An Application of Multi-Proportional Scaling to Social Accounting

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Summary

This paper applies the multi-proportional scaling algorithm described in Cole (1992) to the updating of the Aruba Social Accounting Matrix presented in Cole, et al (1993). The method overcomes certain limitations on the widely used bi-proportional method and its extensions. In particular, it permits additional partial and approximate data about clusters of elements on the interior of a matrix to be applied and adjusted simultaneously, with minimum overall loss of information. This facilitates the construction of local area input-output tables that typically must be based on expert judgment and incomplete and ad-hoc data. The method is demonstrated using a challenging application – the updating of the 1979 Aruba SAM to 1990 during which time the island faced major structural change (the consolidation of government, the closing of a major industry, and massive expansion of tourism and immigration). The final section discusses the complementary role of the algorithm to the expert judgment used in all scaling methods. The appendix summarizes the Lagrangian derivation of the scaling algorithm and discusses the conditions for the existence, uniqueness and convergence of the iterative solutions.

1. Bi-proportional and Multi-proportional RAS

The most common method for constructing input-output tables for a specific locality (sub-county or inner-city neighborhood) is to transform a previously constructed table for the encompassing region or a similar region, using whatever data are available from the locality to augment the scaling. Present extended RAS scaling techniques do not deal well with this kind of partial information, especially when it is represented by entries in the interior of the input-output table. Bi-proportional methods, in particular, demand that information on individual items is taken to be precise, while data on sub-totals (or blocks of entries) cannot be used. This information is therefore wasted. To avoid this requires more sophisticated scaling techniques.

This multi-proportional method is an extension of the RAS technique introduced by Deming and Stephan (1940). RAS algorithms work by eliminating inconsistencies between data losing as little information as possible en route. The process may be visualized by remembering Leonardo de Vinci's famous "metamorphosis" cartoons in which he created grotesque human faces from those of animals - the features are systematically squeezed into a new overall shape while keeping their mutual positions more or less unchanged. The algorithm similarly manipulates data into a new consistent configuration. Thus, although the mathematics may appear complex, it has a familiar analogue. Of course, if the original data are too inconsistent, or too partial, there may be no solution possible.

Since its introduction, the theoretical basis for the RAS method has been strengthened. Notably, Bacharach (1965, 1970) demonstrated that the solution of the simple RAS involves the minimum loss of information from the original matrix. Various modifications to the RAS approach have been suggested, not least by Lecomber (1977). The most significant modification is the prescribing of individual items within the matrix. The approach adopted by Allen (1976), for example, fixes particular elements as well as the row and column totals, and then allows the burden of adjustment to fall on the remaining non-zero entries. A major difficulty with this approach is that, if a high proportion of elements are fixed externally, convergence may be difficult, or even impossible. Indeed, as Miller and Blair (1985) have observed, this can lead to worse results in terms of the overall reliability across the updated matrix as a whole.

Although a variety of alternative non-RAS techniques have been introduced to overcome these limitations of the RAS method (see eg Morisson and Thumann, 1980, Harrigan and Buchanan, 1984), recent empirical comparisons of updating procedures tend to favor the use rectangular RAS methods (see especially, St Louis, 1989). In the method described here, the method of Lagrange is used to derive a multi-proportional scaling algorithm which is a generalization of the simple RAS method. Whereas, in the simple RAS method, individual items are adjusted by two constraints only - the row and column total, in this method, every item may adjust in response to an arbitrary number of constraints on individual items and sub-groups of entries. The matrix may contain an arbitrary number of dimensions: structure, space, and time. It need not be rectangular and so may be applied to, for example, the consistent scaling of multi-regional rectangular input-output tables (see eg. Oosterhaven et al, 1986). In this sense, the algorithm has general application for scaling to a wide range of social science data.

2. The Scaling Algorithm

With the simple RAS method, the elements of the matrix are adjusted successively in a bi-proportional manner, that is, all row elements are scaled successively in a linear fashion to so that their sum matches the externally given total, and then column totals are scaled in like fashion. This round of adjustment is then repeated iteratively until no significant further adjustment takes place. In the minimum information loss interpretation of the RAS, the problem addressed is how to minimize the overall distortion of individual entries in the matrix at each round of the updating procedure. The formal procedure for bi-proportional scaling is given in Macgill (1977) and Miller and Blair (1985).

For the multi-proportional case, a matrix $A_{ij}(\infty)$ of dimension NxM defines the SAM to be constructed. The subscripts i and j label the rows and columns of the accounts represented in the table (production sectors, households and so on) [1]. A base matrix, $A_{ij}(0)$, a national or regional table with the same number of dimensions or an earlier version of the desired SAM, is used as the starting point for the new table.

The new table is to be constructed using current, but partial information. These data may include the all or some of the row and column totals, as with the bi-proportional scaling, together with information about individual entries of sub-totals of entries within the matrix. (This might include, for example, information on total wages or trade). If there are Z constraints, defined by the sub-totals B_z, then, after n adjustments, the Z constraints applied are given by:

$$\sum_{ij\,\varepsilon\, z} Aij(n) = Bz \qquad (1)$$

It is noted that, contrary to other updating procedures, no distinction is made a priori between the constraints on the row and column totals and the constraints on individual elements or blocks of elements on the interior of the matrix. All constraints are treated simply as the desired final sub-totals of specified blocks of entries.

All the entries in each block are scaled by the ratio of the desired block total divided by the current block total as given by (1). However, since items in one block are (in general) affected by the scaling of other blocks condition (1) will no longer hold and so entries will need to be rescaled.

$$A_{ij}(n) = A_{ij}(n-1)B_z / \sum_{ij\,\varepsilon\, z} A_{ij}(n-1) \qquad (2)$$

This rescaling of each block is repeated in order in a round-by-round fashion until the desired degree of convergence C_z for each bock is achieved.[2]

[1] In Cole (1992) the algorithm is presented for the multi-regional case. However, the models constructed are solved using the time-lagged Leontief inverse solution described in Cole (1989) that treats all entries as mathematically equivalent, so it is unnecessary to include the subscript for this spatial dimension.

[2] A given C_z may be interpreted a measure of confidence in the constraint, that depends, for example, on how recent the relevant data are. In some cases it may be useful to relax constraints as a means to circumvent inconsistencies that are preventing overall convergence.

$$\mathrm{Abs}\{\sum_{ij\,\varepsilon\,z} \mathrm{Aij}(n)/\,\mathrm{Bz} - 1\} < \mathrm{Cz} \qquad (3)$$

Overall, the procedure parallels the alternate rescaling of rows and columns in the bi-proportional procedure. The conditions for solutions to be possible are also similar. The Appendix provides a proof that this algorithm leads to a minimum information loss solution, and discusses the conditions for its convergence, and for the existence, and uniqueness of solutions.

3. An Application to a Social Accounting Matrix.

The efficacy of the scaling algorithm is now illustrated using an application to the island of Aruba. For reasons now summarized this presented a challenge for matrix reconstruction. A set of social accounts for the island had been constructed for 1979 (Cole et al, 1983). This SAM was based on a recent detailed Census of Business, the 1980 Census of Population, and current trade and public sector information. Some inter-sector transactions were scaled from a recent input-output table for Puerto Rica. This exercise was used in a macro-economic plan for the then-forthcoming negotiations for independence from Holland. Coincident with independence (formally “status aparte” from the Netherlands Antilles) in 1986 the major industry (oil refining) had closed suddenly and the economy was in grave recession. Equally dramatically, through aggressive expansion of the tourism sector, by 1990, the island was well on the road to recovery, and in even at risk of economic overshoot. The economy had dramatically restructured around tourism, island and central government had consolidated and some public utilities were privatized. The labor force too had restructured through massive emigration followed by rapid immigration. This history provided an excellent opportunity to test the performance of several disaster planning models and model building techniques including the multi-proportional RAS algorithm.

The scaling algorithm uses two sets of data – the initial 1979 SAM and incomplete data at varying levels of aggregation for the economy around 1990. Some of the 1990 data are aggregates for the macro-economic structure of the island (primarily the Central Bank of Aruba National Accounts), with estimates of GDP, total wages, and foreign transactions. Others are meso-level economic data such as wage income by sector, household income, tourism, and commodity trade by broad category, while more detailed micro-level data refer to individual corporations, notably the lifeline sectors (water and electricity and distribution).

These data represent the sub-totals for a variety of nested and over-lapping blocks of entries within the detailed SAM. For clarity, the multi-proportional scaling algorithm was applied by introducing the three levels of information in order - macro, meso, then micro. Before this rescaling, the original 1979 SAM was modified to account for the new institutional structure, and the loss of the oil sector. As a final step in the rescaling the table was balanced to match the total expenditures and income for each account. The overall procedure for scaling the 1990 SAM for Aruba is summarized in Figure 1. The details of the steps are as follows:

The modified 1979 SAM used as the base matrix for rescaling after island and central government and investment accounts have been consolidated is shown in Table 1. The modified table showing the loss of the oil refinery is given in Table 2. This table is unbalanced in that the income and expenditure of each account are not equal. This is relatively unimportant since the majority of entries are subsequently re-scaled using sector specific data. (The "Rest of the World" accounts, the block of entries 21-23 in the bottom right corner of the matrix, were approximately balanced).

The first consolidated table in Table 3 shows the current totals for the blocks to be scaled. The second aggregate matrix shown in Table 3 provides the overall macro-economic targets for 1990[3]. The ratios of these data compared to the corresponding 1979 data typically are between 2 and 3. These ratios are used for first round scaling. This provides an approximate SAM for 1990, measured in current AFl million and consistent with the aggregate national accounts.

Table 4 shows the use of the meso-level information. This is based on IMF estimates of the contribution to GDP from industry, tourism, commerce and construction (IMF, 1990) and CBA data on tourism revenues and commodity and service exports. Information on imports by sector are not known. Data on wage rates by sector (construction and tourism) are used to sub-divide the factor payments by sector between their wage and non-wage components. Again, the ratios shown are for the first round scaling.

The micro-level information on "lifeline" systems shown in Table 5 is based on the annual accounts of the water and electricity production and distribution companies. This includes information on intermediate expenditures on raw materials, maintenance and services, wages, subsidies and taxes. Typically, these data correspond to individual entries in the

[3] The national accounts do not specify the extent of inter-industry transactions, or even aggregate intermediate consumption by sector. Consequently, initially these entries are scaled en bloc using the average ratio of 2.6. In the original matrix, for example, imports of capital goods were treated as a direct import, whereas in the new table these are treated as an indirect import via production sectors.

accounts.

Finally, for accounts where the total expenditures or income are unknown, totals are fixed by scaling the columns and then the rows of every account so that first the column total and then the row total equal their current average.

Table 6 shows the final 1990 SAM. Satisfactory convergence - taken here to mean that all targets are met to within one percent is achieved after about 20 iterations of the above procedure. The path to convergence for the account totals is shown in Figure 2. The income and expenditure totals are in good agreement for all accounts, and the table conforms well to the target data at all levels.

4. Some Comments on Application of Scaling Algorithms.

Overall, the matrix scaling method presented in this paper appears to provide a robust algorithm for data matrices such as input-output tables. It enables additional data and constraints, including cross-regional data, to be introduced. It therefore represents a useful advance on previous RAS type methods since it overcomes what has been viewed a major limitation of the approach (Morrison and Thumann, 1980), and has the advantage over other non-RAS methods of retaining the intuitive appeal of the RAS approach.

Han and Kim (1988), in reviewing the use of information systems distinguish between "expert" and "decision support" systems. The former attempt to incorporate the judgement, experience, intuition and "rules of thumb" of human experts into problem solving, a heuristic rather than an algorithmic approach. The latter access structured data bases using clear-cut decision rules, so as to provide selected information from a large and complex data base. In effect they are a means for filtering out and manipulating relevant information. Matrix building, in practice, requires a considerable degree of expertise and judgement (familiarity with data sources and accounting conventions, elimination of irregularities and reconciling of inconsistences). The method sought here obviously is closer to the decision support system but it will necessarily embody the experiences of practical "hands-on" matrix construction.

It is not difficult to conceive of a "hybrid" approach, such as a computer software package which would facilitate the speedy construction of local-area social accounting matrices, even as a post-event exercise, by small teams of experts with some prior experience in the construction of input-output tables, or by less sophisticated local officials over a longer time-frame, as part of pre-event strategy development. The hybrid system would have an algorithm at its core, but would be backed up by a system for monitoring the results of the procedure (checking for inconsistencies, unreasonable parameters, and so on), and suggest alternative data sources and matrix construction procedures (for example, using a hierarchical "hyper-text" approach). From the technical point of view this appears to be a feasible goal. In particular, the method described and applied in this paper appears to provide a means of constructing social accounting matrices for natural disaster event accounting, and also a potentially useful core algorithm for a hybrid expert system.

Appendix

This appendix discusses the limitations of the method and the necessary conditions for a solution to be possible.

If target data are inconsistent the iteration will not work - individual entries in the input-output table will oscillate (i.e. alternate between two sets of values), or drift (i.e. change incrementally in a non-convergent fashion), or become negligible (even those known to be substantial), or diverge (i.e. become very large). As with other scaling procedures, negative entries may lead to spurious results, and it may be necessary to transform these to positive entries. For example, large negative indirect taxes (i.e. subsidies) or negative saving by government (i.e. a deficit on current account) in expenditure accounts may be moved to the income account (in each case, requiring an adjustment to the calculation of sector value added or income). The causes and results of non-convergence are reasonably clear in any practical situation, and so warnings as to potentially troublesome data may be built into the construction procedure, and these in turn may trigger suggested corrections or alternative procedures. The necessary and sufficient conditions for convergence are not known precisely for this multi-proportional scaling. Nevertheless, it may be shown formally that if the procedure does converge, then the result is unique.

A1. Minimum Information Loss

The constraints are applied in order to the matrix, so that after one full round of adjustments, the information distance of $A_{ij}(Z)$ from the original matrix $A_{ij}(0)$ is:

$$D[A(Z):A(0)] = \sum_{ij} Aij(Z)\log[Aij(Z)/Aij(0)] \qquad \text{(A1)}$$

These constraints are imposed repeatedly so that each is applied once in any full round of Z adjustments. After an arbitrary number of adjustments, the nth adjustment will apply the same constraint as the (n-Z)th adjustment. Thus,

$$D[A(n):A(n-Z)] = \Sigma\, A_{ij}(n)\log[A_{ij}(n)/A_{ij}(n-Z)] \qquad \text{(A2)}$$

$$\qquad ij \qquad\qquad\qquad \text{for all } A_{ij} \neq 0.$$

That the algorithm leads to a minimum information loss solution may be demonstrated using the method of Lagrange. The Lagrangian for the problem is given by:

$$L = D + \sum_{z} l_z(B_z - \sum_{ij\,\varepsilon\, z} A_{ij}(n)) \qquad \text{(A3)}$$

where l_z are the Z Lagrangian parameters, and B_z is given by Equation (1).

The first necessary condition for a minimum is that the first order partial derivatives of L with respect to $A_{ij}(n)$ are zero.

$$dD/dA_{ij}(n) = \{1 + \log [A_{ij}(n)/\log\{A_{ij}(n\text{-}Z)]\} - \sum_{z\,\varepsilon\, ijk} l_z = 0 \qquad (4)$$

The second condition for the solution to be a minimum is that the second order partial derivatives should be positive.

$$\text{i.e.} \quad d^2/dA_{ij}(n)^2 = 1/A_{ij}(n).$$

This shows that the solution is always a minimum since $A_{ij}(n) > 0$. Rewriting (A4) gives:

$$A_{ij}(n) = A_{ij}(n\text{-}Z) \exp(-1) \prod_{z\,\varepsilon\, ij} \exp(l_z) \qquad (5)$$

Substitution of (A5) into (1) gives:

$$B_z = \sum_{ij\,\varepsilon\, z} [A_{ij}(n\text{-}Z) \exp(-1) \prod_{z'\varepsilon\, ij} \exp(l_{z'})]$$

This expression may be rewritten, by separating the term in l_z, after setting $r_{z'} = \exp(l_{z'})$, giving:

$$r_z = \exp(1)\, B_z / \{ \sum_{ij\,\varepsilon\, z} [A_{ij}(n\text{-}Z) \prod_{\substack{z'\varepsilon\, ij \\ z' \neq z}} r_{z'}]\} \qquad (6)$$

Using (A5) and (A6), the problem may be solved in an iterative manner by repeated calculation and substitution of the l_z and the $A_{ij}(n)$ so as to obtain acceptably precise values for $A_{ij}(\infty)$ in terms of $A_{ij}(0)$ and the constraints B_z. This general algorithm is straightforward to program and converges rapidly provided there is a feasible solution. The conditions for solutions to exist and a unique convergence to be attained are now considered.

A2. Existence of Solutions, Uniqueness, and Convergence

The uniqueness of any solutions to the multi-proportional adjustment may be argued in the same manner as for the bi-proportional solution given by Evans (1973) and Bacharach (1965 and 1970) and adopted by Macgill (1977). These authors show that provided the bi-proportional calculation converges, the step-wise solution will provide a unique result. They also demonstrate the conditions for convergence. Evans (1973) has shown that the solution for the A_{ij} resulting from the minimization of the strictly convex objective function will be unique. For the multi-proportional case, it was shown above that, because the $A_{ij} > 0$, the derivatives of the Lagrangian provide local minima. It follows also that, because the constraints given by (1) are all linear, the objective function (2) is strictly convex. Consequently, the solutions of the multi-proportional algorithm, if they exist, will be unique.

Conditions for the existence of solutions are less straightforward than those for uniqueness, but minimum conditions (or "only-just-sufficient" conditions), similar to those discussed by Macgill (1977) for the bi-proportional case may be stated. For the bi-proportional RAS, there is an obvious minimum condition - the sum of the row totals must equal the sum of the column totals X_i and Y_j of the matrix.

i.e. $$\sum_i X_i = \sum_j Y_j$$

Unless this accounting identity is satisfied, there is no solution which will simultaneously satisfy all the external constraints. With the multi-proportional method, the equivalent condition to (7) would be that the sum of the row and column totals must be equal.

i.e. $$\sum_{\text{rows}} B'_z = \sum_{\text{columns}} B'_z$$

The primed B'_z here are the explicit or implicit constraints on the row and column totals. This condition may be relaxed provided the constraints on the interior of the matrix pre-determine the row and column totals. In addition to this, there are minimum conditions on the internal elements - basically, that if a row or column contains zero elements, then there must be sufficient latitude for the adjustment of the elements within the remaining degrees freedom implied by the constraints. For this, the conditions placed on the row and column containing any non-zero element A_{ij} in the matrix are that:

$$X_{i'} \leq \sum_{j \neq j'} Y_j \quad \text{and} \quad Y_{j'} \leq \sum_{i \neq i'} X_i \tag{8}$$

These only-just-sufficient conditions lead to boundary solutions that are fully determined by the externally given row and column totals, so that the original matrix provides no information on the magnitude of the non-zero entries in the final matrix. Corresponding conditions exist for the multi-proportional case, for example, for an internal block within a matrix. The violation of these conditions would mean that one or more elements of the matrix present an inconsistent adjustment, in the sense described by Macgill (1977). The reasons for these conditions again can be demonstrated in the manner used by Macgill (1977) for the bi-proportional case.

The demonstration that the bi-proportional solution is convergent, first proven by Bacharach (1965), consists of showing that, after many iterations, the incremental shift to the individual elements of the matrix in successive row and column adjustments falls monotonically to zero, provided conditions (7) and (8) above are fulfilled. As noted above, the constraints define the bounds on allowable row, column and block totals such that accounting identities are not violated. In this respect, there is the obvious requirement that the sum of all nested blocks and elements cannot exceed the sum of the blocks encompassing them.

i.e. $$\sum_{\substack{\text{inner}\\\text{blocks}}} B_z \leq \sum_{\substack{\text{encompassing}\\\text{blocks}}} B_z$$

This determines that a fixed element or block must not be larger than the row or column, or block containing it. A block spanning one or more rows or columns must be smaller than the row and column totals, and so on. A scaling algorithm cannot, of course, eliminate absolute inconsistencies, for example, when values of particular A_{ij} are so over-determined that the various conditions they are required to meet can never be reconciled. Practically, in an expert system, these problems may be reduced before the final mechanical adjustment process is begun, for example, by prefacing the adjustment procedure with checks ensuring that the sub-totals of nested constraints do not exceed the constrained blocks within which they reside, as indicated by (9) above.

The reason that the approach avoids the major problem of the earlier extended RAS methods for including additional data (such as that adopted by Allen, 1977) is that the multi-proportional scaling algorithm does not impose such rigid constraints on the adjustment process. With the multi-proportional adjustment, the constraints are not applied in an absolute fashion at the outset. Instead, the burden of adjustment is distributed across the matrix, or a particular internal block, until some degree of convergence is attained by balancing the information loss from all constraints. Empirical tests with the multi-proportional scaling algorithm using data from Cole (1987) and Cole (1990b) show it to have good convergence properties provided there are no inconsistencies which cannot be localized. This test for convergence is directly comparable to those applied by both Harrigan and McNicholl (1986) and Morrison and Thumann (1980) to their non-RAS methods.

REFERENCES

Adelman I. et al (1988) Life in a Mexican Village:A SAM Perspective, Journal of Development Studies, Vol 25,1

Allen R. (1976) Some Experiments with the RAS Method of Updating Input-Output Coefficients, Oxford Bulletin of Economics and Statistics, pp 215-228.

Bacharach M. (1965) Estimating Non-negative Matrices from Marginal Data, International Economic Review, Vol 6, pp 294-310.

Bacharach M. (1970) Biproportional Matrices and Input-Output Change, Cambridge University Press, New York.

Bender S. (1989a) Urban Growth, Environmental Change and Natural Hazards in Latin America and the Caribbean, Annual Meeting of the Association of American Geographers, Baltimore.

Bender S. (1989b) Disaster Prevention and Mitigation in Latin America and the Caribbean, Colloquium on Natural Disasters, World Bank, Washington.

Butterfield M. and Mules T. (1980) A Testing Routine for Evaluating Cell Accuracy in Short-Cut Input-Output Tables, Journal of Regional Science, Vol 20, 3.

Cohen S. (1988) Social Accounting Matrices and the Comparative Analysis of Static Systems, International Conference on the Construction and Use of Input-Output Models, Morganstown, West Virginia.

Cole S. (1987) Growth, Equity and Dependence in a Re-structuring Regional Economy, International Journal of Urban and Regional Research, Vol 11,4,pp451-477.

Cole S. (1988) A Multi-proportional Scaling Algorithm, presented at the RSA North American Meeting, Toronto.

Cole S., E. Pantoja, and V. Razak (1993), Social Accounting for Disaster Preparedness and Recovery Planning. National Center for Earthquake Engineering Research, Buffalo. Technical report NCEER-93-0002.

Cole S (1990b) The Construction and Application of a Cultural Accounting Matrix, UNESCO, Paris.

Cuny F (1983) Disasters and Development, Oxford University Press, New York.

Deming W. and Stephan F. (1940) On Least Squares Adjustment of a Sampled Frequency when Expected Marginal Totals are Known, Annals of Mathematical Statistics, Vol 11, No 4.

Ellson R., Milliman J., and Roberts B. (1984) Measuring the Regional Economic Effects of Earthquakes and Earthquake Predictions, Journal of Regional Studies, Vol 24, 4.

Evans S. (1973) A Relationship between the Gravity Model for Trip Distribution and the Transportation Problem in Linear Programming, Transportation Research, Vol 7, pp 19-36.

Friedlander D. (1961) A Technique for Estimating a Contingency Table Given the Marginal Rows and Columns and some Supplementary Data, Journal of the Royal Statistical Society (A), Vol 124, pp 412-420.

Han S and Kim J (1988) Intelligent Urban Information Systems: Review and Prospects, mimeo, University of Illinois.

Harrigan F. and Buchanan I. (1984) A Quadratic Programming Approach to Input-Output Estimation and Simulation, Journal of Regional Science, Vol 24, No 3, pp 339-354. (see also Harrigan F. and McNicholl I. (1986) Data Use and the Simulation of Regional Input-Output Matrices, Environment and Planning (A), Vol 18, pp 1061-1076.

Jahoda M. et al (1988) The Market Place for Expert Systems - Present State and Future Trends, ILO, Geneva.

Jones B (1989) The Need for a Dynamic Approach to Planning for Earthquakes after Reconstruction, NCEER, Buffalo

Jones B (1981) Planning for Reconstruction of Earthquake Stricken Communities, PRC-US Joint Workshop, Beijing.

Kreimer A (1989) The Post-Earthquake Reconstruction Effort in Mexico, World Bank Environment Department, Washington.

Lecomber J. (1975) A Critique of Methods of Adjusting, Updating and Projecting Matrices, in Allen R. and Gossling W. Estimating Input-Output Coefficients, London Input-Output Publishing Co.

OAS (1988) Incorporating Natural Hazard Assessment into Project Preparation, Washington.

Oosterhaven J., Piek G. and Stelder D. (1986) Theory and Practice of Updating Regional versus Inter-regional Inter-industry Tables, Papers of the Regional Science Association, Vol 59, pp 57-72.

Louis St. L. (1989) Empirical Tests of some Semi-survey Update Procedures applied to Rectangular Input-output Tables, Journal of Regional Science, Vol 28, No 23, pp373-385.

Macgill S. (1977) Theoretical Properties of Bi-proportional Matrix Adjustments, Environment and Planning (A), Vol 9, pp 687-701.

Miller R. and Blair P. (1985) Input-Output Analysis: Foundations and Extensions, Prentice-Hall, New Jersey.

Morrison W. and Thumann R. (1980) A Lagrangian Approach to the Solution of a Special Constrained Matrix Problem, Journal of Regional Science, Vol 20, No 3, pp 279-292.

OAS (1990) Natural Hazards Project: Summary of Activities, Washington

Pyatt G. and Roe A. (1979) Social Accounting Matrices for Development Planning, IBRD, Washington.

Rose A. (1988) Review of the Economic Effects of Environmental Hazards, mimeo, North East Regional Science Association, Cornell University, Ithaca.

Rose A. and Beaumont P. (1988) Inter-relational Income Distribution Multipliers, Journal of Regional Science (forthcoming).

Taylor L. (1979) Macro-Models for Developing Countries, McGraw-Hill, New York.

Tubbesing S (1989) Earthquake Reconstruction: Lessons for a Safer Future, NCEER, Buffalo.

FIGURE 1. PROCEDURE FOR MULTI-PROPORTIONAL SCALING OF ARUBA SAM

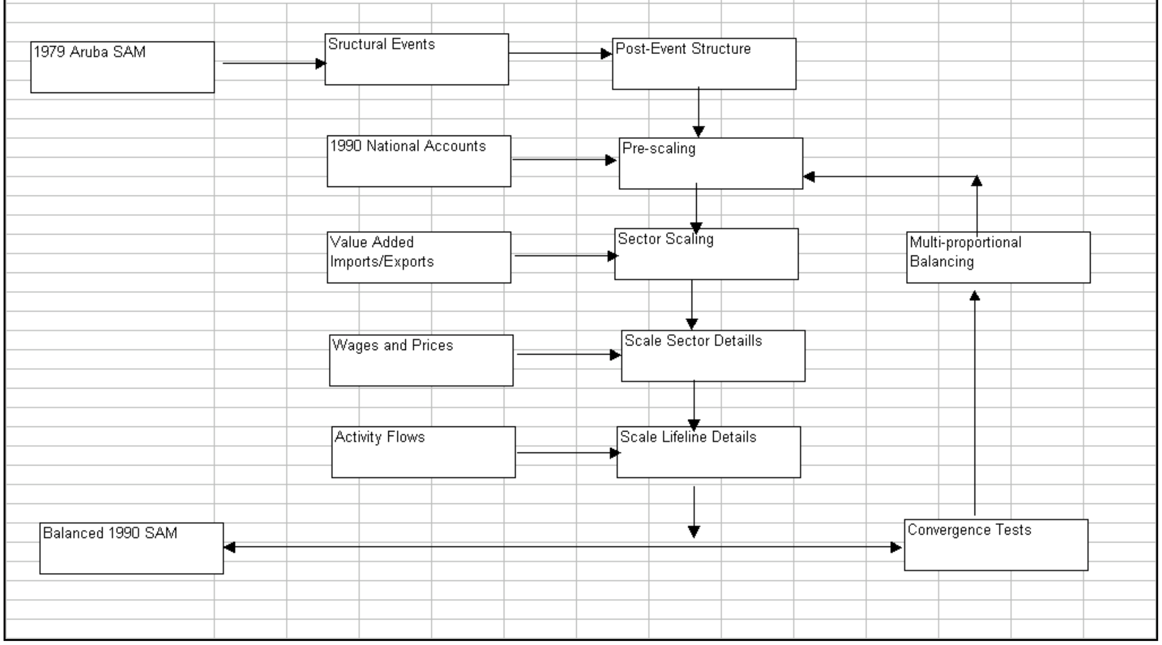

TABLE 1. ARUBA 1979 REORGANIZED SOCIAL ACCOUNTS AND CONSOLIDATED ISLAND ACCOUNTS

		PRODUCTION							FACTORS						DOMESTC				CAPITAL			OVERSEAS			
		IND	OIL	UTIL	CON	COM	HOR	SERV	LOW	MID	HIGH	DEP	SURP		POOR	RICH	FIRM	GOVT	HCAP	FCAP	GCAP	TOUR	TRADE	BOP	TOTAL
SECTOR	Code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
INDUSTRY	1	20	8	7	11	1	3	27							37	87		6		1	8	4	3		222
OIL REFINERY	2	4		34	8	2	1	7							3	7				16			3943		4025
UTILITIES	3	2	19	2		1	13	4							9	16		1							67
CONSTRUCTION	4	8	25	0	0	5	0	20							1	5		2	2	4	4				75
COMMERCE	5	36	5	4	6	0	2	16							67	163		3		0	1	28	26		358
HORECA	6	0	1	0	0	0	0	11							5	9				1		115			143
SERVICES	7	17	9	6	5	7	24	38							17	53		39			1	29	34		279
LOW SKILL	8	9	11	2	10	14	14	11								11		6				10			98
MIDDLE SKILL	9	7	26	4	11	21	16	21										26				4			136
HIGH SKILL	10	5	32	6	8	12	8	43										57							171
DEPRECIATION	11	3	38	6	5	8	7	13										2							82
SURPLUS	12	11	16	8	5	158	19	58																	275
INDIRECT TAXES	13																								
POOR HOUSEHOLDS	14								62	35	7		26					7						3	140
RICH HOUSEHOLDS	15								31	95	156		139					18						26	465
FIRMS	16											80	110												190
GOVERNMENT	17	9	3	-14	3	30	4	1	2	3	3				2	63	71				2				182
HOUSEHOLD CAPITAL	18														-3	40					1				38
FIRMS CAPITAL	19																119	26		15				3	163
GOVERNMENT CAPITAL	20																	-25		4				36	15
TOURISM	21														3	12								193	208
OVERSEAS TRADE	22	88	3551	4	2	101	31	8												123					3908
OVERSEAS PAYMENTS	23		281															13	49			16	−98		261
TOTAL	24	219	4025	69	74	360	142	278	95	133	166	80	275		141	466	190	181	51	164	17	206	3908	261	11501
JOBS	25	1087	1293	652	2500	4451	3271	5845										4589							23688

Amounts: All million 1979

SAM79RED

CONSOLIDATED ACCCOUNTS	Prod	Fact	Priv	Gov	Priv	Gov	Exp	Inflow	Total
Production			490	51	147	14	4182		4883
Factors	646			91					737
Private Current Account		741		25					766
Government Current Account	36	8	136						180
Privite Capital Account			156					32	188
Government Capital Account				-25				36	11
Imports	3908		15						3923
OutFlows	281			13	49		-275		68
Expenditures	4871	749	797	155	196	14	3907	68	10756
Income	4883	737	766	180	188	11	3923	68	10756

Notes: Consolidated Island and Central Government and Indirect Taxes
Some imbalances due to re-definitions in re-scaling.

TABLE 2. UNBALANCED ARUBA 1979-BASED SOCIAL ACCOUNTS WITH STRUCTURAL CHANGES AND CONSOLIDATED ISLAND ACCOUNTS

		PRODUCTION							FACTORS						DOMESTC				CAPITAL			OVERSEAS			
		IND	OIL	UTIL	CON	COM	HOR	SERV	LOW	MID	HIGH	DEP	SURP		POOR	RICH	FIRM	GOVT	HCAP	FCAP	GCAP	TOUR	TRADE	BOP	TOTAL
SECTORS		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
INDUSTRY	1	9.2		3.3	9.4	0.6	2.6	16.4							23.1	54.6		3.9		0.6	5.0	2.5	1.9		133.1
OIL REFINERY	2																								
UTILITIES	3	0.9		1.0		0.6	11.4	2.5							5.8	10.3		0.7							33.2
CONSTRUCTION	4	6.8		0.1	0.2	5.5	0.2	22.4							0.6	5.8		1.8	2.3	4.6	4.6				54.8
COMMERCE	5	21.3		2.4	6.5	0.1	2.2	12.4							54.3	131.8		2.5		0.1	0.8	22.6	21.0		277.9
HORECA	6	0.1		0.1	0.2	0.1	0.2	12.5							5.9	10.6				1.2		135.3			166.0
SERVICES	7	10.3		3.7	5.6	5.4	27.2	30.3							14.1	43.9		33.4			0.8	24.0	28.1		226.9
LOW SKILL	8	6.1		1.4	12.5	12.2	17.8	9.8								10.2		5.8				9.3			85.0
MIDDLE SKILL	9	4.8		2.8	13.8	18.3	20.3	18.8										24.9				3.7			107.3
HIGH SKILL	10	3.4		4.2	10.0	10.4	10.1	38.4										54.7							131.2
DEPRECIATION	11	2.0		4.2	6.3	7.0	8.9	11.6										1.9							41.8
SURPLUS	12	7.5		5.5	6.3	137.5	24.1	51.8																	232.7
	13																								
POOR HOUSEHOLDS	14								57.4	32.8	6.4		24.1					6.7						2.8	130.1
RICH HOUSEHOLDS	15								29.1	88.2	144.5		128.9					17.3						24.1	432.0
FIRMS	16											74.2	102.0												176.2
GOVERNMENT	17	6.1		-9.7	3.8	26.1	5.1	0.9	1.6	2.4	3.1				1.9	58.4	65.8								165.4
HOUSEHOLD CAPITAL	18														-2.8	37.1									34.3
FIRMS CAPITAL	19																110.3	24.9						2.8	138.1
GOVERNMENT CAPITAL	20																	-24.0						33.4	9.4
TOURISM	21														3.0	12.0								290.0	305.0
OVERSEAS TRADE	22	67.5		28.3	17.0	89.8	46.9	22.2												123.0					394.7
OVERSEAS PAYMENTS	23																	13.0	49.0	50.0		16.0	365.0		493.0
TOTAL EXPENDITURES	24	146.0		47.2	91.4	313.5	176.9	249.9	88.1	123.3	153.9	74.2	255.0		105.8	374.6	176.2	167.4	51.3	179.5	11.3	213.4	416.0	353.1	3768.0

Amounts: All million 1979

CONSOLIDATED ACCCOUNTS	Prod	Fact	Priv	Gov	Priv	Gov	Exp	Inflow	Total
Production			360.6	42.3	8.9	11.3	235.4		658.5
Factors	487.5			87.3					574.8
Private Current Account		687.4		24.0					711.4
Government Current Account	32.2	7.0	126.1						165.4
Privite Capital Account			144.6					29.7	174.3
Government Capital Account				-24.0				33.4	9.4
Imports	394.7		15.0		123.0			290.0	822.7
OutFlows				13.0	99.0		381.0		493.0
Expenditures	914.5	694.5	646.4	142.5	230.9	11.3	616.4	353.1	3609.5
Income	658	575	711	165	174	9	823	493	3610

Note: Re-organized 1979 SAM - 1979-90 employment changes
Amalgamation of government and revised oil imports
Trade Adjustment 486.338

TABLE 3. CURRENT AND TARGET NATIONAL ACCOUNTS

CURRENT	Prod	Fact	Priv	Gov	Priv	Gov	Exp	Inflow	Rows
Production			361	42	9	11	235		658
Factors	488			87					575
Priv Cur		687		24					711
Gov Cur	32	7	126						165
Priv Cap			145					3	147
Gov Cap				-24				33	9
Imports	272		15		123			290	700
OutFlows				13	99		502		614
Cols	792	694	646	143	231	11	738	326	3581
Rows	658	575	711	165	147	9	700	614	3581

TARGET	Prod	Fact	Priv	Gov	Priv	Gov	Exp	Inflow	Rows
Production			1083	107	378	35	1041		2644
Factors	1389			167					1556
Priv Cur		1467		54					1521
Gov Cur	139	89	91						319
Priv Cap			275					219	494
Gov Cap				-23				58	35
Imports	1117		72					626	1815
OutFlows				14	116		773		903
Cols	2645	1556	1521	319	494	35	1814	903	9287
Rows	2644	1556	1521	319	494	35	1815	903	9287

TABLE 4. SCALING OF TRADE AND FACTOR INCOME

OVERSEAS TRADE BY CATEGORY

Exports	Tour	Merch	Serv	Total	Imports	Tour	Merch	Serv	Total
Estimate	625	241	175	1041	Estimate	72	1116		1188
Matrix	815	101	124	1041	Matrix	25	1117		1142
Ratio	77%	238%	141%	100%	Ratio	293%	100%		104%

WAGES BY SECTOR

	IND	OIL	UTIL	CON	COM	HOR	SERV	PUB
1990 Rate				1.90	1.30	1.60	1.90	
Employment	738		460	4382	4673	5950	6617	4400
1984 Rate	1.3	4.7	2.7	1.9	1.3	1.4	2.1	1.8
Estimate	11.3		14.7	99.9	72.9	114.2	150.9	92.1
Matrix	40.6		23.7	103.5	116.5	137.4	190.8	163.3
Ratio	28%		62%	97%	63%	83%	79%	56%

RATIO	Prod	Fact	Priv	Gov	Priv	Gov	Exp	Inflow	Rows
Production	0.0	0.0	3.0	2.5	42.7	3.1	4.4	0.0	4.0
Factors	2.8	0.0	0.0	1.9	0.0	0.0	0.0	0.0	2.7
Priv Cur	0.0	2.1	0.0	2.3	0.0	0.0	0.0	0.0	2.1
Gov Cur	4.3	12.6	0.7	0.0	0.0	0.0	0.0	0.0	1.9
Priv Cap	0.0	0.0	1.9	0.0	0.0	0.0	0.0	78.7	3.3
Gov Cap	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.7	3.7
Imports	4.1	0.0	4.8	0.0		0.0	0.0	2.2	2.6
OutFlows	0.0	0.0	0.0	1.1	1.2	0.0	1.5	0.0	1.5
Cols	3.3	2.2	2.4	2.2	2.1	3.1	2.5	2.8	2.6
Rows	4.0	2.7	2.1	1.9	3.3	3.7	2.6	1.5	21.9

TABLE 5. ADJUSTMENT OF DETAILES OF LIFELINE SECTORS

		Electric & Water	Power Distribution	Combined		
		WEB	ELMAR	Estimate	Matrix	Ratio
	SAM Sect	76.1	67.6	143.7		
INDUSTRY	1	17.0	3.8	20.8	20.5	101%
OIL REFINERY	2					
UTILITIES	3		7.8	7.8	2.1	380%
CONSTRUCTION	4					
COMMERCE	5					
HORECA	6					
SERVICES	7					
LOW SKILL	8	10.8	5.5	16.3	36.3	45%
MIDDLE SKILL	9					
HIGH SKILL	10					
DEPRECIATION	11		4.4	4.4	18.1	24%
SURPLUS	12		11.2	11.2	24.2	46%
	13					
POOR HOUSEHOLDS	14					
RICH HOUSEHOLDS	15					
FIRMS	16					
GOVERNMENT	17		34.9	34.9	-64.1	-54%
HOUSEHOLD CAPITAL	18					
FIRMS CAPITAL	19					
GOVERNMENT CAPITAL	20					
TOURISM	21					
OVERSEAS TRADE	22	48.3		48.3	116.4	41%
OVERSEAS PAYMENTS	23					
TOTAL EXPENDITURES	24			143.7	153.6	94%

TABLE 6. ARUBA 1990 APPROXIMATE SOCIAL ACCOUNTS

		PRODUCTION							FACTORS						DOMESTC			CAPITAL				OVERSEAS				
	CODE	IND	OIL	UTIL	CON	COM	HOR	SERV	LOW	MID	HIGH	DEP	SURP		POOR	RICH	FIRM	GOVT	HCAP	FCAP	GCAP	TOUR	TRADE	BOP	TOTAL	TARGET
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
INDUSTRY	1.0	18.6		7.1	31.0	1.9	6.3	26.6							71.8	177.6		8.7		37.2	18.3	5.5	27.1		437.8	437.8
OIL REFINERY	2.0																									
UTILITIES	3.0	2.9		7.8		2.9	42.3	6.1							27.2	50.7		2.2							142.1	142.1
CONSTRUCTION	4.0	8.9		0.1	0.3	11.3	0.3	23.6							1.2	12.3		2.6	37.1	178.1	11.0				286.7	286.6
COMMERCE	5.0	30.6		3.7	15.4	0.2	3.8	14.4							120.0	305.5		4.0		3.4	2.1	35.3	214.0		752.4	752.3
HORECA	6.0	0.3		0.3	0.9	0.6	0.7	35.6							32.1	60.5				122.2		521.0			774.3	773.9
SERVICES	7.0	25.0		9.6	22.3	20.8	79.9	59.2							52.5	171.7		89.5			3.6	63.3	175.1		772.5	772.0
LOW SKILL	8.0	5.2		2.8	37.6	23.8	45.7	25.0								2.6		12.8				0.9			156.3	156.2
MIDDLE SKILL	9.0	3.6		4.9	36.4	31.5	46.0	42.1										49.0				0.3			213.8	213.6
HIGH SKILL	10.0	2.5		7.1	25.7	17.5	22.4	83.6										104.2							263.0	262.8
DEPRECIATION	11.0	11.5		4.4	7.1	4.7	59.1	52.7										0.9							140.4	140.3
SURPLUS	12.0	60.5		11.2	10.2	134.6	230.2	337.7																	784.4	783.8
	13.0																									
POOR HOUSEHOLDS	14.0								98.1	58.9	11.8		127.2					17.9						0.2	314.0	314.1
RICH HOUSEHOLDS	15.0								39.2	124.6	211.0		535.3					36.1						1.3	947.4	947.8
FIRMS	16.0											140.3	121.2												261.6	261.7
GOVERNMENT	17.0	38.0		34.9	4.7	19.6	37.2	4.5	18.9	30.1	40.0				1.0	32.7	57.5								319.2	318.9
HOUSEHOLD CAPITAL	18.0														-5.4	76.1									70.7	70.7
FIRMS CAPITAL	19.0																204.2							219.0	423.2	423.4
GOVERNMENT CAPITAL	20.0																	-23.0						58.0	35.0	35.0
TOURISM	21.0														13.9	58.2								626.1	698.1	698.4
OVERSEAS TRADE	22.0	230.1		48.3	94.8	482.9	200.0	61.0																	1117.0	1117.7
OVERSEAS PAYMENTS	23.0																	14.0	33.6	82.4		72.1	701.5		903.7	904.6
TOTAL EXPENDITURES	24.0	437.8		142.1	286.6	752.3	773.9	771.9	156.2	213.6	262.8	140.3	783.8		314.1	947.8	261.7	318.9	70.7	423.4	35.0	698.4	1117.7	904.6	9813.5	9813.5
Amounts: Afl million 1979	Jobs	738		460	4382	4673	5950	6617										4400							27220	

FINAL CONSOLIDATED ACCOUNTS	Prod	Fact	Priv	Gov	Priv	Gov	Exp	Inflow	Rows
Production			1083	107	378	35	1041		2644
Factors	1387			167					1554
Private Current Account		1468		54					1522
Government Current Account	139	89	91						319
Privite Capital Account			275					220	495
Government Capital Account				-23				58	35
Imports	1117		72					626	1815
OutFlows				14	116		774		904
Expenditures	2643	1557	1521	319	494	35	1815	905	9288
Income	2644	1554	1522	319	495	35	1815	904	9288

MATCH	Prod	Fact	Priv	Gov	Priv	Gov	Exp	Inflow	Rows
Production			100%	100%	100%	100%	100%		100%
Factors	100%			100%					100%
Priv Cur		100%		100%					100%
Gov Cur	100%	100%	100%						100%
Priv Cap			100%					101%	100%
Gov Cap				100%				100%	100%
Imports	100%		100%					100%	100%
OutFlows				100%	100%		100%		100%
Cols	100%	100%	100%	100%	100%	100%	100%	100%	100%
Rows	100%	100%	100%	100%	100%	100%	100%	100%	100%