	2.67	1.04	7.07	2.83	2.22	.39	14.31	.00	33.70	16.08	49.78
8. Electricity	.06	.06	.74	.43	.54	.12	.09	.00	2.28	.00	4.32	2.30	6.62
9. Services (incl. govt.)	.63	.72	.13	5.08	5.80	.73	.35	.02	4.80	.00	18.26	156.04	174.30
10. Nonmarket production	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	0	223.90
Total intermediate	15.81	2.48	31.42	18.01	15.51	42.31	14.51	.94	44.60	.00	185.59		
Imported goods (cif)	5.50	2.40	21.90	1.78	12.15	40.01	8.36	1.04	21.27	.00			
Value-added	56.13	5.87	42.93	38.47	.55	32.13	26.91	4.64	108.43	223.90			
Total Supply	77.44	10.75	96.25	58.26	28.21	114.45	49.78	6.62	174.30	223.90			

Source: [10].

TABLE III

INPUT-OUTPUT COEFFICIENTS FOR PAPUA NEW GUINEA (1970)

Input Sector \ Output Sector	1	2	3	4	5	6	7	8	9	10	Palm Oil
1. Agriculture	.0198	.0000	.0713	.0000	.0007	.0000	.0000	.0000	.0026	.0000	.3504
2. Fishing, forestry, mining	.001	.000	.0337	.0000	.0004	.0003	.0000	.0000	.0004	.0000	.0000
3. Manufacturing	.0732	.0205	.0350	.0196	.0376	.2315	.1495	.0015	.0271	.0000	.1389
4. Commerce	.0455	.0893	.1127	.0088	.0340	.0536	.0516	.0514	.0038	.0000	.0025
5. Business expenses	.0150	.0298	.0318	.1607	.0000	.0480	.0344	.0257	.0259	.0000	.0000
6. Building & construction	.0034	.0000	.0015	.0077	.0018	.0041	.0026	.0015	.0734	.0000	.0193
7. Transport & communication	.0384	.0186	.0277	.0179	.2506	.0247	.0446	.0589	.0821	.000	.0319
8. Electricity	.0008	.0056	.0077	.0074	.191	.0010	.0018	.0000	.0131	.0000	.0021
9. Services (incl. govt.)	.0081	.0670	.0014	.0872	.2056	.0064	.0070	.0030	.0275	.0000	.1638
10. Nonmarket production	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
Intermediate inputs	.2042	.2307	.3264	.3091	.5498	.3697	.2915	.1420	.2559	.0000	.7089
Imports (cif)	.0710	.2233	.2275	.0306	.4307	.3496	.1679	.1571	.1220	.0000	.0000
Value-added	.7248	.5460	.4460	.6603	.0195	.2807	.5406	.7009	.6221	1.000	.2911
Total supply	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Capital-output ratio*	1.0	2.5	2.0	.50	.50	0.50	3.00	7.0	4.0	0.1	.46

Sources: R.S. Eckaus, and K.S. Parikh, *Planning for Growth: Multi-Sectoral Intertemporal Models Applied to India* (Cambridge, Mass.: MIT Press, [1968); N.D. Karunaratne, *Techno-Economic Survey of Industrial Potential in Sri Lanka* (Colombo: Industrial Development Board of Ceylon, 1973); G. Rasul, *Input-Output Relationships in Pakistan, 1954* (Rotterdam: Rotterdam University Press, 1964); Netherlands Economic Institute, *Identification of Potential Industries in Ethiopia* (Rotterdam: Division of Balanced International Growth, 1969).

* Sectoral capital-output ratios.

The sectoral rankings that emerge from the application of the semi-input criterion to Papua New Guinea would be of special interest to policymakers in the Bureau of Industrial Organisation, National Investment and Development Authority, the Papua New Guinea Development Bank, PNG Banking Corporation, the Tariff Advisory Committee, and the Department of Business Development. The sectoral ranking would indicate which sectors are consistent with both private sector profit maximization as well as long-term macroeconomic development objectives. Such sectoral ranking, if effected with a more disaggregated version of a transaction table, would yield more meaningful and operational guidelines for policy formulation to those institutions dealing with private enterprise in a "mixed economy."

TABLE IV

TRADEABLE SECTOR RANKINGS ACCORDING TO DIRECT AND SEMI-INPUT-OUTPUT COST-BENEFIT CRITERIA

Tradeable Sector	Direct Cost-Benefit Ratio k_j	Rank	Semi-Input-Output Criterion T_j	Rank	T_j/k_j
(1) Agriculture	1.0000	3	1.5437	2	1.5437
(2) Fishing, forestry, and mining	2.5000	5	4.5583	3	1.8233
(3) Manufacturing	2.0000	4	4.5850	4	2.2925
(4) Commerce	0.50000	1	1.3616	1	2.7237
(5) Business expenses	0.50000	2	7.2567	5	14.5134

The sectoral ranking of cost-benefits calculated according to the proposed semi-input criterion are shown in Table IV. The sectors in ascending order of cost-benefits or descending order of attractiveness for Papua New Guinea are: (4) commerce, (1) agriculture, (2) fishing, forestry, and mining, (3) manufacturing, and (5) business expenses. The corresponding ranking of sectors according to direct cost-benefit ratios is as follows: (1) agriculture, (2) fishing, forestry, and mining, (3) manufacturing, (4) commerce, and (5) business expenses. There is no strong correlation between the two rankings as the correlation is $R=0.4160$. The use of direct cost-benefit ratio would, however, lead to serious distortions in correct appraisal of true cost-benefits. In the optimum sector, (4) commerce, according to the semi-input-output criterion, the use of the crude direct cost-benefit ratio would lead to an underestimate of cost-benefits by nearly 172 per cent for PNG. In sectors like business expenses, the gross underestimation could score as high as 1,351 per cent.

The semi-input criterion not only provides guidelines to policymakers by its sector rankings, but it is also an ordinal index. It enables us to quantify, by what magnitude, the optimal sector is more attractive than the next sub-optimal sector, etc. In the case of PNG we could state, for example, that optimal sector commerce is nearly 12 per cent more attractive than the next sub-optimal sector, agriculture. (See Table IV.)

Sector ranking for the Papua New Guinea economy using the semi-input-output criterion reveals an export-import orientation. The economy is heavily dependent

on sectors like commerce, export, agriculture (predominantly expatriate plantation), forestry, and mining. The ranking indicates that development within the given economic structure would demand the fostering of foreign private enterprise if the goals of maximization of national income, employment, and balance of payments stability are maintained.

F. *Extension of Semi-Input-Output Criterion to Project Appraisal—Palm Oil Project*

The rationale of semi-input-output criterion for sector appraisal can be easily extended to project appraisal. The input-output profile of a project can be easily converted into a column vector of input coefficients that would augment the static Leontief input-output coefficients table for PNG. (See Table III.) In order to demonstrate the integration of project analysis via semi-input-output

TABLE V

PROFILE OF PALM OIL PROJECT FOR PNG

1. Capital costs:	
Water & electricity	3.2
Maintenance shops	1.6
Accommodation	21.36
Mill	80.0
Terminal	17.2
Vehicle—FFB cartage	12.8
Transport—management	1.04
Transport—plantation	2.52
Plantation establishment	45.72
Subtotal capital costs	185.44
Contingency 10%	18.54
Total capital costs	203.98
2. Operating costs:	
Crop maintenance	99.36
Harvesting	35.8
Processing	85.68
Terminal op. costs	8.96
General charges—mill	124.24
General charges—plantation	125.80
Op. cost FFB cartage	21.00
Cartage—palm oil	11.40
—kernel	3.76
Purchase—S.H.—FFB	534.76
Maintenance bldgs.	8.12
	1,058.88
3. Revenue	1,526.16
4. Profit	263.30
Rate of return on capital is 263.30/5,099.5=5.16%	

Source: Department of Agriculture, Stock and Fisheries, *An Agricultural Project for the Re-development of the Popendetta Area of the Northern District* (1973).

criterion, the palm oil project proposed for the Popendetta region[3] in the Northern District has been selected for elaboration. Plant and equipment for the project would involve a capital expenditure of 2 million dollars. The mill would have a rated capacity of thirty tons of fresh fruit processing per hour. The annual value of the project's tradeable output during the twenty-five-year time-horizon assumed for the project is estimated at $1.53 million. (See Table V.) The project will have tradeable inputs mainly from agriculture, manufacturing, and commerce sectors and non-tradeable inputs from construction, transport and communication, and services.

The success of the joint venture in oil palm between the government and M/S. Harrison & Grossfield in Kimbe, West New Britain, underlines the tremendous potential of oil palm for PNG. This type of project is consistent with the current development planning strategy based on Somare's eight aims. The project in Kimbe has benefited more than 1,500 villagers who have resettled on fifteen acre plots. Average income from a plot during the last year was reported to be $15,000—"much higher than the salary of Papua New Guineans in the Senior Public Service!" [3]. The proposed project for Popendetta analyzed here is similar to the Kimbe project of a nucleus oil palm estate. The costs of the palm oil project consist of direct capital investment plus indirect repercussions which take the form of costs incurred by non-tradeable sectors. The non-tradeable sector costs are computed by multiplying the output repercussions on national sectors, due to the palm oil project (X_N), by direct capital-output ratios (K_N) (i.e., column (3) × column (1) in Table VI). Since these capital costs are

TABLE VI

PALM OIL PROJECT COST-BENEFITS ACCORDING TO SEMI-INPUT-OUTPUT CRITERION INCORPORATING TIME LAG

	Capital-Output Ratio	Value-Added Coefficient	Palm-Oil Project Repercussions on Non-Tradeable Sectors	Capital Investment	Value-Added on Benefits	Gestation Lag	Discount Benefit $i=10\%$
	(1)	(2)	($ Million)(3)	($ Million) (4)	(5)	(Years) (6)	(7)
Building & construction	0.50	.2807	.0493	.0246	.0138	20	.1175
Transport & communication	3.00	.5406	.0748	.2243	.0404	20	.3440
Electricity	7.00	.7009	.0067	.0470	.0047	30	.0443
Services (incl. govt.)	4.00	.6221	.2578	1.0311	.1603	10	.9850
Nonmarket production	0.10	1.0000	.0000	.0000	.2193	5	.8156
Palm oil	0.46	.2911	1.5261	.7020	.4442	25	2.3480
Total				2.0290	.8827		4.6904

[3] See Department of Agriculture, Stock and Fisheries, *An Agricultural Project for the Redevelopment of the Popendetta Area of the Northern District* (1973). The input-output coefficients for the palm oil project were calculated by averaging data detailed in [10, pp. 48–50, Table 8/1].

assumed to be incurred in the initial year of the project no discounting is required. Generally, discounting of capital costs can be easily incorporated as shown by the formula proposed below.

The benefits of the project are evaluated by multiplying the output repercussions on national sectors by value-added coefficients and then discounting them by the use of an appropriate sectoral lag. Output repercussions are given in column (3), value-added coefficients in column (2), and the benefits derived by multiplying (3)×(2) are shown in column (5) of Table VI. The discounted value of benefits according to gestation lags, assumed in column (6), is shown in column (7) of Table VI.

In discounting project benefits it is assumed that the palm oil project will be at full capacity production in the fifth year after commissioning and thereafter maintain a rated capacity until the end of the 25th year. A rate of 10 per cent was selected to discount benefits. This rate is the minimum recommended by Tinbergen for evaluating such projects in developing economies [13].

The cost-benefit ratio incorporating semi-input-output rationale, together with direct cost-benefits of the project, are shown in columns (4) and (5) of Table VI. The quotient of the sum of these respective columns gives a cost-benefit ratio of 0.43. This shows that the use of a direct capital-output ratio 0.46 for palm oil project evaluation overestimates the true cost-benefits of the project by 7 per cent and renders it unattractive.

G. *A Formula for Project Appraisal Using Semi-Input-Output Rationale and Discounting for Time Lag*

The procedure for project appraisal incorporating time-phasing of cost-benefit streams of a project using the semi-input-output criterion is recapitulated in the sequel in algebraic notation:

NATIONAL SECTOR DATA

Direct Capital-Output Ratio	Value-Added Coefficient	Output Repercussions due to Project	Total Sectoral Costs	Total Sectoral Benefits	Assumed Gestation Lag
k_1	v_1	X_1	k_1X_1	v_1X_1	t_1
k_2	v_2	X_2	k_2X_2	v_2X_2	t_2
⋮	⋮	⋮	⋮	⋮	⋮
k_j	v_j	X_j	k_jX_j	v_jX_j	t_j
⋮	⋮	⋮	⋮	⋮	⋮
k_n	v_n	X_n	k_nX_n	v_nX_n	t_n
Project Data					
k_p	v_p	X_p	k_pX_p	v_pX_p	t_p

Discounted costs: $$C=\frac{k_pX_p}{(1+i)^{t_p}}+\sum_{j=1}^{n}\frac{k_jX_j}{(1+i)^{t_j}}.$$

Discounted benefits: $$B=\frac{v_pX_p}{(1+i)^{t_p}}+\sum_{j=1}^{n}\frac{v_jX_j}{(1+i)^{t_j}}.$$

(i: assumed discount rate.)

Cost-benefits according to semi-input-output criterion incorporating gestation lag of a project is:

$$S=[C/B].$$

(Note that $S \neq k_p X_p / v_p X_p$, the direct capital-output ratio.)

H. *The Rasmussen Criteria of Linkage and Spread for Public Sector Appraisal*

In sector and project appraisal for public sector investment it is assumed that structural change and development are dominant objectives. The Rasmussen criterion for sector appraisal is based on the Leontief static input-output coefficient matrix inverse and Hirschman's concept of backward and forward linkage [4] [11]. (See Table VII for inverse.) The sectoral ranking is based purely on static structural interdependence exhibited by the economy simulated by the input-output matrix. In developing economies, strengthening linkages is an important consideration in short-term planning. Hence, identification of key sectors on the basis of linkages provides rational guidelines for public sector investment.

TABLE VII

LEONTIEF INVERSE CORRECTED FOR IMPORT LEAKAGE FOR PNG

$K=[I-A+M]^{-1}$.

Sector	1	2	3	4	5	6	7	8	9	10
1. Agriculture	.9558	.0019	.0663	.0530	.0176	.0037	.0404	.0020	.0152	.0000
2. Fishing, forestry & mining	.0016	.8181	.0218	.0770	.0282	.0040	.0266	.0058	.0623	.0000
3. Manufacturing	.0577	.0234	.8504	.1018	.0327	.0028	.0340	.0072	.0176	.0000
4. Commerce	.0024	.0009	.0310	.9901	.1156	.0115	.0506	.0097	.1020	.0000
5. Business expenses	.0042	.0016	.0499	.0399	.7118	.0092	.1719	.0142	.1395	.0000
6. Building & construction	.0103	.0043	.1517	.0596	.0363	.7447	.0310	.0029	.0169	.0000
7. Transport & communication	.0080	.0032	.1168	.0606	.0317	.0032	.9030	.0033	.0171	.0000
8. Electricity	.0007	.0003	.0097	.0482	.0226	.0018	.0521	.8051	.0085	.0000
9. Services (incl. govt.)	.0051	.0014	.0419	.0163	.0234	.0510	.0763	.0114	.9288	.0000
10. Nonmarket prod.	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	1.0000

The Rasmussen backward linkages are arithmetic means of column vectors of the inverted Leontief matrix. The forward linkages are row-means. Both means have been normalized by dividing by the grand mean of all coefficients to obtain indices of backward and forward linkage. If the index of backward linkage is greater than unity it implies that the sector concerned would require more than average intermediate inputs from other sectors to sustain a unit increase in the sector's final demand. If, on the other hand, the forward linkage is greater than unity it implies that the sector concerned will have to increase its intermediate inputs by more than the average increase in other sectors in order to sustain a unit expansion of final demand.

The arithmetic means which measure linkages in the structure of a developing economy are prone to instability due to the wide dispersion of sectoral technical coefficients in a developing economy. Hence, Rasmussen proposed that these linkage measures based on means or central tendency should be assessed in the light of their relative dispersion as quantified by the coefficient of variation. The larger the coefficient of variation the lower the consistency of a sector. A sector which has a high consistency or a low coefficient of variation would be attractive for investment as it indicates a development impact or "spread effect" on other sectors. The coefficient of variation is chosen as a proxy spread index.

The key sectors according to the Rasmussen criterion would be those which have high arithmetic means and low coefficients of variation since this would imply high linkage and high development spread effect of a given investment.

In developing economies like Papua New Guinea, which are open or export-import oriented, there is a substantial leakage of investment effect on development through imports. Hence, it is quite logical to correct the Leontief coefficient matrix by netting out these import leakages, subtracting a diagonal matrix of import coefficients [1, pp. 107–15].

A resume of the foregoing text is given algebraically.

I. *Algebraic Exposition of Rasmussen Linkage and Spread Indices*

Let $K=[k_{ij}]=[I-A+M]^{-1}$ (i.e., inverse of Leontief technical coefficient matrix corrected for imports),

$$m=\sum_{i=1}^{n}\sum_{j=1}^{n}k_{ij}/n^2\,. \quad \text{(Grand mean of all elements in } K\text{-matrix.)}$$

Index of backward linkage: $b_j=(j\text{-th column mean of } K\text{-matrix} \div m)\times 100$.
Index of forward linkage: $f_i=(i\text{-th row mean of } K\text{-matrix} \div m)\times 100$.
Coefficient of variation: $V_j=(j\text{-th column standard deviation} \div j\text{-th column mean})$.
Coefficient of variation: $V_i=(i\text{-th row standard deviation} \div i\text{-th row mean})$.

Index of backward spread effect: $S_j{}^b=\left[V_j \div \sum_{j=1}^{n} V_j/n\right]\times 100\,.$

Index of forward spread effect: $S_i{}^f=\left[V_i \div \sum_{i=1}^{n} V_i/n\right]\times 100\,.$

If $b_j>100$, we conclude that backward linkages are strong and that sector j demands from other sectors more than an average level of intermediate inputs to sustain a unit of sector j's demand expansion. If $f_i>100$, the forward linkages are strong and the sector j should supply more than an average level of intermediate inputs to other sectors to sustain a unit expansion of sector i's demand. The sectors that exhibit backward and forward linkage indices of over 100 are defined as key sectors suitable for investment programing by public enterprise. The backward and forward spread effect indices $S_j{}^b$ and $S_i{}^f$ are based on the coefficient of variation divided by the sectoral coefficients of variation. If the index is less than 100, this signifies a more than average spread or development

impact on other sectors due to an expansion of one related sector. The maximization of such spread effects in public sector investment programing is of crucial importance in infrastructure capital budgeting in developing economies. The higher the spread effect the lower the coefficient of variation and hence the spread index should be less than 100. The sectors with dominant spread effects will have indices $S_j^b < S_i^f < 100$.

J. *Key Public Enterprise Sectors in PNG with Dominant Linkage and Spread Indices*

The sectors with dominant backward and forward linkage greater than 100 are shown by cardinal indices b_j and f_i in Table VIII. According to the cardinal index b_j, commerce (4), agriculture (1), transport and communication (7), business expenses (5), manufacturing (3), and services (9) are sectors with significant backward linkage. Sectors like commerce (4), transport and communication (7), manufacturing (3), services (9) indicate dominant forward linkage. Dominant sectors that satisfy both constraints of backward and forward linkage and qualify as key sectors according to Rasmussen's linkage criteria could be analyzed diagramatically. (See Venn diagram I in Figure 1.) Sectors (3), (4), (7), and (9) qualify as key sectors on the basis of linkage criteria.

TABLE VIII

LINKAGE AND SPREAD INDICES

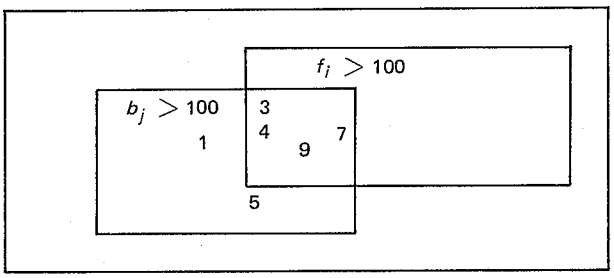
Sector	Cardinal Indices of Linkage & Spread				Ordinal Index or Rank			
	b_j	f_j	S_j^b	S_i^f	b_j	f_i	S_j^b	S_i^f
1	103.62	93.77	104.88	114.57	3	5	8	6
2	93.72	76.68	98.71	120.00	8	9	5	9
3	101.09	120.08	94.70	76.46	6	3	3	1
4	117.79	129.67	94.89	82.50	1	1	4	3
5	102.41	91.43	78.32	84.87	5	6	1	4
6	94.83	74.59	88.61	112.07	7	10	2	8
7	102.81	124.24	99.68	78.93	4	2	6	2
8	90.46	82.63	109.25	117.23	9	8	9	7
9	103.62	117.25	101.55	86.89	2	4	7	5
10	89.64	89.64	129.43	126.51	10	7	10	10

Note: b_j=backward linkage (index and attractiveness are directly correlated); f_i= forward linkage (index and attractiveness are directly correlated); S_j^b=backward spread (index and attractiveness are inversely correlated); S_i^f=forward spread (index and attractiveness are inversely correlated).

The cardinal measure of dominant backward and forward spread is shown in Table VIII. There are six sectors with a backward spread index of less than 100, in order of importance they are (5), (6), (3), (4), (2), and (7). Five sectors have a forward spread index of less than 100 and in order of importance they are (3), (7), (4), (9), and (5). (See Table IX.) Venn diagram II in the intersection region portrays the sectors that have both strong backward and forward spread effects. They are commerce (4) and manufacturing (3).

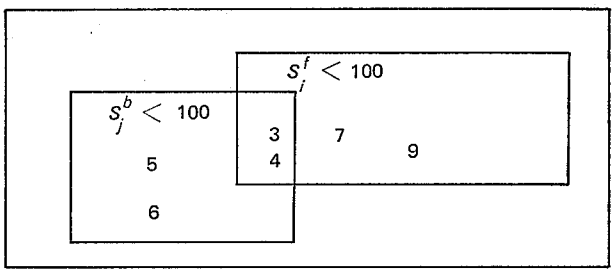
Fig. 1.

Venn Diagram I



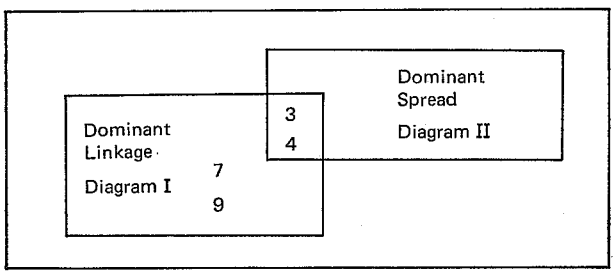
Linkage Indices
$b_j > 100$; $f_i > 100$

Venn Diagram II



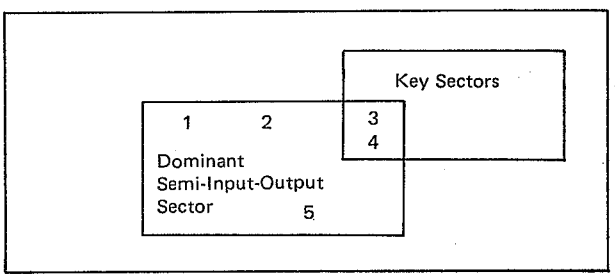
Spread Indices
$S_i^b < 100$; $S_i^f < 100$

Venn Diagram III



Key Sectors
$b_j \geqslant 100$; $f_i \geqslant 100$
$S_j^b \leqslant 100$; $S_i^f \leqslant 100$

Venn Diagram IV



Dominant Sectors in the Mixed Economy

TABLE IX

RANKING OF SECTORS ACCORDING TO LINKAGE AND SPREAD INDICES

Rank (Sector) b_j	Backward Linkage (Sector) b_j	Forward Linkage (Sector) f_i	Spread Index (Sector) S_j^b	Spread Index (Sector) S_i^f	Semi-Input-Output Criterion (Sector) t_j
1	(4)	(4)	(5)	(3)	(4)
2	(9)	(7)	(6)	(7)	(1)
3	(1)	(3)	(3)	(4)	(2)
4	(7)	(9)	(4)	(9)	(3)
5	(5)	(1)	(2)	(5)	(5)
6	(3)	(5)	(7)	(6)	
7	(6)	(10)	(9)	(1)	
8	(2)	(8)	(1)	(8)	
9	(8)	(2)	(8)	(2)	
10	(10)	(6)	(10)	(10)	

By superimposition of Venn diagrams I and II in Venn diagram III we isolate the time key sectors according to Rasmussen's criteria. These are sectors with dominant linkage and spread effects. For PNG, commerce (4) and manufacturing (3) qualify on the basis of Rasmussen's dual criteria. We could, therefore, infer that public enterprise geared to long-term structural change in the PNG economy should concentrate its resource allocation on investment programing efforts in sectors (4) and (3). In these sectors the potential for structural change is maximal.

K. *A Correlation Analysis of Linkage and Spread Effects in PNG*

It has been mentioned that PNG economy sectors with strong backward linkages also possessed strong forward linkages as indicated by a correlation coefficient of $R = +0.7647$. Spread effects were also positively correlated but not as strongly as indicated by $R = +0.5785$. Backward linkages and backward spread effects for PNG were revealed to be very weak by the rank correlation coefficient $R = +0.2606$. Although backward linkages showed a much stronger relation to forward spread effects with $R = +0.6485$, forward linkages showed a very strong rank correlation with forward spread effects with $R = +0.8303$ but forward linkages were only weakly correlated to backward spread as shown by $R = +0.0424$.

L. *Reconcilation of Semi-Input-Output and Key Sector Criteria Rationale in Planning for PNG*

Although divergences in planning strategy have been discussed, a strategy which the semi-input-output criteria implements to foster private enterprise and the linkage and spread criteria geared to foster "key" public enterprises for structural change in the economy; a reconcilation of these two approaches at sector level is possible. Those sectors that qualify as leading or dominant sectors on the basis of both approaches would be confined to tradeable sectors. Hence, when government or public enterprise aims at bolstering private enterprise by

investment grants, development rebates, tariff concessions, or tax holidays, it should concentrate on those sectors that qualify on both semi-input-output and key sector criteria. The methodology for selecting such sectors does not involve complicated programing models but could be achieved by a Venn diagram analysis, as before. (See Venn diagram IV in Figure 1.) The sectors that appear to qualify on the basis of semi-input criterion and key sector criterion are commerce (4) and manufacturing (3). These are dominant sectors in macro-planning for development in a mixed economy qualifying in terms of both private and public sector entrepreneurial development goals.

M. *Application of Rasmussen's Criteria to a Disaggregated Inter-Industry Table of PNG's Economy*

In order to derive operational policy guidelines, Rasmussen's "key sector" criteria have been applied to a more disaggregated (49×49 sector) inter-industry table. This table was prepared and kindly made available by Bob Wilson of the Department of Economics, University of Papua New Guinea, and is based on Parker's figures [10].

The sectoral classifications used are referred to in Table X. Rasmussen linkage indices were compiled for the Leontief inverse corrected for import leakage

TABLE X

INTER-INDUSTRY SECTORS

1. Plant coconut	26. Cement
2. Smallhold coconut	27. Paint
3. Plant cocoa	28. Other chemicals
4. Smallhold cocoa	29. Clothing
5. Plant coffee	30. Furniture
6. Smallhold coffee	31. Printing/paper
7. Rubber	32. Other manufactures
8. Tea	33. Village
9. Cattle	34. Electricity
10. Poultry/milk	35.
11. Other crops	36. Building
12. Rural development	37. Road transport
13. Fishing	38. Coastal transport
14. Forest production	39. Air transport
15. Mining	40. Communications
16. Sawmills	41. Commerce
17. Joineries	42. Finance
18. Engineering	43. Dwelling
19. Motor vehicle repair	44. Education
20. Aircraft	45. Health ,
21. Bakeries	46. Prof. services
22. Beverages	47. Government services
23. Crop processing	48. Personal services
24. Other processing	49. Religion
25. Tobacco	50. Business expenses

Note: Sector 35 (petroleum) was not included in this analysis because of the lack of information on related transactions.

TABLE XI

SECTORS WITH STRONG BACKWARD LINKAGE COMPUTED BY USING $(I-A+M)^{-1}$

b_j Value (to the Nearest 100)	Rank	Industry (No., Name)	Relative Position of v_j (Numbers in Parentheses Give the *Actual* Position in the Sorted Array)	
200	1)	41. Commerce	1	(1)
100	2)	33. Village	2	(2)
	3)	24. Other processing	6	(6)
	4)	38. Coastal transport	3	(3)
	5)	9. Cattle	7	(7)
	6)	43. Dwelling	9	(9)
	7)	17. Joineries	5	(5)
	8)	22. Beverages	4	(4)
	9)	16. Sawmills	10	(10)
	10)	23. Crop processing	11	(11)
	11)	6. Smallhold coffee	13	(16)
	12)	50. Business expenses	8	(8)
	13)	4. Smallhold cocoa	14	(18)
	14)	42. Finance	16	(22)
	15)	40. Communications	17	(28)
	16)	8. Tea	12	(15)
	17)	46. Prof. services	18	(32)
	18)	7. Rubber	15	(21)

Note: Table reads, e.g., "5) 9. Cattle 7 (7)" means that industry number 9 (cattle) ranks 5th in the descending order array of b_j. It is also the 7 element in the ascending order array of v_j and this position in the array of v_j means it is the 7th industry of the 18 identified and marked with $b_j>100$ to appear in the v_j array. (I am grateful to Mr. W. M. MaCallum, post-graduate student in Development Economics, University of Queensland for computational assistance in preparing Tables XI to XXIII.)

TABLE XII

SECTOR WITH STRONG FORWARD LINKAGE COMPUTED BY USING $(I-A+M)^{-1}$

f_i Value (to the Nearest 100)	Rank	Industry (No., Name)	Relative Position of v_i (Numbers in Parentheses Give the *Actual* Position in the Sorted Array)	
300	1)	50. Business expenses	1	(1)
200	2)	41. Commerce	2	(2)
100	3)	47. Govt. services	4	(4)
	4)	39. Air transport	3	(3)
	5)	48. Personal services	5	(5)
	6)	1. Plant coconut	12	(13)
	7)	40. Communications	9	(9)
	8)	46. Prof. services	11	(11)
	9)	37. Road transport	7	(7)
	10)	16. Sawmills	13	(14)
	11)	23. Crop processing	14	(15)
	12)	34. Electricity	10	(10)
	13)	42. Finance	16	(18)
	14)	18. Engineering	6	(6)
	15)	36. Building	8	(8)
	16)	38. Coastal transport	15	(17)

TABLE XIII

BACKWARD LINKAGE—UNCORRECTED FOR IMPORTS COMPUTED BY USING $(I-A)^{-1}$

b_j Value (to the Nearest 100)	Rank	Industry (No., Name)
200	1)	41 Commerce
100	2)	33. Village
	3)	24. Forest products
	4)	38. Coastal transport
	5)	22. Beverages
	6)	9. Cattle
	7)	17. Joineries
	8)	43. Dwelling
	9)	16. Sawmills
	10)	50. Business expenses
	11)	23. Crop processing
	12)	21. Bakeries
	13)	25. Tobacco
	14)	10. Poultry/milk
	15)	8. Tea
	16)	6. Smallhold coffee
	17)	31. Printing/paper

TABLE XIV

FORWARD LINKAGE—UNCORRECTED FOR IMPORTS COMPUTED BY USING $(I-A)^{-1}$

f_i Value (to the Nearest 100)	Rank	Industry (No., Name)
400	1)	50. Business expenses
200	2)	41. Commerce
	3)	39. Air transport
100	4)	47. Govt. services
	5)	48. Personal services
	6)	18. Engineering
	7)	1. Plant. coconut
	8)	37. Road transport
	9)	40. Communications
	10)	36. Building
	11)	34. Electricity
	12)	46. Prof. services
	13)	16. Sawmills
	14)	31. Printing/paper
	15)	19. Motor vehicle repairs
	16)	23. Crop processing

$[I-A+M]^{-1}$ and for the uncorrected version $[I-A]^{-1}$. Sectoral rankings according to order of dominance of backward and forward linkages for the corrected and uncorrected versions vary considerably, indicating the strong import-dependence of the Papua New Guinea economy. Compare, for example, Tables XI and XIII for backward linkages and Tables XII and XIV for forward linkage.

The key sectors that qualify on the basis of backward and forward linkage in the "corrected" version can be identified by comparing the results in Tables XI and XII. These are: commerce (41), coastal transport (38), sawmills (16), business expenses (50), finance (42), communications (40), professional services (46). In the implementation of structural changes in the economy, planners and policy-makers should seek to formulate appropriate policies and undertake suitable projects in these key sectors to capitalize on strong linkage effects.

N. *Sectors Dominant for an Import-Substituting Development Strategy Policy*

The implementation of an import-substituting development strategy could derive guidelines by import-weighted forward and backward linkages quantified for the PNG economy. The import linkages for Papua New Guinea—backward and forward for sectors in PNG economy according to descending order of importance

TABLE XV

DESCENDING ORDER OF IMPORTANCE ACCORDING TO BACKWARD LINKAGE: IMPORTS VERSION

b_j^{IM} Value (to the Nearest 100)	Rank	Industry (No., Name)
800	1)	36. Building
500	2)	47. Govt. services
200	3)	43. Dwelling
	3)	41. Commerce
100	4)	18. Engineering
	5)	22. Beverages
	6)	50. Business expenses
	7)	38. Coastal transport
	8)	39. Air transport
	9)	34. Electricity
	10)	45. Health
	11)	44. Education
	12)	33. Village
	13)	14. Forest products
	14)	9. Cattle

TABLE XVI

DESCENDING ORDER OF IMPORTANCE ACCORDING TO FORWARD LINKAGE: IMPORTS VERSION

f_i^{IM} Value (to the Nearest 100)	Rank	Industry (No., Name)
1300	1)	36. Building
900	2)	47. Govt. services
500	3)	50. Business expenses
300	4)	18. Engineering
200	5)	39. Air transport
100	6)	41. Commerce
	7)	37. Road transport

—are shown in Tables XV and XVI. A comparison of these two tables indicates that the pursuit of an import-substituting development strategy aiming to whittle down the heavy import dependence of the economy should concentrate on the following key sectors that qualify in terms of Rasmussen's strong backward and forward import linkages: building (36), government services (47), commerce (41), engineering (18), etc. in that order of importance. (See Tables XV and XVI.)

O. *Sectors Dominant for an Export-Promotion Development Strategy*

If the development strategy is directed toward export-promotion in PNG the sectors that have strong backward and forward linkages when the Leontief inverse is weighted by export coefficients are shown in Tables XVII and XVIII respectively. The key sectors that emerge as dominant in the implementations of an export-promotion strategy are: smallholder coffee (6), plant cocoa (3), plant

TABLE XVII

DESCENDING ORDER OF IMPORTANCE ACCORDING TO BACKWARD LINKAGE: EXPORT VERSION

b_j^{ex} Value (to the Nearest 100)	Rank	Industry (No., Name)
900	1)	6. Smallhold coffee
800	2)	24. Other processing
700	3)	3. Plant cocoa
400	4)	2. Smallhold coconut
	5)	1. Plant coconut
200	6)	5. Plant coffee
	6)	16. Sawmills
	7)	4. Smallhold cocoa
100	8)	7. Rubber
	9)	13. Fishing
	10)	14. Forest products

TABLE XVIII

DESCENDING ORDER OF IMPORTANCE ACCORDING TO FORWARD LINKAGE: EXPORTS VERSION

f_i^{ex} Value (to the Nearest 100)	Rank	Industry (No., Name)
900	1)	6. Smallhold coffee
700	2)	3. Plant cocoa
	3)	1. Plant coconut
400	4)	24. Other processing
	5)	2. Smallhold coconut
300	6)	16. Sawmills
200	7)	5. Plant coffee
	8)	4. Smallhold cocoa
100	9)	14. Forest products
	10)	7. Rubber
	11)	13. Fishing

coconut (1), smallholder coconut (2), plant coffee (5), sawmills (16), rubber (7), fishing (13). The structure of the PNG economy favors plantation agriculture, sawmills, fishing in executing an export promotion development strategy. The sectors and projects associated with them should receive special attention for public sector investment programs. OECD studies of several developing countries indicate that neglect of export-promoting sectors and projects and the concentration of import-substitution developments under protectionist policies have led to a structural malaise in the development of many economies.

P. *Employment-Oriented Development Strategy and Localization of Employment*

The sectors with dominant backward and forward wage-linkages have been derived by pre-multiplying the Leontief inverse by normalized indigenous wage coefficients and computation of Rasmussen's indices. These wage coefficients have been assumed to be good proxy measures for sectoral employment coefficients.

Government services (47), commerce (41), building (36), personal services (48), and education (44) in that order emerge as key sectors in terms of indigenous as well as non-indigenous employment or wage linkage. See Tables XIX, XX, XXI, XXII for sectoral orderings of labor-intensive or employment-intensive sectors. On closer scrutinization of the cardinal indices of backward and forward linkages, the dominance of expatriate vis-à-vis indigenous wage earners in most of the key sectors identified above is discernible. For example, in government services (47) backward linkages and forward linkages are one and a half times stronger for the non-indigenous ranking than for the indigenous. There is a general pattern showing that the PNG economy is structurally in the grip of

TABLE XIX

DESCENDING ORDER OF IMPORTANCE ACCORDING TO BACKWARD LINKAGE: INDIGENOUS WAGE INCOME VERSION

b_j^{iw} Value (to the Nearest 100)	Rank	Industry (No, Name)
600	1)	47. Govt. services
300	2)	41. Commerce
	3)	43. Dwelling
200	4)	36. Building
	5)	48. Personal services
	6)	44. Education
	7)	12. Rural development
100	8)	45. Health
	9)	1. Plant coconut
	10)	37. Road transport
	11)	33. Village
	12)	24. Other processing
	13)	9. Cattle
	14)	34. Electricity

TABLE XX

DESCENDING ORDER OF IMPORTANCE ACCORDING TO FORWARD LINKAGE: INDIGENOUS WAGE INCOME VERSION

f_i^{iw} Value (to the Nearest 100)	Rank	Industry (No., Name)
1400	1)	47. Govt. services
500	2)	41. Commerce
	3)	48. Personal services
400	4)	36. Building
200	5)	1. Plant coconut
	6)	37. Road transport
	7)	44. Education
100	8)	12. Rural development
	9)	45. Health

TABLE XXI

DESCENDING ORDER OF IMPORTANCE ACCORDING TO BACKWARD LINKAGE: NON-INDIGENOUS WAGE INCOME VERSION

b_j^{NIW} Value (to the Nearest 100)	Rank	Industry (No., Name)
900	1)	47. Govt. services
400	2)	43. Dwelling
300	3)	44. Education
	4)	41. Commerce
200	5)	36. Building
100	6)	34. Electricity
	7)	45. Health
	8)	9. Cattle
	9)	33. Village
	10)	39. Air transport
	11)	40. Communications
	12)	42. Finance
	13)	14. Forest products

TABLE XXII

DESCENDING ORDER OF IMPORTANCE ACCORDING TO FORWARD LINKAGE: NON-INDIGENOUS WAGE INCOME VERSION

f_i^{NIW} Value (to the Nearest 100)	Rank	Industry (No., Name)
2100	1)	47. Govt. services
500	2)	41. Commerce
400	3)	36. Building
300	4)	44. Education
	5)	39. Air transport
100	6)	45. Health
	7)	42. Finance
	8)	40. Communications

expatriate income earners because linkage effects in terms of wage incomes are stronger for expatriates than natives. Hence, public sector planning strategy aimed at remedying this imbalance should concentrate on sectors such as services, commerce, and building, in order to implement successful localization of employment in the economy.

The same key sectors that figured in wage income rankings of indigenous and non-indigenous figure prominently in non-wage income or employment linkage ranking of sectors (see Tables XXIII and XXIV). Wage and non-wage income

TABLE XXIII

DESCENDING ORDER OF IMPORTANCE ACCORDING TO BACKWARD LINKAGE: NON-WAGE INCOME VERSION

b_j^{NW} Value (to the Nearest 100)	Rank	Industry (No., Name)
600	1)	41. Commerce
300	2)	6. Smallhold coffee
200	3)	33. Village
	4)	3. Plant cocoa
	5)	2. Smallhold coconut
100	6)	23. Crop processing
	7)	22. Beverages
	8)	11. Other crops
	9)	36. Building
	10)	1. Plant coconut
	11)	24. Other processing
	12)	4. Smallhold cocoa
	13)	43. Dwelling
	14)	16. Sawmills
	15)	25. Tobacco
	16)	9. Cattle
	17)	38. Coastal transport

TABLE XXIV

DESCENDING ORDER OF IMPORTANCE ACCORDING TO FORWARD LINKAGE: NON-WAGE INCOME VERSION

f_i^{NW} Value (to the Nearest 100)	Rank	Industry (No., Name)
1800	1)	41. Commerce
300	2)	6. Smallhold coffee
200	3)	1. Plant coconut
	4)	36. Building
	5)	39. Air transport
100	6)	11. Other crops
	7)	2. Smallhold coconut
	8)	48. Personal services
	9)	16. Sawmills
	10)	18. Engineering
	11)	23. Crop processing
	12)	43. Dwelling

coefficients used in weighting the Leontief inverse are proxy measures for employment, and as such their rankings indicate employment potential of sectors in terms of backward and forward linkages. A comparative analysis of Tables XIX to XXIV indicates that key sectors in non-wage income groups have more employment generation potential than for wage income groups. Similarly, indigenous-based sectors are more promising than expatriate-based sectors for employment generation. A cardinal analysis of a non-wage income key sector with high forward linkage, e.g., commerce (41), shows that it has double the backward linkages of indigenous and non-indigenous wage income weighted sector rankings, and more than treble the strength with respect to backward linkages. This reveals a general pattern for sectoral rankings in PNG and indicates that an employment-oriented strategy should concentrate on the non-wage, subsistence, or barter based sectors of the PNG economy in order to favor non-indigenous income generation.

Q. *Concluding Remarks*

The semi-input-output and Rasmussen cost-benefit criteria for sector ranking have been applied first to a condensed matrix and, in addition, the Rasmussen criteria have been worked out for a disaggregated inter-industry table incorporating policy weights. The major part of the study, using the condensed inter-industry version has concentrated on supply considerations of intermediate demand, thus, ignoring final demand implications. In the semi-input-output application, demand factors were ignored deliberately as a simplifying device for demonstrating the calculus of cost-benefits for private enterprise investment programing. The inversion of the non-tradeable sectors matrix could be weighted by demand as well as other policy vectors to determine the implications of import-substituting, export-promoting, employment generation strategies of development. This was done in detail only for Rasmussen's key sector analysis. The full application of the semi-input-output model to Papua New Guinea was thwarted by the non-availability of reliable data on sectoral capital coefficients and the lack of a capital matrix. This gap in the statistics would hinder the proper application of inter-industry planning techniques to PNG. The compilation of a capital matrix is a necessary requirement for accurate planning in PNG. The data base on which the semi-input-output and Rasmussen linkage and spread indices were compiled benefited from Parker's inter-industry tables. These inter-industry statistics are now outdated as the implications of the Bougainville copper project are not fully reflected in the 1970 data base I have used. There is a need to apply the techniques demonstrated in this paper to a more updated and disaggregated version of the industry table. The techniques proposed and elaborated in this paper for providing rational guidelines for planning committed to a "mixed economy," as in PNG, are firmly founded on the cornerstones of the economic criteria of efficiency and optimality. They should prove particularly instructive to policymakers in PNG whose judgment and analysis could be clouded by extra-economic enthusiasm on the threshold and aftermath of political independence. The techniques proposed do not demand complicated mathematics

or computations and could be easily applied by planners in any developing economy. The reconcilation of conflicting planning goals in a mixed economy with regard to maximization of national income subject to scarce capital, maximization of employment, maximization of export earning, minimization of import dependence—all making full use of the structural interdependence of the economy—have been resolved. It has been demonstrated that this could be achieved by simple intersecting Venn diagrams and comparisons of sector rankings according to different cost-benefit criteria rather than by complicated and sophisticated development programing models which are likely to run into insurmountable difficulties in the context of lacunae in basic planning statistical data in developing economies like Papua New Guinea.

REFERENCES

1. ACHARYA, S. H., and HAZAN, B. R. "Linkages and Imports: A Comparative Study of India and Pakistan," *Journal of Development Studies*, Vol. 8, No. 1 (October 1971).
2. CORNELISSE, P. A., and VERSLUIS, J. "The Semi–Input Output Method under Upper Bounds," in *Towards Balanced International Growth*, ed. H. C. Bos (Amsterdam: North-Holland, 1969).
3. *Courier-Mail*, August 5, 1975.
4. HIRSCHMAN, A. O. *The Strategy of Economic Development* (New Haven: Yale University Press, 1958).
5. LITTLE, I.; SCITOVSKY, T.; and SCOTT, M. *Industry and Trade in Some Developing Countries: A Comparative Study* (London: Oxford University Press, 1970).
6. Papua New Guinea, Central Planning Office. *Policies and Issues* (Port Moresby: Government Printer, 1974).
7. ————. *Strategies for Nationhood: Programmes and Performance* (Port Moresby: Government Printer, 1974).
8. Papua New Guinea, Government. *Programmes and Policies for the Economic Development of Papua and New Guinea* (Port Moresby: Government Printer, 1968).
9. ————. *The Development Programme Reviewed* (Port Moresby: Government Printer, 1971).
10. PARKER, M. L. *Papua New Guinea: An Inter-Industry Study* (Canberra: Research School of Pacific Studies, Australian National University, 1973).
11. RASMUSSEN, N. P. *Studies in Inter-Sectoral Relations* (Amsterdam: North-Holland, 1956).
12. REDDAWAY, W. B. *The Development of the Indian Economy* (London: Allen and Unwin, 1962).
13. TINBERGEN, J. *The Design of Development* (Baltimore: Johns Hopkins, 1958).
14. ————. *Development Planning* (London: Weidenfeld and Nicholson, 1967).