REGIONAL INFORMATION DESIGN FOR PUBLIC DECISIONS*

BY WERNER Z. HIRSCH

University of California, Los Angeles

Regional information designs are tools for decision makers at subnational levels; their principal purpose is to improve the dialogue between the decision maker and the analyst as a means of improving the quality of policy decisions. This paper first examines key characteristics of regional accounts and regional information systems of relevance primarily at the state or province level. Then the nature and scope of regional decisions are reviewed with a view of delineating the problems encountered in developing systematic regional information to help make those decisions. Both policy and program decisions are considered in terms of scanning the horizon for potential opportunities and problems and of identifying preferred solutions to the problems. Finally, one regional information design is sketched out which classifies in an orderly fashion the environmental and program information useful in regional decision making.

INTRODUCTION

Concern with improving regional (subnational) decision making has been on the increase all over the world. Regional economists started some years ago to examine the possibility of developing regional accounts and other relevant regional information systems to aid decision makers. The Committee on Regional Accounts, which I chair, was established in 1959. This Committee has held a number of conferences resulting in the publication of three volumes—*Design of Regional Accounts*, *Elements of Regional Accounts*, and *Regional Accounts for Policy Decisions*. Recently the Committee's emphasis has shifted to regional information systems and designs; a regional information design will be presented in a fourth volume, *Selecting Regional Information for Government Planning and Decision Making* by the author and Sidney Sonenblum, to be published by Praeger later this year.

REGIONAL ACCOUNTS VERSUS REGIONAL INFORMATION SYSTEMS

Regional accounts and regional information systems do not have an existence or significance of their own—their significance depends on their usefulness. Both accounts and information systems must be placed in a useful framework to provide decision makers with the information they need to help them understand and solve significant policy problems. Just as it would be pointless to make up a set of accounts for a private firm without knowing its objectives in advance (what the firm seeks to maximize), accounts analysis in the public sphere requires agreed upon objectives and policy issues.

Central governments are concerned with one all-important parameter—income (and indirectly employment). Thus, national accounts can be built to

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focus on income policy. National income and product accounts can provide a powerful framework to analyze interdependence and interaction of producers, consumers, and government in the economy as well as in imports and exports. They cover much of the information that facilitates short-run projections of national economic activity.

If there were a single regional policy issue, we could carefully specify it, then design a generalized regional accounts structure, and finally perfect details for an accounting framework. However, as we know all too well, subnational policy issues are numerous, particularly those on which subnational governments have a major influence. As a result, it appears impossible to design a single, all-purpose set of regional accounts.

Regional accounts conform with accounting identities and algebraic formulations that guarantee consistency among the variables in the account—supplies equal demands, debits equal credits, inputs equal outputs, sectoral expenditures sum to total expenditures, etc.

Regional information systems, however, are not constrained by accounting rules and incorporate, in an organized fashion, information that is considered relevant to analyses of public and private activities at the regional level. Because of their added constraint it would be logical to assume that regional accounts should be designed after progress had been made in designing a regional information system. Since the reverse has happened, it is worth asking why.

The availability of national accounts, designed for specific purposes, made it easy for analysts to assume that these same purposes were also applicable at the regional level, and that the same kinds of analyses necessary at the national level would also be useful at the regional level. If these assumptions were correct the regional account building problem would be to assign appropriate regional subscripts to the data in national accounts, while taking particular care to elaborate on the trading and income transfer relations between the region and the rest of the world. This would involve elaborate and highly technical discussions as to the region in which to "account for" such activities as the post office or retained earnings of nationally owned business enterprises.

Two regional accounts are shown in an appendix to this paper. One is an ingeniously constructed set of income and product accounts developed by Charles Leven, which corresponds almost exactly with the accounting rules established for the national income and product accounts.[1] The second is a regional input-output account developed by Floyd Harmston and Richard Lund which also follows the accounting rules used in the design of national input-output tables and which makes appropriate allowance for the fact that many important transactions take place between regions as well as within a region.[2]

If these kinds of accounts were built for all regions in the nation in a consistent fashion, they would be a powerful addition to the analysis of nationwide issues even if their relevance for regional issues is in doubt.

[1]Charles L. Leven, "Regional Income and Product Account," in *Design of Regional Accounts*, Werner Hochwald, ed. (Baltimore: Johns Hopkins Press, 1961) pp. 148–195.

[2]Floyd K. Harmston and Richard E. Lund, *Application of an Input-Output Framework to a Community Economic System* (Columbia, Missouri: University of Missouri Press, 1967) pp. 24–26.

However, Richard and Nancy Ruggles argue that there is little rationale for building up national accounts at the regional level.[3] Instead, they suggest that pieces of the national income and product accounts would be useful on a regional basis. An example is expenditure breakdown—specifically, consumer expenditures on a regional basis. Regional per capita expenditure comparisons yield insight into welfare levels and changes in consumption over time and would be an indicator of regional progress. Regional consumer expenditure information also helps firms who are contemplating the establishment of retail outlets or production facilities for goods consumed locally.

Gross capital expenditures by region shed light on regional growth and changes in productivity. Also useful are data on imports and exports at the regional level. Finally, there is an interest in evaluating the impact government expenditure on goods and services has upon particular regions. Clearly, serious data problems exist in relation to such regional information.

Analysis and projection of regional activity levels, because of the openness of the regional economy, are often facilitated by industry and geographic detail within a regional input-output framework.

An input-output account presents information on purchases of industries from each other and thus shows what items of input are required for any given industry to operate, and how the outputs of this industry are distributed among other industries and final users. Thus, given a final bill of goods and a set of "structural" coefficients that link the different intermediate and primary inputs to each other, we can calculate the total amount of various inputs needed for the production of the final bill of goods. A regional input-output table adds a regional dimension. It provides an ingenious device for gathering and organizing regional economic information and facilitates detailed studies of individual industries in a region. For example, there is much interest in estimating the impact of changes in national defense purchases upon regional industries. Also, preparation of regional economic development plans calls for estimated future requirements for such inputs as power, steel, water, and labor.

In recent years some subnational governmental jurisdictions have produced regional input-output accounts, mainly useful for regional impact analysis.[4] But so far little systematic production of regional input-output accounts on a centralized basis has been undertaken.

As experimentation with regional accounts continued many of the accounting problems were resolved. Yet, it became increasingly disturbing that the accounts seemed to have relatively little application at the regional level. At this point some analysts began to ask questions about what kind of regional information is needed for what analytical and policy purposes. That is, they turned to the

[3]Richard Ruggles and Nancy D. Ruggles, "Regional Breakdowns of National Economic Accounts," in *Design of Regional Accounts*, Werner Hochwald, ed. (Baltimore: Johns Hopkins Press, 1961) p. 132.

[4]Roland Artle, *The Structure of the Stockholm Economy* (Ithaca, New York: Cornell University Press, 1965); Werner Hochwald, *et al.*, *Local Impact of Foreign Trade* (Washington, D.C.: National Planning Association, 1960); William H. Miernick, *et al.*, *Impact of the Space Program on a Local Economy* (Morgantown, West Virginia: West Virginia University Library, 1967); Floyd K. Harmston and Richard E. Lund, *Application of an Input-Output Framework to a Community Economic System* (Columbia: University of Missouri Press, 1967); Werner Z. Hirsch, "Inter-industry Relations of a Metropolitan Area," *The Review of Economics and Statistics*, November 1959.

design of regional information systems, with specific regional accounts, perhaps, being one element in the information system.

Determination of what is included in an appropriate regional information system requires clear specification of relevant regional policy issues and relevant regional policy variables. For different governments, different variables are policy variables. For example, a state or local government can do relatively little about raising regional income levels when the national government has all the important fiscal and monetary tools at its disposal. Instead, many state and local decisions are programmatic in nature, involving the efficient and equitable distribution of public services and financing burdens.

Regional economists' efforts to design and build regional information systems are of recent vintage. The more modest efforts have been on regional information for specific, limited decisions; the more ambitious efforts have been concerned with the development of comprehensive regional information systems to facilitate making decisions in a wide range of regional policy issues.

For example, a limited regional information system has been presented in relation to primary and secondary education under fiscal federalism.[5] This limited information system has a number of components, one of which is a benefit-burden statement. This statement presents benefits from, and burdens of, primary and secondary education, and distinguishes those upon whom the benefits and burdens fall. Another component is a program budget which organizes the input into the educational process by specific end-product activities. Also included is an administrative budget. In addition to these three components are three accounts of quite general applicability: a regional input-output account, a human resources account, and a non-human resources account. The regional input-output account is an economic activity account which identifies public education as a separate sector of the economy. In the human resources account, the stock of human resources is increased by the benefits of educational activities and decreased by the resource cost burdens of those activities. The impact educational activities have on this account serves as a basis for evaluating a community's effort and ability to provide additional or improved services.

Implementation of this limited regional information system depends on such analytical tools as the education production function (which helps us link educational activity with educational benefits), and benefit-cost analyses (which help us evaluate the relative efficiencies of different end-product activities).

Alternatives to even a limited information system can be visualized. Case book studies in depth showing how regional decisions have been made in the past could guide decision makers. Such case book studies could offer more than data: they could indicate relevant analytic techniques, projection methods and even time series data that had been projected into the future.

The approach adopted in the next sections of this paper sacrifices the detail and depth of specific case studies in favor of comparability and possibly broader coverage in a generalized information design. Even if there were good relevant case studies, generalized information would have certain advantages.

[5]Werner Z. Hirsch, "Regional Accounts for Public School Decisions," in *Regional Accounts for Policy Decisions*, Werner Z. Hirsch, ed. (Baltimore, Maryland: The Johns Hopkins Press, 1966) pp. 39–72.

Nature of Regional Decisions

Under political and fiscal federalism, subnational governments have many responsibilities, including planning to meet social objectives and providing public services to meet the objectives. In this paper we are concerned mainly with decisions on the state or province level. In order to achieve their long run economic potential, state and provincial governments are concerned about such things as wise investments in human and physical capital, ways to improve productivity and competitiveness for private industry in the region, expenditures and tax policies, and regulation laws and other laws designed to offer the private sector a healthy environment for growth. In a sense these are macroeconomic decisions related to economic development. But microeconomic decisions must also be made; these decisions are mainly programmatic in nature (for example, to produce and distribute water efficiently and equitably). Clearly, programmatic decisions and overall economic development decisions are closely linked.

But we can also look at the nature of regional decisions from a slightly different vantage point. Decision makers must scan the horizon to improve their view of what the future is likely to be so their actions, and the processes they set in motion by their actions, are not incompatible with events that may be beyond their control. Hopefully, this allows them sufficient lead time to react purposively to events that are likely to occur. More importantly, they might be able to take actions that will generate lines of development not otherwise possible. In this way decision makers can create a future that is closer to the aspirations and objectives of their region—and sometimes even encourage changes in the aspirations and objectives by determining the feasibility of objectives, changing past trends, establishing new machinery for achieving objectives and even defining new objectives.

To assist decision makers in horizon scanning, information available to them should not only depict alternative futures but should also highlight potential areas of concern. From the economist's perspective, areas of concern arise when resources are underutilized, are insufficient to achieve objectives, or are allocated in ways inconsistent with objectives. Areas of concern relate both to microeconomic program issues usually involving near future resource imbalances and to macroeconomic policy issues, usually related to more distant future goal setting and priority decisions. Resource imbalances are likely to result from scarcities, affluence, and new technology. But because all segments of the region will not be equally affected by imbalances, information is needed about the target groups likely to be affected, such as age groups, geographic areas, special types of economic activities, and groups with special socioeconomic handicaps.

Once a region's goals, opportunities, problems, and possible solutions for the problems have been identified, the relative merits of alternative solutions to the problems must be analyzed. Programs and policies must be evaluated in an effort to select preferred solutions to the problems that are consistent with the goals of the region and the opportunities available to it.

Like horizon scanning, preferred solutions are needed for problems related to both program and policy issues. Program problems tend to involve microeconomic concerns related to the achievement of specific kinds of social, political,

technological and economic objectives; policy problems tend to involve macroeconomic concerns and are related to the adequate performance of the economic and political system on an overall basis.

Selection among competing programs and subprograms is the primary means by which regional decision makers allocate scarce resources under their control; it is also the primary way they influence the development of their region. An important analytical tool for preferred solution selections is a benefit-cost analysis within a program budgeting framework.

What implications do these kinds of regional decisions have for a regional information design? They give an indication of which regional issues should be elucidated and which decision rules should be applied to arrive at relevant decisions.

Two broadly defined decision rules emerge. In selecting a preferred solution, the economic efficiency rule is maximization of net social benefits, as long as the solution is politically consistent with the decision maker's survival. Political survival relates to the distribution of net benefits among different power groups. Because of great uncertainties, the economic efficiency rule can seldom be applied to scanning the horizon. Here the decision rule is to look for large discrepancies or imbalances in the future environment.

A Comprehensive Regional Information Design

A regional information design is an orderly classification of information designed to facilitate decision making about regions in accordance with specified decision rules. The design presented in this paper is based on decision rules that relate to a horizon scanning process for uncovering probable future problems and opportunities, and to a preferred solution selection process for determining which among many alternative possible actions should be implemented. Each of these processes is concerned with problems pertaining to state governments, although they may also be germane to local and regional governments.

The regional information design is built around a distinction between macroeconomic—or policy—concerns (economic development decisions) versus microeconomic—or program—concerns (specific program decisions). Environmental information is used mainly for analyses of economic development, and program information for the evaluation of programs and subprograms.

A comprehensive regional information system should help make a variety of regional decisions and have three components—a policy oriented information design, data banks, and analytic models. This paper concentrates on the first component, a policy oriented information design. The following specialized terminology is used:

Data is the term used to denote any or all facts or estimates, expressed in letters or other symbols, that refer to or describe an object, idea, condition, or situation.

A *variable* is a specified kind of data. We distinguish between *final variables* (or determinants or indicators) and *determining variables*. The first are mainly of concern to the policy maker and the second to the analyst. Final variables relate to those parts of the environment that the decision maker observes for horizon scanning or preferred solution selection. A final variable can be an analytical output, such as an imputed cost measure; an observed characteristic of the

environment, such as the population of a given area; or a behavioral or statistical relationship between several variables. Determining variables are those characteristics in the environment that must be identified so a measure of the final variable can be derived.

A variable is defined so it has no specific content except that it characterizes some part of the environment; it becomes a datum when it is specified in certain dimensions. Important *dimensions* are space, time, and unit. Specifically, we must know the geographic area to which the variable applies, the time to which it relates, and the unit of measurement. A further dimension can be control, that is, the extent to which various kinds of decision makers have sufficient leverage and knowledge to change the pace or direction of the variable.

Past, present, and future *statistics* are needed for regional decision making. Historical statistics are particularly important for the identification of new problems and goals. They give a bench mark against which the decision maker can evaluate his judgment. Current statistics enable him to identify differences between the present, past, and expected future environments. Finally, statistics about the future are crucial both for the consideration of new policies and for program formulation.

Let us turn to the questions, Who makes decisions? Who needs information? and Who uses the information design? The most significant public decisions are made on the executive and departmental levels with considerable overlap of information requirements between the two. Usually, however, on the departmental (or program) level, more detailed information is needed than on the executive level; in turn, more comparative information for a variety of programs is required on the executive level. The regional information design in this paper is more suited to the needs of the executive than to those of the program head.

Furthermore, the main purpose of the information design presented here is to improve the dialogue between the decision maker and the analyst. This dialogue tends to be complex and often starts with the decision maker seeking a clear definition of a specific problem along with its key components. The analyst with the aid of the regional information design seeks to produce a clear statement of possible problems and potential solutions; ensuing dialogues probably expose important new dimensions of the problem. By producing further information in relation to these new dimensions, the analyst produces helpful background for the decision maker to arrive at a judicious decision.

In the information design, information is arranged so it will flow in an orderly way between its sources and its users, with four basic objectives in mind:

- To identify decision areas, decision criteria, and decision rules.
- To specify information requirements.
- To identify when to refer to a data bank for detailed information, and use such data for models and analytical techniques.
- To allow those who are engaged in the decision making process to retrieve information easily and put it to use.

The information is structured in five General Environment Accounts and a Public Services Account, which includes specific program accounts. The General Environment Accounts given in summary form in Table I, are: Population,

TABLE I

SUMMARY OF THE GENERAL ENVIRONMENT ACCOUNTS

(Accounts 1 to 5)

Account 1. *Population and Human Resources*

1 : 1 Characteristics of Total Population
- 1 : 1.1 Number of people
- 1 : 1.2 Sources of change in population
- 1 : 1.3 Household characteristics
- 1 : 1.4 Budgetary characteristics
- 1 : 1.5 Income characteristics
- 1 : 1.6 Place of residence characteristics

1 : 2 Work Force Characteristics
- 1 : 2.1 Employees
- 1 : 2.2 Labor force
- 1 : 2.3 Unemployment
- 1 : 2.4 Job vacancies
- 1 : 2.5 Labor participation
- 1 : 2.6 Work week
- 1 : 2.7 Labor attitudes
- 1 : 2.8 Labor commuting

Account 2. *Wealth and Investment*

2 : 1 Physical Resource Stocks
- 2 : 1.1 Private plant
- 2 : 1.2 Private equipment
- 2 : 1.3 Public plant and equipment

2 : 2 Natural Resources
- 2 : 2.1 Private
- 2 : 2.2 Public
- 2 : 2.3 Undeveloped land

2 : 3 Investment
- 2 : 3.1 Private
- 2 : 3.2 Public
- 2 : 3.3 Semipublic
- 2 : 3.4 Reasons for investment

2 : 4 Financial Wealth

Account 3. *Attitudes*

3 : 1 Private Sector Aspirations
3 : 2 Private Sector Evaluation of Performance
3 : 3 Public Sector Aspirations
3 : 4 Attitudes Towards Financing Public Programs
3 : 5 Attitudes of Community Leaders

Account 4. *Public Revenues and Expenditures*

4 : 1 Sources of Funds
4 : 2 Current Expenditures
4 : 3 Capital Expenditures
4 : 4 Financial Information
4 : 5 Federal Budget

Account 5. *Economic Activity*

5 : 1 Industry Indicators
- 5 : 1.1 Output
- 5 : 1.2 Distribution of output
- 5 : 1.3 Factor purchases
- 5 : 1.4 Purchases from outside the region
- 5 : 1.5 Industrial organization

5 : 2 Areawide Indicators
- 5 : 2.1 Net output produced
- 5 : 2.2 Income produced
- 5 : 2.3 Productivity

Assets, Attitudes, Public Revenues and Expenditures, and Economic Activity. The Public Services Account includes information directly related to each specific program: it is also given in summary form in a Generalized Public Services Account in Table II.

These accounts could be viewed from a somewhat different perspective; the Population Account is a human resources account; the Assets Account is a wealth, or nonhuman, resources account; the Attitudes Account is an aspirations

TABLE II
SUMMARY OF THE GENERALIZED PUBLIC SERVICES ACCOUNT
(Account 6)

- 6 : 1 Selected Population Characteristics
  - 6 : 1.1 Characteristics of actual and potential users in population
    - 6 : 1.11 Total number of people
    - 6 : 1.12 Migration
    - 6 : 1.13 Household characteristics
    - 6 : 1.14 Selected program-related expenditures
    - 6 : 1.15 Income characteristics
    - 6 : 1.16 Leisure characteristics
    - 6 : 1.17 Density characteristics
    - 6 : 1.18 Specialized program services required
  - 6 : 1.2 Characteristics of employees
    - 6 : 1.21 Employees by subprogram
    - 6 : 1.22 Employee characteristics in public programs
    - 6 : 1.23 Employees in counterpart private programs
    - 6 : 1.24 Volunteer workers and consultants
    - 6 : 1.25 Unemployed in program occupations
- 6 : 2 Assets
  - 6 : 2.1 Physical resources
    - 6 : 2.11 Public program systems
    - 6 : 2.12 Comparable systems in private sector
    - 6 : 2.13 Related (complementary) systems
    - 6 : 2.14 By-product (secondary outputs of program systems)
  - 6 : 2.2 Natural resources
    - 6 : 2.21 Water
    - 6 : 2.22 Forests
    - 6 : 2.23 Land
    - 6 : 2.24 Air
- 6 : 3 Policies and Attitudes
  - 6 : 3.1 Actual and potential user constraints and attitudes
  - 6 : 3.2 Producer attitudes
  - 6 : 3.3 Legal controls
- 6 : 4 Program Revenues and Expenditures
  - 6 : 4.1 Sources of funds
  - 6 : 4.2 Direct current expenditures
  - 6 : 4.3 Direct capital expenditures
  - 6 : 4.4 Financing information
- 6 : 5 Characteristics of Service
  - 6 : 5.1 To final consumers (households, business, government) and subprograms
  - 6 : 5.2 To distribution channels
  - 6 : 5.3 Competing private goods and services
  - 6 : 5.4 Imputed and indirect benefits and costs
    - 6 : 5.41 Indirect employment and income created
    - 6 : 5.42 Imputed benefits
    - 6 : 5.43 Imputed costs
    - 6 : 5.44 Indirect (complementary or related) customer expenditures

or goals account; the Public Revenues and Expenditures Account is a public finance account; the Economic Activity Account is a goods and services transactions account; and the Public Services Account is a program account.

Several guidelines were used in specifying the structure and content of the accounts. Information about specific programs (as found in the Public Services Account) must include data about the objectives, needs, costs (resource and financial), and consequences (program-specific as well as spillover) of each program. Program information must also be related to measures found in the Environment Accounts; aggregate measures describe the overall welfare of the region. The aggregate indicators about a region are useful not only to compare with program information but also because their trends should be monitored for an evaluation of economic performance, which often represents the targets for policy.

State and regional performance is evaluated not only in the context of the pace of improvement over time and the gap between performance and objective but in relation to the performance by other areas. Therefore, the Environment Accounts should include performance indicators for areas other than the region under study and, most importantly, indicators for the nation as a whole. Finally, the performance indicators for other areas often serve as impact indicators because changes in these areas will have consequences for the region under study. Therefore an assessment of such changes is needed to determine the appropriate regional response to factors beyond its control and to project the region's future.

Another question comes to mind: Since state decisions ultimately relate to specific programs, why are general environment accounts necessary? The answer is that the decision maker cannot properly evaluate the program account information without relating it to the general environment. This is another way of saying that the decision maker cannot simply accept the analyst's conclusions, even when they are sets of conclusions under alternative assumptions, but must relate them to a broader picture. The broader view facilitates the decision maker-analyst dialogue.

It should also be noted that the program accounts are to a large extent a selection of more detailed information about items found in the general environment accounts. For example, the users of a public service represent some specific part of the population; the personnel in the public program represent some specific part of human resources; the costs of a public program represent some part of the total public expenditures; the indirect expenditures attached to public services use represent some part of the general goods and services transactions.

There are several operational implications to this structuring of the system. The general environment variables can be at fairly high levels of aggregation and relate to information requirements common to all programs. The program environment variables are presented in more detail and are specific to each program.

Conclusion

Economists only recently have turned to the study and building of regional accounts and regional information systems. While we can learn from our experience in building national accounts, we must be aware that national and

regional policy making are very different. Regionalizing national accounts is not the answer. Designing accounts and information sytems to facilitate and improve regional decision making will require much further theoretical and empirical work.

Appendix

Charles Leven has offered the following mathematical specifications for a set of key regional income and product accounts.[6]

Consolidated Income and Product Account:

$$(1) \qquad V_C + V_I + V_e = C + I + e - (m_C{}^1 + m_C{}^2) - (m_I{}^1 + m_I{}^2) - m_e$$

Consumption Account:

$$(2) \qquad V_C = C - (m_C{}^1 + m_C{}^2)$$

Investment Account:

$$(3) \qquad V_I = I - (m_I{}^1 + m_I{}^2)$$

Rest of the World Account:

$$(4) \qquad V_e + (F_{zx} - F_{xz}) + (T_{zx} - T_{xz}) + (U_{zx} - U_{xz}) - (m_C{}^1 + m_C{}^2) - (m_I{}^1 + m_I{}^2) = r_{zx}$$

Savings and Investment Account:

$$(5) \qquad I = (W_x - B_{xx}) + (Y_R - C) + G_I - r_{zx} + d_x$$

where,

V = value added in production
C = consumption expenditure
I = gross private domestic investment
F_{xz} = factor payments from region x to z, The Rest of the World
T_{xz} = tax payments from region x to z, The Rest of the World
U_{xz} = unilateral payments from region x to z, The Rest of the World
W_x = undistributed profits of corporations headquartered in region x
B_{xx} = business transfer payments from area enterprises to area residents
Y = gross national product
G = government purchases of goods and services
e = exports
m = imports
r = net investment in The Rest of the World
d = capital consumption allowances and statistical discrepancy
superscript 1 = goods in final form
superscript 2 = intermediate goods

Harmston and Lund offer the following specifications for a regional input-output model. An industry is defined as a grouping of microunits, reasonably similar in input and trading characteristics. For any industry, say the ith industry, total output over a particular time period, e.g., one year, equals the sum of its

[6]Charles L. Leven, *op. cit.*, pp. 148–195.

outputs going to each industry in the region plus the output going to markets outside the region. That is, if there are n regional industries,[7]

$$O_i = \sum_1^n o_{ij} + e_i, \qquad i, j = 1, 2, \ldots, n \tag{6}$$

where,

O_i = total output for the ith industry
o_{ij} = output by ith industry going to jth industry (endogenous transactions)
e_i = output traded outside the region (exogenous transactions)

In making the assumption of constant input coefficients, i.e., that input from the ith industry to the jth industry is a linear homogenous function of total output by the ith industry for all values of output to be confronted in usage of the model,

$$a_{ij} = \frac{o_{ij}}{O_j} = \text{ constant value} \tag{7}$$

and upon substitution into equation (6),

$$O_i = \sum_1^n a_{ij} O_j + e_i, \qquad j = 1, 2, \ldots, n \tag{8}$$

This relationship may also be written,

$$e_i = O_i - \sum a_{ij} O_j \tag{9}$$

and in matrix notation this becomes,

$$e = O - AO \tag{10}$$

$$e = [I - A]O \tag{11}$$

where $e = \text{col } (o_1, o_2, \ldots, o_n)$

$$O = \text{col } (O_1, O_2, \ldots, O_n) \tag{12}$$

$$A = [a_{ij}]n \times n \tag{13}$$

and I is an $n \times n$ identity matrix.

On the assumption that $(I - A)$ has an inverse,

$$O = [I - A]^{-1} e \tag{14}$$

Each element in the inverse matrix $[I - A]^{-1}$, denotes the amount of output from the ith industry used both directly and indirectly per unit of output traded by the jth industry outside the region.

[7]Floyd K. Harmston and Richard E. Lund, *op. cit.*, pp. 24–26.