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16. Abstract (Limit: 200 words)

This report describes the first two phases of a project to develop a Social Accounting Matrix (SAM) modeling system as a tool for assessing the economic damage arising from natural disasters and for helping to devise recovery strategies. The resulting system may be used to design proactive strategies for regions known to be vulnerable to specific natural disasters (such as earthquakes and hurricanes), as well as to assess damage and aid recovery in localities which have suffered an unanticipated disaster. This report describes the methods used to construct and test the SAM, based on work in a small Caribbean island. This study shows that a suitable SAM model which takes account of the destructive effects of a disaster can be constructed rather rapidly, and that this model can reproduce the events of an economic disaster and recovery for employment and income over an extended period. Special attention has been paid to the lifeline sectors. More detailed versions of the model to account for the differential impacts across social groups by occupation, education, geography and demography among the affected regions population are also described.

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NATIONAL CENTER FOR EARTHQUAKE ENGINEERING RESEARCH

State University of New York at Buffalo

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by

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NOTICE

Social Accounting for Disaster Preparedness and Recovery Planning

by

S. Cole[1], E. Pantoja[2] and V. Razak[3]

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Technical Report NCEER-93-0002

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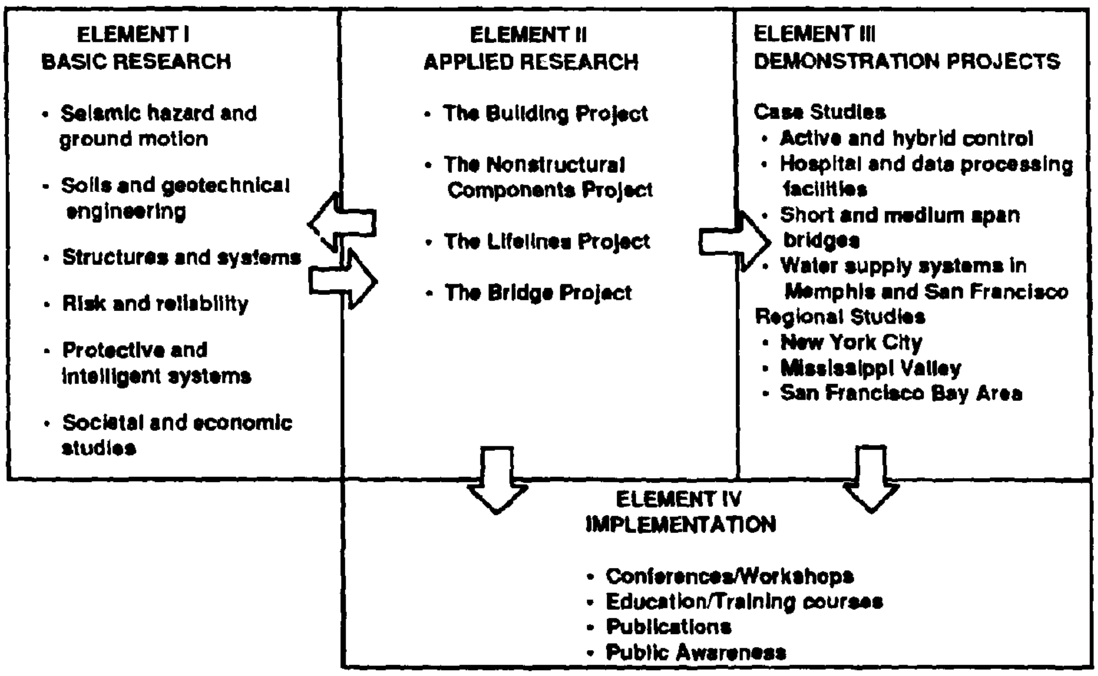
PREFACE

The National Center for Earthquake Engineering Research (NCEER) was established to expand and disseminate knowledge about earthquakes, improve earthquake-resistant design, and implement seismic hazard mitigation procedures to minimize loss of lives and property. The emphasis is on structures in the eastern and central United States and lifelines throughout the country that are found in zones of low, moderate, and high seismicity.

NCEER's research and implementation plan in years six through ten (1991-1996) comprises four interlocked elements, as shown in the figure below. Element I, Basic Research, is carried out to support projects in the Applied Research area. Element II, Applied Research, is the major focus of work for years six through ten. Element III, Demonstration Projects, have been planned to support Applied Research projects, and will be either case studies or regional studies. Element IV, Implementation, will result from activity in the four Applied Research projects, and from Demonstration Projects.



Research in the **Building Project** focuses on the evaluation and retrofit of buildings in regions of moderate seismicity. Emphasis is on lightly reinforced concrete buildings, steel semi-rigid frames, and masonry walls or infills. The research involves small- and medium-scale shake table tests and full-scale component tests at several institutions. In a parallel effort, analytical models and computer programs are being developed to aid in the prediction of the response of these buildings to various types of ground motion.

Two of the short-term products of the **Building Project** will be a monograph on the evaluation of lightly reinforced concrete buildings and a state-of-the-art report on unreinforced masonry.

The **societal and economic impact program** constitutes one of the important areas of research in the **Building Project**. The program involves identifying, quantifying, and analyzing the impacts earthquakes and other natural disasters have on the populations and socio-economic systems of impacted regions. The primary focus of this program is on the interaction between the social and economic system and the built physical environment which accommodates it. The major tasks are as follows:

1. Fundamental research concerning the built physical environment system.
2. Fundamental research concerning the social and economic system, including investigations of macro-economic impact, epidemiology of casualties, and housing reconstruction.
3. Specific research concerning the social and economic system such as the economics of non-structural component and lifeline failures, and the social consequences of lifeline failures.
4. Knowledge utilization research focused on professional and private acceptance of research results.

The overall goal of the project is to develop a Disaster Accounting System for use in localities and populations which either have recently suffered a disaster, or which are considered vulnerable to a catastrophe. In the first case, the aim would be to construct a model as speedily and efficiently as possible following the disaster. This should be done at a sufficiently early stage in the recovery process for the Social Accounting Matrix (SAM) to contribute to the earliest assessments of the disaster, and to be used in evaluating details of alternative recovery strategies. In the second case, the model would be built in anticipation of a catastrophe, and also would be used to evaluate the contribution of alternative proactive measures. For example, these might be designed to enhance the robustness of the local economy, as well as lifelines and physical infrastructure.

ABSTRACT

This report describes the first two phases of a project to develop a Social Accounting Matrix (SAM) modeling system as a tool for assessing the economic damage arising from natural disasters and for helping to devise recovery strategies. The resulting system may be used to design proactive strategies for regions known to be vulnerable to specific natural disasters (such as earthquakes and hurricanes), as well as to assess damage and aid recovery in localities which have suffered an unanticipated disaster.

In many cases, natural disasters have their most severe impacts on isolated localities and small or marginal communities, affecting all segments of its population and economy, directly or indirectly, through the loss of homes or livelihood, or through damage to lifelines such as water supply, energy or roads. Even though they take place with little warning, disasters affect places for an extended period. To address these disasters requires tools which can be quickly constructed and integrated into the recovery process, which can help to assess the economic damage caused by the disaster, and which then can be used to assist in the long-term recovery process. The overall goal of the project therefore is to use the latest modeling techniques to assemble data and build a suitably detailed impact models of the devastated area in a matter of days following the disaster.

This report describes the methods used to construct and test the SAM, based on the work in a small Caribbean island. This study shows that a suitable SAM model which takes account of the destructive effects of a disaster can be constructed rather rapidly, and that this model can reproduce the events of an economic disaster and recovery for employment and income over an extended period. Special attention has been paid to the lifeline sectors. More detailed versions of the model to account for the differential impacts across social groups by occupation, education, geography and demography among the affected regions population are also described.

ACKNOWLEDGEMENTS

Support fcr this research has come from the National Center for Earthquake Engineering Research under grants from the New York State Science and Technology Foundation and the National Science Foundation of the United States. The cooperation by several departments of the Government of Aruba is also gratefully acknowledged. The Horizon model described in the last part of the report has been developed by CENDA (The Center for Development Analysis) with support from the Scottish Development Agency. The Research Assistant for Phase One of the project was Enrique Pantoja, and for Phase Two was Victoria Razak. Full responsibility for all results rests with the Project Director. Work on this project is continuing with support from NCEER and the Center for Infrastructure Research and Development, State University of New York at Buffalo.

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SECTION 1
OVERVIEW OF PROJECT

1.1 Objective - A Disaster Accounting System

The National Center for Earthquake Engineering Research (NCEER), with funding from the National Science Foundation of the United States and the New York State Office of Science and Technology, is supporting an effort to develop Social Accounting Matrix modeling techniques as a means of assessing the economic damage arising from natural disasters and helping to devise recovery strategies. Such models could be used to design strategies for specific disaster prone regions and eventually develop into a rapid response Expert System for application in remote regions. This report describes the work carried out in the first two phases of the project.

Natural Disasters include earthquakes, cyclones, floods mud slides, and volcanoes. Because these events can take place with little warning, they can disrupt all sectors of an economy and all segments of a population for an extended period of time. Even when they are not impacted directly, people and businesses may be affected indirectly through damage to lifelines such as water supply or roads, or through the loss of livelihood or markets. In many cases, these disasters have their most severe impacts on isolated localities and small or marginal communities. For these people and places, the extreme severity of impacts can be linked to poverty and inappropriate development, and deficient recovery programs. Thus, while the main priority must be to deal with the immediate needs of the disaster (such as medical and shelter), it is also necessary to plan for an economic recovery which also provides the opportunity to improve the quality of development to reduce hardship from future disasters.

This type of planning requires tools which can be integrated into the recovery process, in order to assess the economic damage caused by the disaster, and to guide the long-term recovery process. Unfortunately, natural disasters often occur in out-of-the-way regions where ready made planning tools are not available and the expertise to develop these rapidly is limited. Moreover, because natural disasters tend to disrupt specific industries or populations, the planning tools which are available may not include the necessary details.

Social Accounting Matrices (SAMs) are a type of economic model which are already widely used for measuring the consequences of planned and unplanned economic events. In contrast to previous and more conventional input-output models, SAMs may include a wider range of sectors, and provide more details of impacts on the household and public sectors, or on special classes of economic activity, such as small businesses. They have been used for evaluating the social and economic impacts of structural change, new technologies and public policies. The value of these models has been clearly established at the national and regional level in industrial and developing countries, as well as for small communities such as islands or villages. They can also provide the basis for the assessment of disaster prevention and recovery programs. The obvious potential of the SAM approach is that it might calculate the impacts on particular social groups or economic sectors affected by disasters such as earthquakes or hurricanes. This is important because disasters generally have quite varied consequences across the affected communities.

A key challenge for the project is to provide means for "translating" the assessments of the physical damage arising from a natural phenomenon into the economic disaster to be assessed using the model. Essentially, the approach offered here is to use an Event Accounting Matrix (EAM) whose elements correspond to the entries in the SAM, allowing the direct impacts of the disaster to be mapped onto the economic model. With this system, the model could be used to design strategies for specific vulnerable natural disaster prone regions. This in turn might be developed into a full-fledged expert system for use in post-disaster economic recovery efforts, which could provide a framework for integrating the sector-specific expert systems now being developed in transport and water supply systems, and other public and private sector activities.

Expert systems are a computer aided method for making applications easier to build and apply. Essentially, the approach builds a set of guidelines into a computer program, which then may be used to guide fairly sophisticated problem solving. The expert system approach is most advanced for specific "engineering" systems such as those now being developed by NCEER in the area of transport, water supplies and other public and private sector activities. Although less developed, some progress has also been made with socio-economic planning applications, particularly in the area of environmental studies. The intention of the present project eventually is to develop the SAM into an appropriate Expert Planning System for use in post-disaster economic recovery efforts. This could eventually provide a framework for integrating the sector-specific expert systems.

The overall goal of the project is to develop a Disaster Accounting System for use in localities and populations which either have recently suffered a disaster, or which are considered vulnerable to a catastrophe. In the first case, the aim would be to construct a model as speedily and efficiently possible following the disaster. This should be done at a sufficiently early stage in the recovery process for the SAM to contribute to the earliest assessments of the disaster, and to be used in evaluating details of alternative recovery strategies. In the second case, the model would be built in anticipation of a catastrophe, and also would be used to evaluate the contribution of alternative proactive measures. These might be designed, for example, to enhance the robustness of the local economy, as well as lifelines and physical infrastructure. While this report primarily concentrates on the technical questions of model construction and testing, as far as possible this work has been carried out in conjunction with institutions concerned with disaster planning so that the most appropriate interface can be developed.

1.2 Project Strategy and Progress

The overall strategy for the project and the relationship between the basic research, applications and demonstration phases of the project are indicated in Figure 1-1.

Phase One of the project provided a sector-by-sector review of disaster related impacts, cross-linkages and prevention technologies and programs based on literature review and discussion with experts in the field of earthquake studies and expert systems. It demonstrated the possibility of adapting existing theories and impact models to deal with the particular supply- and demand-side

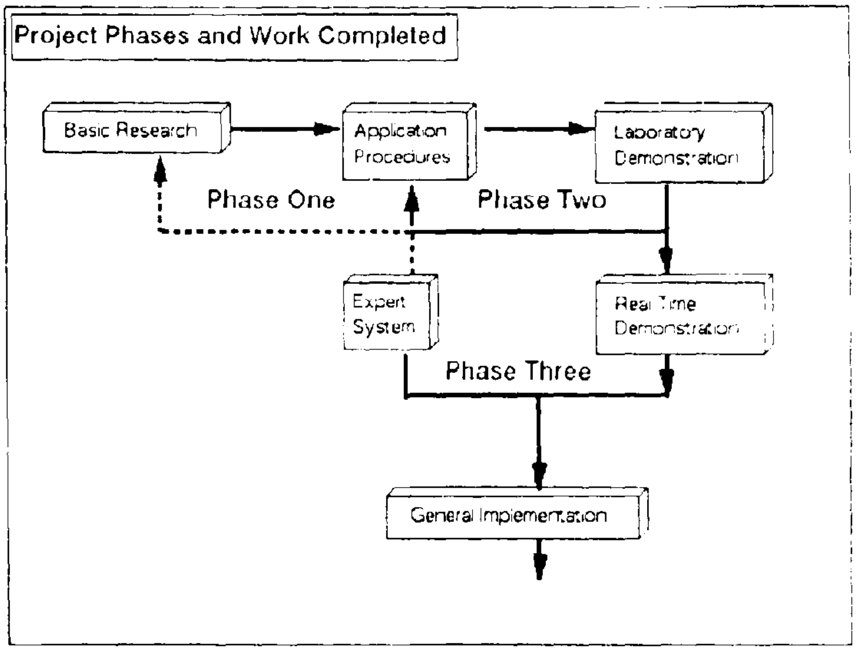


FIGURE 1-1 Project Phases and Work Completed

issues posed by natural disaster phenomena such as destruction of particular production activities, public infrastructure (transport and public utilities) or social groups unevenly affected by the disaster. The results of Phase One may be summarized as follows:

Review of Policy Variables:

> A literature review and discussion with experts in the field of earthquake studies has demonstrated that a first step in developing the impact system would be the adaptation of existing impact models to deal with the particular supply- and demand-side issues posed by natural disaster phenomena. There is extensive literature on the likelihood of disasters of particular magnitudes (in particular earthquakes, as well as volcanic eruptions and hurricanes), and of the engineering performance of individual proactive technologies, survivability, etc. There is less extensive literature on the post disaster effects and costs. Nevertheless, the available material provides important insights on the type of damage - both direct and indirect - suffered in the wake of a natural disaster such as destruction of particular production activities, public infrastructure (transport and public utilities) or social groups unevenly affected by the disaster, as well as the developmental and institutional context of disaster recovery programs.

In particular, the literature demonstrates that:

i) while there is considerable variation in the precise impact of natural disasters such as earthquakes, cyclones, floods and volcanoes, particular localities, communities and types of economic activities are especially vulnerable.

ii) the severity of impacts is often a consequence of mal-development, such as squatter settlements, farming, etc, in potentially vulnerable locations.

iii) recovery should be seen as part of an on-going development process.

iv) disaster may provide opportunity to improve the quality of development, because victims and administrations are responsive to new ideas, rebuilding is essential and funds are available.

v) the possibility of redirecting the development process in a system wide manner to promote development and reduce vulnerability to natural disasters by using "systems" principles in economic structure and organization.

vi) the institutional context of disaster recovery programs (including the technical tools it employs) must account for specific interests, cultural norms and organization of victims.

Such conclusions provide clues as to the most appropriate specification of planning instruments including SAM's if they are to useful in the recovery planning process.

Methods for SAM Construction:

The categories to be included in the SAM have been investigated in light of the above review. Ideally, the economic impact system would include all activities which might be impacted by a natural disaster, or might affect the subsequent reconstruction. These activities may be varied and detailed since the impact of a disaster and the rate of recovery are usually specific to the location and depend, for example, on the types and magnitude of the event, the associated geological factors, the composition of the local industry, public services and demography, the extent of proactive planning and the availability of recovery services, and the relationship with the external world. Since data are not available on all these issues, and because such details could lead to an overly cumbersome planning tool, it is necessary to compromise between what is desirable, and what is practical, given the information available in particular circumstances and the degree of urgency of the analysis.

The merits of different categorizations and levels of detail, and methods of SAM construction are considered. Because the construction of a social accounting matrix on the basis of complete surveys is extremely expensive and very time-consuming, it is seldom done. Rather, the most common method for constructing input-output tables for a specific locality is to transform a previously constructed national or regional table, or a table from an area with similar economic structure. This involves using available data from the locality, such as employment and household and government expenditures, to adjust the available table. Various techniques have been devised for this, including an efficient multi-proportional scaling algorithm which allow all available data to be included into the reconciliation process according to the principle of minimum information loss. This algorithm would form the heart of the eventual expert system. Because data on imports and exports into a locality are among the most critical for a proper assessment of economic impact, yet are generally the least readily available, it is necessary to devise techniques for generating them from other information.

Methods for Incorporating and Simulating Events:

Having constructed a suitable SAM for the pre-disaster economy, it is then necessary to devise methods for incorporating the direct effects of disasters into the SAM and calculate the region-wide repercussions of a disaster. This calculation involves a time-lagged solution for the Leontief matrix using a method which allows both the intensity and the time-scale for recovery of each link in the economic network represented by the SAM to be included in the calculation using the concept of the "event map." The alternative reconstruction opportunities may be mapped onto the SAM system in a similar manner. Preliminary applications of a detailed simulation of a disaster and subsequent recovery policies based on a previously constructed SAM are presented. This pilot model may be used to assess the effects of "simple" disasters and individual proactive and reactive social and technological measures, as well some more "complex" disasters and corresponding "policy packages" involving combinations of economic and institutional measures.

Expert System Requirements:

Some preliminary evaluation of the technical and interface requirements of the eventual on-site expert system for constructing post-disaster impact models will be made in light of work carried out under i) - iii) above. This discussion contrasts the possibility of applying expert system concepts in a social accounting matrix building system with those for its application. Because the matrix building system has a well-defined algorithm at its core, but requires a considerable degree of expertise (familiarity with data sources, accounting conventions, and intuition), this is a good candidate for some form of expert system approach. From a purely technical point of view, it also appears feasible to use the expert systems approach to integrate the SAM system with other sector-specific expert systems. However, there must be concerns as to how the expert system fits in with the organization of the relief operation as a whole (not least the involvement of the disaster victims themselves).

The primary purpose of Phase Two was technical - to test the proposed theoretical methods for SAM construction and use in more detail, and to test the model empirically, again using the recent experience of a small Caribbean island, Aruba.

Testing the Capability of the Model to "Track" a Disaster and Recovery Scenario:

The initial empirical tests are carried out using a modified version of a previously constructed SAM for Aruba for the year 1979 to "predict" the employment and GDP data for the Island from 1979 to 1990. These tests demonstrate that the model can reproduce the events of an economic crisis on the employment and income of the Island over this period. This is a relatively severe test for any planning model and overall suggests that the SAM may be used to evaluate the impacts of major natural disasters and the performance of recovery strategies for medium term recovery strategies.

Testing Methods for Model Construction:

The possibilities for the rapid construction of new SAM's at a national level taking into account the destructive effects of the disaster are demonstrated through the construction of a new 1990 SAM for the Island based on the "event map" and multi-proportional scaling procedures advocated in Phase I. Special attention was paid to the "lifeline" sectors - water and electricity. Given the relatively favorable situation in Aruba, the preliminary data collection and construction of the model was completed over a period of about one month.

Forecasting the Side-Effects of the Recovery Strategy:

The possibilities for using the model to evaluate the impact of reconstruction strategies is demonstrated by using the 1990 model to review the consequences of the national recovery program to date, as well as the proposed capital expenditure program of the Island Government. This review includes estimates of employment by sector, occupation and households, as well as macro-economic variables such as balance of payments. The results suggest that some of the unwelcome side-effects of the recovery strategy itself could have been avoided, had a more adequate planning instrument been used to develop the programs.

Constructing Models to Address Regional and Social Issues:

The possibility of constructing new SAM's at the local level (for example, the locality directly affected by the disaster) is demonstrated through construction of a multi-regional SAM for Aruba based on the regions identified by the Island's Disaster Preparedness Committee. In addition, versions of the model which describe the cultural division of labor among the Island population are presented. These models also provide a satisfactory match to the regional employment shifts on the Island resulting from the crisis and recovery, and suggest more appropriate development programs for the Island.

The overall approach to the construction and use of the impact model in a particular disaster situation is shown in Figure 1-2. In each of the three main stages, information is "mapped" systematically onto the basic framework of the input-output table. The first stage is the construction of the "pre-event" model of the regional economy from a variety of data, including national data. The second stage involves preparing "event maps" to represent the immediate

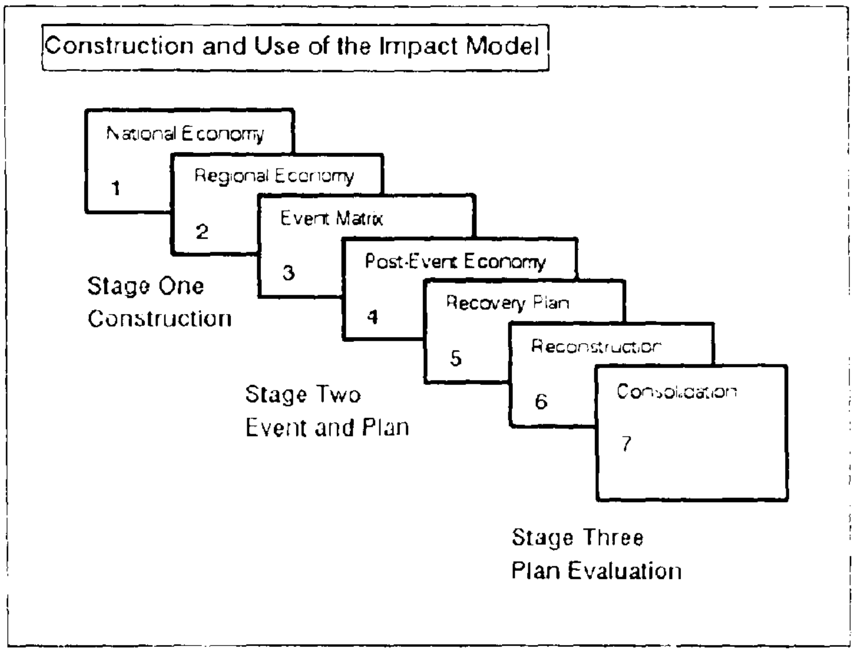


FIGURE 1-2 Construction and Use of the Impact Model

effects of the disaster, calculating its impact on all actors in the community, and preparing preliminary recovery plans. The third stage involves the adjustment of the plan in the light of the revealed short and long run impacts.

1.3 An Aid to Integrated Recovery Planning

The expert system is not intended to replace the judgments made by the disaster relief teams and organizations involved, but would provide an additional tool for evaluating and testing alternative ways for coping with the post-disaster reconstruction. The notion here is to use the latest techniques to assemble data and build a suitably precise impact model of the devastated area in a matter of days following the disaster. This would help the team and local authorities to assess the overall costs of the damage sustained, and determine the priorities for reconstruction.

The overall framework for this integration of sector-specific expert systems and the SAM impact model is indicated by Figure 1-3. This shows how the information from the sector specific damage/response expert systems would feed into the rapid-build/rapid-response macro-impact model, and how both would relate to the planning team in charge of reviewing scenarios and mapping strategies. Using the various expert systems, an "event-map" could be constructed, which would be evaluated together with the alternative recovery scenarios, and in this way, something approximating to an "optimal strategy" formulated. This would include, for example, the priority and sequencing of medical and housing and other lifeline reconstruction, as well as longer-term economic and infrastructure recovery.

1.4 Future Work

Future work on this project will continue the detailed simulation of technologies and recovery policies in typical regions or islands vulnerable to earthquakes or other natural and non-natural disasters. The aim is to systematically extend understanding of how to model the effects of individual proactive and reactive social and technological measures and to evaluate pro-active and post-disaster "policy packages" consisting of combinations of technological and institutional

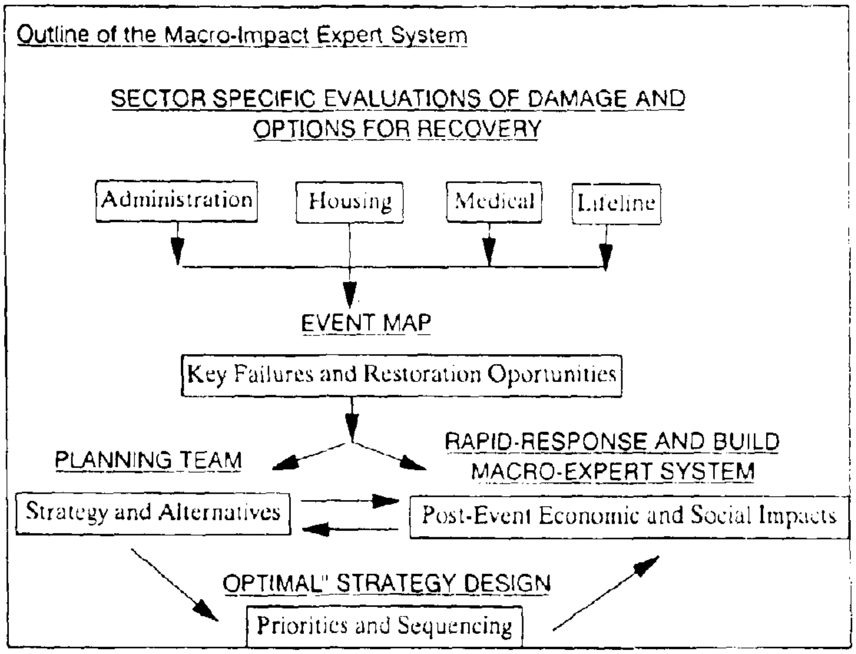


FIGURE 1-3 Outline of the Macro-Impact Expert System

measures. This should lead to the formulation of a set of "rules" for SAM construction and application which will be used in the final step, the prototype expert system. Following this, the computer programs and user interfaces would be refined for general implementation into a more readily usable system, which would then be tested on a number of pre-event representative scenarios, and customized to the needs of specific disaster preparedness agencies. Until the expert system is developed, the SAM may be used as a pro-active system for vulnerable regions. In the current stage of the work which began in November 1992, the techniques developed for small islands in the Caribbean is being incorporated with similar work in the United States. This involves theoretical, empirical and evaluative studies. The theoretical work includes devising ways for transforming physical damage to infrastructure and business activities caused by an earthquake or other natural disaster into the economic "event map" used in the model, making use of existing research in the systems and transportation sciences. The theory of the lagged input-output method used to solve the multi-regional SAM also will be extended to interface the damage functions with the economic model.

The primary goal of the empirical studies will be to show that it is possible to construct locality specific regional social account matrices for "disaster prone" localities in the continental United States using readily available information (such as Department of Commerce Surveys of Current Business, Department of Labor and the Census of Population, and the recently published 1987 United States Input Output table). Extending previous work in New York State and Western New York, in the first stage a SAM has been constructed for the economically debilitated central city neighborhoods of Buffalo. This will provide the basic procedures needed to generalize the matrix construction to two other localities in the United States, localities in Florida affected by the recent hurricane Andrew, and Memphis, Tennessee. The extreme circumstances of Florida will provide insights as how the varied and changing damage assessments during and after a natural disaster can be introduced into the model. This will help to assess the limitations and capability of the SAM approach. The study of Memphis will be coordinated with other projects supported by NCEER, as part of the effort by NCEER to focus a wide range of analysis on this region of the United States.

This work will be coordinated with the evaluative component of the project, which will make use of the models constructed during the previous phase to evaluate the cost effectiveness of a recently completed lifeline water supply system designed to prevent disruption to public utility services on the Island. This work will be carried out in cooperation with the Island's Calamity Planning Committee and the relevant public utility companies. This will also involve an elaboration of the "lifeline" sectors in the model to better represent their inter-sectorial and inter-regional character. The evaluative studies also will require a deeper and more structured review of social networking and other "insurance" strategies adopted by the different communities on the Island described in the SAM model during the period of disaster and recovery. Again, this work should augment similar efforts already underway in NCEER, and improve ways for taking account of these sociological and cultural aspects of disaster mitigation and recovery planning in economic analysis with the SAM.

1.5 Layout of this Report

The first section of this report briefly considers the requirements of a model which might usefully address some of the economic issues arising from natural disasters. The second section describes the theory of input-output analysis and social accounting and their potential contribution to disaster recovery planning. The choice of the demonstration project in Aruba and the goals for model testing are explained. The third section uses an existing model to track levels of employment and national income through a disaster and recovery scenario. The fourth section describes the construction of an updated model which is used to examine the unforeseen consequences of the recovery program. The fifth section illustrates regional, social and cultural accounting versions of the model, each designed to address more directly the consequences of natural and other disasters. The final sixth section summarizes the conclusions and uses an economic planning model to illustrate one possibility for a "user friendly" interface for the expert system model proposed in this report.

SECTION 2
DEFINING THE PROBLEM

2.1 Natural Disasters, Localities and Communities

The methods for building and applying social accounting matrices which are suggested in this report are adapted from studies of small developing countries (specifically, Caribbean island economies), and county-sized regions in industrial countries (in the United States and Scotland). The point of specifying a characteristic locality is therefore to provide a realistic challenge in terms of the empirical constraints, technical difficulty and the institutional and economic context of the exercise.

Natural disasters strike all sizes of regions and populations. Although there have been several major disasters this century where major cities (such as San Francisco) or massively populated areas (such as coastal Bangladesh, and provinces in China), the most damaged places in the majority of natural disasters are small districts and communities, often in the poorer areas of developing countries. While, in view of the variability of disasters and their impact, it is not especially useful to speak of "average" localities or "typical" impacts, this report aims to develop systems which can contribute to disaster planning in developing countries in localities with populations of, say, from ten thousand to one million, with low to middle per-capita incomes, and a geographical area of up to one thousand square miles. This reflects the locations many times affected by disaster, often sub-regions of a state or province, or small island territories, with a reasonably diverse and well-developed economic and institutional base. Often in these areas, there has been little pro-active disaster planning. This is despite the efforts of international agencies in the areas of assessing hazard risk, identifying and formulating mitigation measures, and providing information and training (e.g. OAS, 1990 Natural Hazards Project), or the work of the United Nations disaster relief operations (in particular, UNDRO, UNHCR and the World Bank), and NGO and volunteer organizations (such as Oxfam, Save the Children and CARE).

If a useful system can be developed with these poor and less developed regions in mind, then it is also likely to be applicable to similarly sized areas in more developed countries (such as individual counties in the United States). As indicated above, larger cities in industrial countries often are equipped with planning tools similar to those demonstrated in this project - such as input-output tables, or have the data and local capability to create them, and already undertake pro-active disaster planning - or have the capability to do so. Nevertheless, since many disasters have a very localized impact, the planning instruments which are available may not be sufficiently geographically targeted to be of use in the wake of a specific disaster. Therefore, here too, it may be necessary to have ways of transforming available tools match the parameters of the localized impact of a specific disaster.

2.2 Physical Damage versus Economic Disaster

Cuny (1983) categorizes disasters as "cataclysmic" disasters - earthquakes, cyclones, floods, tsunami, volcanoes and fire - and long-term and continuing disasters - war, drought and famine. This project is concerned with the former, in particular, disasters which are "sudden" i.e. fairly likely, but relatively unpredictable (such as earthquakes and volcanoes), and disasters which are "regular" i.e. seasonal with some warning (such as hurricanes or floods). The physical characteristics these events and the structural damage they cause is summarized in Table 2-I.

Cuny (1983, p. 44) observes that while "no two disasters are alike," different kinds of disasters can have a number of disruptive effects, which in turn cause characteristic problems and needs. These are of four kinds:

- i) environmental,
- ii) medical,
- iii) social and economic, and
- iv) administrative and managerial.

TABLE 2-1 Physical Damage Caused by Natural Disasters

Earthquakes (tremors, soil liquefaction, ground rupture and failure, tsunamis):

Fissures - damage to buildings, roads, dams and bridges.

Landslides and avalanches - buildings, roads etc buried, foods from temporarily blocked rivers.

Liquefaction and collapse of underground geological structures- damage to buildings, underground and surface structures.

Tsunamis - flooding and impact from giant sea-waves

Cyclones, Hurricanes and Typhoons (high winds, intense rains and storm surge):

Winds - damage to buildings, power lines and water towers.

Flooding from run-off and surges - damage to buildings, roads and bridges.

Floods (inundation):

Erosion - undercuts foundations

Mud slides - buries buildings and other surface structures

Volcanoes (blast, ash and lava):

Blast - destroys buildings and other surface structures

Lava Flows - buries buildings and starts fires

Localized fissures - damages buildings, dams and bridges.

(adapted from Cuny, 1983, Tables 2.1 - 2.6).

Unless a natural event such as an earthquake causes significant damage in one of these categories, it remains merely an "interesting geological phenomenon" rather than a natural disaster. In this sense, whether or not the event is to be classified as a "disaster" will depend on the extent of its human-related secondary effects.

While the present study is concerned primarily with the social and economic impacts that can be measured in economic terms - the approach to evaluating these must interface with other aspects of the disaster. Moreover, since it is apparent that most disasters have the potential to cause the full range of problems - albeit with different specific impacts (in terms of the type of damage or costs of recovery), any planning instrument which can usefully address the economic consequences of one type of disaster is also likely to be of use for others. Thus, although most of the literature referred to in this report is concerned with the impacts and recovery from earthquakes, the aim is to develop tools that can be used for other types of disaster recovery programs, including those which arise primarily from economic causes.

TABLE 2-II Immediate Economic Consequences of Disasters

	Earthquake	Cyclone	Flood	Volcano
Migration:				
Temporary			x	x
Permanent				
Production:				
Agriculture		x	x	x
Industry	x	x	x	
Business	x	x	x	
Infrastructure	x	x	x	
Marketing	x	x		x
Transport	x		x	
Communications	x	x	x	

Based on Cuny (1983) Table 2-5, p 48.

Specifically, the economic costs of disasters may arise from one or all of the following:

i) **Direct costs** of the disaster, which includes loss of capital plant and infrastructure, direct loss of output, jobs and household income, and human resources.

ii) **Indirect costs** of the disaster, which includes losses to other parts of the local economy and neighboring regions, not directly affected by the disaster.

iii) **Post-disaster costs**, including recovery costs for reconstruction or relocation, and services such as medical and counselling of victims.

iv) **Proactive prevention costs**, (against future disasters) including hardware such as meeting higher building code standards, zoning of new construction, retro-fitting of buildings; and software such as disaster forecasting, education and planning for safety or evacuation.

In principle, all these items may be accounted for within an input-output framework. For example, comparison of the anticipatory and recovery costs with the short-and long-run costs (discounted to an appropriate base, and differences between the pre- and post-disaster situations) allows various "cost-benefit" evaluations to be made. However, the way in which these items are dealt with is important, since the economic impact of a disaster varies according to the types of business and community impacted.

2.3 Recovery from Disaster

There are important variations in the way different economic activities and actors respond to disaster - both in the immediate and the longer-term. In general, Cuny suggests that disasters disrupt, rather than destroy economies. In the immediate aftermath, "during the emergency," people leave their jobs to devote time to disaster relief, and this may curtail normal economic activities, even if sources of employment are not themselves damaged. Subsequently, attention is given to restoring businesses. Whether or not an economy can recover quickly depends on the losses sustained. Cuny suggests that the ability to sustain damage and recover, differs greatly between formal and informal sector activities, or between large and small scale activities. For larger enterprises, physical damage to business and industry may temporarily halt some activities, but most enterprise can generally operate at reduced levels even with the loss of equipment - in any case, Cuny suggests that the loss of employment is usually only temporary.

In contrast, the impact of a disaster is usually far greater on people who are "participating only marginally in the economy, such as subsistence farmers, small shopkeepers and fishermen. After a disaster, it is not uncommon for many small enterprises to fail. For many owners, a disaster can wipe out their not only their investments, but also their savings." While, the relative importance of the large and small scale activities depends on the nature of the economy (city versus remote rural, wealthy versus poor country etc.) as well as its composition, his review suggests that, if possible, the scale of activity should be accounted for in the SAM.

This differential impact is not confined to poor developing countries, for example, in the Whittier earthquake, the impacts seem to have been most severe on local, small business owners (Tubbesing, 1989, p. 3). Generally, impacts are felt unevenly. This is recognized in recent studies to the point that a knowledge of the size-distribution of buildings in a disaster-prone locality provides insights as to the likely extent of damage (see e.g. Jones and Lewis, 1990). A recent study evaluating the need for earthquake insurance in the United States shows that typically, the majority of direct losses are to commercial, industrial and government owned property and facilities, especially damage to utilities, transportation and communication.

2.4 The Developmental Context of Disaster Planning

Although the more immediate impacts of natural events and cost of recovery may be identified, as above, several authors (see especially Jones, 1982) have emphasized that a disastrous event is a crisis in the historical evolution of the economic system of the impacted region and that "Reconstruction planning should be approached in the context of the continuum of the systems evolution. Planning should guide the rebuilding so as not either to result in stasis in the system, nor in excessive discontinuity, but rather the facilitation of development trends. At the same time, it should improve the rapidity and efficiency of the process and insure that the reconstructed system is less vulnerable to future earthquakes." Jones argues further that in order to accomplish these aims, reconstruction must take into account the trends that have characterized the changing composition and spatial distribution of the population and economic activity within the region and make use of the rebuilding process to facilitate adjustment to new requirements.

Several authors conclude that "A strong local economy is the best protection against a future earthquake... by contrast a marginal community is always the most vulnerable. The effect of the reconstruction activity on the local economy is a primary factor to be considered in planning the reconstruction." According to Aysan et al (1989), there have been many well-documented cases where the reconstruction itself has contributed to further economic decline, exacerbating the damage to the economy caused by the earthquake, and causing the victims of the disaster to become dependent on aid from the outside. In particular, they criticize the use of external contractors in rebuilding. "This may lead to the collapse of the local building industry, because these contractors typically export profits and use non-local labor, creating a "leakage" of income from the local economy. By contrast, local contractors tend to employ local labor who, in turn, spend their earnings in local shops and the local economy is perpetuated."

Essentially, Aysan et al (1989) are describing here the multiplier processes which input-output models are designed to explain and quantify. Thus they explain that "The reconstruction itself can be used to reinforce and revitalize local economies." It is evident therefore that the recycling of any external economic assistance aid for reconstruction within the local economy is an important principle in using the injected funds to bring about economic development.

Aysan et al (1989) argue for a balance between a rapid reconstruction program - which is likely to involve a high level of leakages of this kind, with a slower pace in which external aid is used to restructure the local building industry to carry out as much of the reconstruction work as possible. In a large scale disaster, the scale of reconstruction activity is obviously way beyond the normal capacity of local building industries, with the sudden massive demand for building skills, material supplies and labor making the use of external contractors seem inevitable. However, Aysan et al (1989) suggest that this sense of urgency (to bring about rapid reconstruction) may be the result of perceived shelter needs and external pressures by political authorities and aid donors. "The additional time taken (to plan for recovery) can be accommodated within the recovery plan provided the objectives are well-enough understood." The economic basis of a city needs to be rebuilt, not just its fabric. People need jobs and income to afford to contribute to the reconstruction. Recovery planning should consider how badly each employment sector is hit, and prioritize the use of reconstruction funds to revitalize lost employment and damaged economic production."

2.5 Poverty and Culture Related Impacts

Cuny (1983) emphasizes that the scale of impact of natural disaster too is a developmental phenomenon, in that much of the damage is a result of long-run mal-development. He states that in developing countries, the magnitude of each disaster in terms of deaths and damage costs has increased due to recent and rapid urbanization. For example, extensive squatter settlements constructed on land subject to landslides or flood, millions of families worldwide have become vulnerable to a range of natural disasters. He suggests that "recognizing poverty as the primary root of vulnerability and disaster in the Third World is the first step towards developing an understanding of the need for change in current disaster response practices." Although the present project is not concerned specifically with wider issues of development per se, or only with natural disasters in developing countries, it is the poorest families and the informal sector that are most severely impacted. In general, poor and large families had the greatest difficulty in recovering from a disaster (Bolin and Bolton, 1986) - typically they have fewer savings, political empowerment or other means of coping with trauma.

The principal difficulty in representing this strong association between poverty and underdevelopment in a SAM is the paucity of suitable data. Nevertheless, several SAM's have been constructed for developing countries, and a number of industrial countries which include many of the necessary details. Even when no explicit data are available, the informal sector may be represented, for instance, by estimating its size (in terms of output or employment or as a share of household income) and then assuming a cost structure similar to that of small businesses. Usually some information related to the latter is available.

A closely related issue here is the association between ethnicity and the impact of disasters and reconstruction programs. Bolin and Bolton (1986), for example, conclude that in the Coalinga earthquake, Hispanics suffered the highest levels of damage and the lowest levels of economic recovery. While some part of the ethnicity related impacts and responses may be correlated directly with the relative poverty of victims, distinct cultural behaviors must also be taken into account. Tubbesing (1989), in reviewing the emerging lessons of earthquake reconstruction efforts, provides examples of this in the Soviet Union, Mexico and the United States.

The "culture related" aspects of disasters involves a mix of economic and institutional issues which often come to the fore during periods of hardship (such as the aftermath of a natural disaster). From the economic standpoint, it is almost inevitable that a disaster will affect different ethnic groups differentially. Many societies are multi-cultural and comprise peoples of varied ethnicity and cultural heritage. This is reflected in a segmentation of economic roles, income differences, consumption patterns, geographic concentrations and the like across identifiable ethnic and other groups (Horowitz, 1971). The resulting cultural division of labor typically exhibits complex vertical and horizontal segmentation across groups. With the horizontal division, certain groups predominate in particular industries - a particular group may both work in and own the industry. With the vertical division, certain groups occupy jobs of particular status or those requiring particular skills. In either case, occupations and ownership may be closely linked to the regional, age or gender divisions within a distinct ethnic group (see e.g. Cole, 1989).

Because different groups manifest contrasting attitudes towards insuring against, and dealing with disaster (such as migration or local economic support systems), as well as different work habits and lifestyles, their needs should be accounted for explicitly in disaster relief programming. This suggests that the usefulness of the social accounting matrix will be increased if the population affected by the disaster can be sub-divided in the model in a manner which reflects the needs of the various socio-economic and cultural groups of the region, as well as the situation of specific minorities. While this again may pose difficulties because of a lack of data, it is generally possible to take some account of this aspect of socio-economic structure.

2.6 The Institutional Context of Disaster Planning

Tne last consideration also raises a number of institutional issues, related to the way in which planning tools such as the "event accounting matrix" will be used. The cultural division of labor and ethnic differences may be closely related to political differences, and the ability of the community to respond to events (see Tubbesing, 1989). For example, Mileti (1989, cited in Tubbesing) observes that in the recent Armenian disaster, ethnicity played a major role in coloring how earthquake victims, perceive and react to recovery programs, and suggests that, given the ethnic diversity in the United States, "Public response...would likely to be splintered and directed by the ethnic identification of victims."

Several authors warn against failing to involve all local interests in the reconstruction process. Cuny (1983, p. 104) in reviewing lessons from the past concludes that "The subject of disaster assistance has been viewed predominantly from the standpoint of the intervenors. Thus many of the common relief approaches have evolved in ways that facilitate delivery of relief assistance. If agencies are to provide effective aid, they must view disaster assistance from the standpoint of the victims and their requirements." He observes (p. 201) "Often in the rush to provide assistance, agencies will undertake programs without considering their acceptability to the victims. There are numerous examples of victims rejecting aid offered by intervenors, both governmental and non-governmental. The reasons may be that the aid is culturally unacceptable or too costly."

Cuny (p. 86) points out that a common myth among disaster relief agencies is that disasters wipe out indigenous coping mechanisms so that local formal and informal institutions are not capable of functioning normally. In fact, he suggests that quite the reverse is true, and that aid programs often serve to disrupt indigenous capability and to undermine its credibility in the community. He concludes (p. 201) "reconstruction is a complex process and often involves sophisticated techniques and activities with which local groups will need assistance. Providing assistance at this point is a meaningful role that intervenors can play."

The way in which this empowerment may best be done brings together several issues raised by the authors cited above. The need to act swiftly to deal with the immediate consequences of a disaster, must not undermine the longer term efficacy of the economy (as Aysan et al 1989) or the local institutions, especially when it may be possible to transform some aspects of the disaster into positive development opportunities. However, as Jones (1989) emphasizes, if the measures taken to ameliorate the effects of natural disasters are to be as cost-effective as possible, it is necessary to have a framework for evaluating individual activities and packages of policies within a regional economic context, and within a broader planning framework. Thus, he concludes that, "Analytic techniques must be applied rapidly to develop a sufficiently profound comprehension of the nature of the spatial system in the impacted area and the way in which it has been transforming over time." Thus while there may be good developmental reasons to time-phase the process of reconstruction, so that the locality recovers in the most favorable way, there is a need for tools which as soon as possible assist in the short-run decisions which will facilitate long-run recovery. It is necessary for analysis to be both speedy and relevant.

The need for quick access to data and analysis is apparent. Toki (1989), contemplating the disaster planning requirements of Japanese cities says, "A prompt grasp of the extent of damage and prompt determination of the most effective plan for carrying out restoration and reconstruction activities in the damaged city are essential...a well thought out procedure for implementing reconstruction plans must have been decided upon or done well ahead of a disaster."

SECTION 3
DESIGNING THE MODEL

3.1 Economic Structure and Input-Output Models

Social Accounting Matrices are a development of the Input-Output tables invented by Wassily Leontief in the 1930's and are quantified descriptions of economic structures. They show the flows of goods, services and income between the various actors in society and are used to demonstrate how importa .t changes in a locality affect the economic well-being of its population. For example, they may be used to calculate the employment or financial loss should a particular activity or linkage in the economy be lost through a firm closing down, or how much an economy may gain through a new activity starting up. Such a device is obviously useful also for assessing the economic damage resulting from a natural disaster such as an earthquake or a typhoon, or human-made disasters such as an oil-spill or civil war. Indeed, a number of authors have used economic models, including input-output tables to calculate the impact of real and hypothetical natural disasters on economies, and propose alternative recovery "scenarios."

All input-output models are a quantified description of the network of economic transactions in a society. The entries in Table 3-I measure the amounts of money paid by the "actors" in the economy - production activities, households, government and overseas interests - to each other over a year time period. The layout of entries in a typical table is shown opposite. In this table, the top left hand entries are payments between production activities; the entries below show payments to workers and entrepreneurs and how this is distributed to households and businesses. The lower left entries show imports and profits repatriated overseas. The middle entries show expenditures by households and government including personal tax and public welfare. Entries to the right show earnings from overseas. The row and column totals for each actor are respectively their total income and total expenditures; these are balanced so that any net imbalance is recorded as a net saving or loss. Key physical data, in particular, employment by occupation and population are appended to the bottom of the table, together with additional information about household and wage distribution.

TABLE 3-1 Layout of a Social Accounting Matrix

CATEGORY	PRODUCTION	LABOR	HOUSEHOLDS	GOVERNMENT	INVESTMENT	OVERSEAS	
PRODUCTION	Transactions by Types of Production Activity		Household Consumption by Population sub-Groups	Government Expenditures by Activity		Exports of Goods and Services	Total
LABOR	Wage Income by Skill or Education			Government Wages			
HOUSEHOLDS		Wage Transfers to Population sub-Groups		Public Transfers to Households	Investment Income by sub-Groups	Income from Abroad	Income
GOVERNMENT	Indirect Taxes		Direct Taxes		Corporate Taxes	Development Aid	
FIRMS AND CAPITAL	Capital Payments by Type of Ownership		Savings by Households	Financial Transactions by sub-Groups	Financial Transactions by sub-Groups	Foreign Investment and Balance of Payments	
OVERSEAS	Imports and Repatriation		Other Extra-Regional Payments				
	Total Expenditures by Each Activity						

By constructing appropriate input-output tables and manipulating the information they contain, it is possible to evaluate how specified events, such as the failure of an industry or lifeline, will affect each actor in the economy. For the demonstration, examples have been chosen to reflect key aspects of natural disasters such as the failure of major industries, the impact on specific population groups, the failure of major inter-regional lifelines, the consequences of defective recovery programs, and the search for more appropriate alternatives. In each case, although there are some conventions as to what is to be included, in any particular situation, the details represented depend on the key features of the economy, the requirements for the model and the available data.

3.2 Simulating the Economic Impacts of Disasters

The possibility of simulating the effects of a natural disaster, and the reconstruction strategy, in a given input-output table depends on a two principle conditions. First, whether the table includes items relevant to the disaster, and second whether the method can reflect the complexity of the disaster or the proposed reconstruction programs.

Input-output tables are most widely used to estimate the impact of single events - such as the opening or closing of a business. The most common means of calculating the impact is to base the calculation on previously calculated employment or gross output multiplier for the local economy. The multiplier for the business is taken to be the same as the average for the production sector to which it belongs. For example, if jobs lost or gained directly is **J**, and if the employment multiplier for this sector is **M**, then the total loss of jobs in the economy as whole will be **J x M**.

This procedure rests on a number of assumptions, in particular that the technology (cost structure) of the particular firm is the same as the average for the sector as a whole. Since all businesses are different, the calculation is much improved by taking explicit account of the details of the business (ie how much it actually pays workers, buys from other local businesses, pays in taxes, or imports from outside the area). Usually this additional sophistication is added by calculating the effect of the loss of income to each of these actors separately (using the previously calculated multipliers) and adding them to the direct impact of the original change. The same principle applies in calculating the economy-wide impacts of a natural disaster.

In general, in the circumstances following a natural disaster, some of the assumptions used in standard input-output calculations must be modified. For example, if businesses are only partly damaged, but in such a way as to change the composition of inputs (for example, additional raw materials are shipped into the region), there will be a change in technology within each affected sector. In this case, the standard multipliers for a particular activity may be unreliable, and it will usually be necessary to use a more sophisticated approach. For a "simple disaster" - resulting in the partial failure of one or more production activities, the second method mentioned above may be sufficient to estimate the indirect impact of the event. This approach may be extended to changes in the demand-side of the economy. For example, a disaster may have little direct effect on production activities, but very great impact on demand - say, if many homes are destroyed and a good proportion of the population temporarily or permanently migrated from the area.

However, even this approach is likely to be insufficient for simulating a wide range of natural disasters - especially where there is a complex of events arising from the partial failure of several activities, resulting in a more general failure of the economic network as a whole. Here, it seems more appropriate to proceed from the fact that input-output table is a network representation of the economy, and to "map" the direct effects of the disaster onto the economic network. Moreover, if the recommendation to conceive of reconstruction within the framework of an ongoing development process (Jones, 1989) and to transform the tragedy into an opportunity to construct more forward looking development plans (Aysan et al, 1989), then evidently a more sophisticated approach is warranted.

The technique adopted for this project rests on a time-dependent approach for conceptualizing and solving input-output tables. The method is considered in more detail later and in an appendix. From the point of view of assessing the economic damage arising from natural disasters, the advantage of this method is that it provides a more straightforward solution of extending input output tables (than the commonly used "matrix decomposition" method) and, more especially, it enables the magnitude and time-scale of failures and subsequent reconstruction efforts to be straightforwardly integrated into the solution of the social accounting matrix. The essential theory of the method is described below. First, however, it is necessary to consider the characteristic time-scales of disasters and reconstruction, and which can be accommodated satisfactorily by the technique.

3.3 Time-scales for the Event and Recovery

Rates of recovery from disasters are usually specific to the location depending, for example, on the magnitude of the earthquake, associated geological factors (such as landslides), the composition of the local economy (industry, public services and demography), the extent of proactive planning and the availability or recovery services, and the relationship with the external world. Broadly speaking, the time sequencing of economic events encompassing the disaster may be sub-divided as follows:

- i) Immediate and Short-Run Effects
- ii) Restructuring and Medium-Run Effects
- iii) Long Run Developmental Trends and Opportunities.

With respect to i), the SAM provides an estimate of the impact on the whole economy of the partial or total breakdown of individual activities, lifeline networks, external supply links and so on, which are included in the event map, and the way these build-up over time. Although these may be classed as "immediate or short run," the full impact may take several years to percolate through the economy since there are always considerable lags in transmitting indirect effects through any economy. For example, in normal circumstances, businesses and people may have stockpiles of raw materials or savings sufficient for several months and, if these are not destroyed, the real "crisis" may be delayed until these are exhausted. Clearly, then the immediate impacts interact with the medium term restructuring efforts, and because of the growth of indirect impacts over time, the severity of the disaster may be worse than at first sight.

The time-scale for reconstruction depends very much on the strategy for reconstruction that is adopted. Again these may be "short" or "long term." Cuny (p. 202) distinguishes between strategies which provide aid to victims until they recover and strategies which help them to recover. He notes that relief programs which concentrate simply on helping victims until they can "get going" again, in general, have little impact on the overall recovery time. "Helping people to recover, on the other hand, can demonstrably reduce recovery time. Such programs provide the resources needed and generally concentrate on longer-term objectives." He also recommends approaches which facilitate intervention both in the emergency as well as the subsequent transition and reconstruction phases. "The strategy is to identify and provide those resources or actions that can accelerate recovery." Typical actions are the provision of building materials for temporary shelters that can later be incorporated into permanent housing; stimulation of markets or the normal economic systems; the setting up of work programs for victims that not only provide resources but also accomplish reconstruction objectives. "In short, to accelerate the recovery process, agencies provide or restore the infrastructures of a community, provide the materials required, and make opportunities for the victims."

This approach is echoed by Aysan et al (1989) and Jones (1982) who also argue that there should be an overall structure to long term recovery and reconstruction plans, and that recovery should be viewed as part of an on-going development process. Input-output type models are somewhat circumscribed in terms of longer term development strategy. This is because, even time-varying models such as that proposed here, do not take account of some dynamic and market-oriented processes. These include, for example, changes in competitiveness or levels of investment locally as a result of improved productivity. Such processes are likely to become important if the long-run aim is to improve the self-sustainability of the local economy. Nevertheless, the models are entirely appropriate for evaluating and comparing the variety of disaster-related economic activities, impacts, reconstruction programs, and aid and assistance packages considered above, over the short and medium run, and indicating opportunities for longer-run change.

3.4 Categories in the Impact Model

The above discussion suggests that a natural disaster accounting system should "sub-divide" households by level of income or, better (and if possible), by ethnic identity, gender or social affiliation. Similarly, sectors of production should highlight correlations with particular households, and to highlight critical relationships between skills, ownership and consumption, and the internal lifelines and their links with the outside world. Empirically and theoretically, this is a challenge. Fortunately, constructing a useful social accounting matrix does not require the "accountant's mentality" that every penny matters.

In any case, there is no doubt that in most small settlements and localities (as well as the largest countries such as the United States or India), a good deal of the economic activity goes un-accounted. Incomes may be misreported or belong to the informal or underground economy. As far as possible it is better that social accounts show all the essential links between production and distribution activities in the area and the regional division of labor, rather than omit activities because detailed official statistics are not available. If a fair approximation to the structure of the full economy is achieved, then the accounts should provide a reasonable starting point for assessing the impact of major disasters or consequences of reconstruction policies.

In building a model to calculate the effects of natural disasters and recovery programs, the aim is to use available data so as to introduce as much "socially relevant" variation into the matrix as possible. Given the earlier discussion, it is desirable that the social accounts include the following characteristics:

(i) Households by type (high income/low income, ethnicity, gender, etc).

(ii) Major economic sectors by type and ownership including links between sectors (such as agriculture, public utilities, local industry and services, and export activities such as mining and tourism).

(iii) Differences in production techniques within sectors (for example, sub-divided into large and small enterprises).

(iv) Employment by level of education and occupation (such as administration, clerical agriculture, production or sales worker).

(v) Income of households by source (wages, investments and transfers).

(vi) Consumption, savings and other expenditures by household type.

(vii) Government income and transfers (central and local agencies).

(viii) External payments (e.g. repatriation of profits and development assistance).

3.5 Layout of a Social Accounting Matrix

The layout of the information listed in i) to viii) above is given in Table 3-1. In any particular situation, the details would depend on the key features of the economy, the requirements for the model and the available data. The actual entries are the amounts of money paid (in local currency) by the various economic actors - production activities, households, government and overseas interests - to each other over a year time period. In the table, the top left hand entries are payments between production activities; the entries below show payments to workers and entrepreneurs and how this is distributed to households and businesses. The lower left entries show imports and profits repatriated overseas. The middle entries show expenditures by households and government including personal tax and public welfare. Entries to the right show earnings from overseas. The row and column totals for each actor are respectively their total income and total expenditures; these are balanced so that any net imbalance is recorded as a net saving or loss. Key physical data, in particular, employment by occupation and population are appended to the bottom of the table, together with additional information about household and wage distribution. (An example of the SAM accounts is given in Section 6 below).

3.6 Construction of the Social Accounts

In most situations, the construction of a social accounting matrix for a locality impacted by a disaster would not begin from raw survey data, but be based on an existing input-output table for the nation or region containing the locality, or if neither was available, from a matrix for a similar economy. For example, input-output tables for states or counties in the United States usually begin with the 1981 United States input-output table. Tables for islands in the Caribbean, for example, may be based on tables from other islands, during the 1960's a considerable amount of data were "shared" when constructing the original European national input-output tables. While the tables constructed by national planning offices and international agencies sometimes sub-divide some industries and households along the lines indicated above, the majority concentrate on providing great detail on the production side of the economy, with rather few subdivisions on the demand-side. Nevertheless, several international agencies (previously the World Bank) and independent agencies and researchers have constructed social accounts following the work on social accounting initiated by Stone. Construction of these tables already poses many empirical problems similar to those faced in building input-output tables generally - problems of inconsistent or inadequate definition, data from different sources are incompatible, data are available only for different years, data have been over-aggregated at source, key questions were omitted from the original survey, samples are inadequate, respondents are untruthful, and so on.

The data required for a SAM and the approach to construction will be considered in more detail later. It is not necessary at this stage to discuss these details, except insofar as they illustrate general principles in construction of the social accounts. The construction of a detailed set of social accounts shares all of the problems of constructing input-output tables generally, plus a few more. Moreover, the details of construction tend to be very specific to the locality considered.

A number of so-called "mechanical" techniques are available for resolving inconsistencies in data, updating existing tables to account for more recent or more reliable data, or generating a table for one region from the table for another. The methods described in Appendix A have been adapted to the needs of the present study, and could provide the core algorithm for developing local area social accounts suitable for natural disaster accounting. Inevitably, however, a certain amount of judgement enters into the way in which inconsistencies are finally reconciled, and it is largely for this reason that some familiarity with the economy concerned is essential. For this reason also, it seems unlikely that a useful SAM could be built in a purely mechanical fashion (using only an algorithmic approach), but requires a more sophisticated combination of mechanical and heuristic methods.

3.7 Representation of "Lifeline" Systems

Many authors point to the importance of lifeline systems to economies and their vulnerability to natural disasters (Kameda and Shinozuka, 1989). Most economic transactions depend directly on physical lifeline systems - for example, purchases of power and water by businesses and households, the trucking of goods between industrial areas and to markets, the flow of information within and without the region via telecommunication links. Even though, in many situations the direct impact of a natural disaster affects a very limited part of the economy with only a small number of activities sustaining physical damage, especially in the case of lifeline activities, such as transportation, water and power supply, and the like, the indirect effects can be ubiquitous across the whole local economy. Toki (1989, p. 1) observes that, "When, for example, one section of a lifeline system which is an important part of urban functions is disrupted, the entire system ceases to function over a wide area. Such disruptions tend to occur simultaneously in many places during major earthquakes." Because they describe an economic network, input-output tables are especially appropriate for estimating the extent of the generalized economy-wide collapse as a consequence of the failure of a specific activity.

Nevertheless, simply because lifeline systems comprise networks covering the entire region, and the behavior of the goods and information delivery systems (transportation and communication) is dispersed across the input-output table, its representation in the table and the way in which the behavior changes following a disaster deserves particular attention. In particular, although all the lifeline items - at least those for which some payment is made - are represented in an input-output table, they may not be treated in a manner that makes them immediately amenable to analysis.

Accounts sub-divided as in Table 3-I can represent well the existing (i.e. pre-event) circumstances of an economy, and some of the changes arising because of damage to the technological system (e.g. levels of output by sectors) or the institutional system (e.g. an inability to distribute resources), or some types of damage to the economic network. However, in order to represent satisfactorily specific systems (such as "lifeline" systems) that are internal or external to the locality, it may be necessary to sub-divide some parts of the SAM further. In this case it may be necessary:

(i) to introduce new sectors into the SAM to in order to make lifeline links within the locality more explicit, or

(ii) to sub-divide the social accounts geographically to show explicit links between the locality and neighboring regions.

The difficulty in representing damage to the economic network is partly a matter of accounting conventions in the way data are categorized in conventional input-output tables. For example, although a transportation sector is typically included in most tables, the entries between any other production activity represents the payments by that activity to transport companies. While this payment would obviously be lost should the transport sector be damaged, more important to understanding the effect of this failure is its effect on the flows of goods between production activities. In an input-output table this is measured by the transactions between production sectors, for example, between agriculture and food processor, or between the latter and retailers.

This means that simulation of changes in lifeline systems in an input-output table must be performed in an appropriate manner. In the context of a disaster planning exercise involving people with expert knowledge of the local lifeline systems, the most appropriate approach is to assess the specific implications of lifeline failures directly in terms of the categories included in the matrix. For an integrated "expert" system (such as that considered later) it would be necessary to construct a transformation matrix to convert physical lifeline changes into their economic equivalents (equivalent to a "make-matrix' between commodity and production categories).

3.8 The Event Accounting Matrix

The above discussion suggests that four kinds of calculation involving different levels of sophistication may be required to evaluate the various impacts and reconstruction programs:

i) estimate the loss in output, employment in income directly and indirectly as a result of the "simple" disasters. For example, where some production capacity is lost, but the average technology used remains the same.

ii) more "complicated" disasters where the composition of inputs to particular sectors or households is changed in a non-linear fashion.

iii) as with ii), but taking account of recovery or reconstruction of the activity over some specified time period.

iv) as with iii), but recognizing that the recovery is part of a program which incorporates reconstruction into a broader development strategy (ie deals with aspects of the economy not affected by the disaster), and which, in particular, is designed to enhance the robustness of the economy against future disaster.

As considered earlier, a natural disaster is likely to pose a sufficiently complex set of changes, and that these are not dealt with satisfactorily in standard input-output models or by the standard methods of solution. In many situations, the linear assumptions for intermediate and final consumption assumed in i) will be obviated by the circumstances of the disaster. To take a rather simple example, if the power networks (generating or refining capacity) are destroyed, but water and transportation relatively unaffected by the disaster, then it may be possible for the necessary fuel to be shipped into the region. In this case, the "technology" represented in the input-output table should be changed to show that inputs of domestic fuel has changed. Moreover, since this may be a temporary event with the expectation that domestic power systems will be brought up to full capacity after a specified period, this too should be included in the longer run calculation. Beyond this, it may be that the recovery strategy involves an expansion, and an upgrading of the power production system. In this case, both the level of production, and the technology used are to be adjusted.

In general, to extend input-output calculations to deal with non-linear behavior significantly complicates analysis, and also undermines one of the most attractive features of this type of analysis, namely its intuitive and analytic simplicity. For present purposes, however, a suitable extension of the linear method may be used which allows discrete non-linear changes (such as those immediately following a disaster), and steady changes (such as those during restructuring) to be accounted for. This involves specifying an "event accounting matrix" (EAM) - essentially a table with entries corresponding to those in the social accounting matrix, which are added into the solution of the SAM when multipliers and other indirect effects are calculated.

The EAM provides information on the intensity of the impacts to each activity and transaction and the response (or recovery rate) of each activity or transaction. Formally, the event matrix might show:

i) the proportion of each transaction not affected directly by the disaster.

ii) the time taken for the transaction to recover to its previous or some specified level.

iii) the new level (if different from the old level).

In effect, this provides information with which to modify the existing SAM. The precise form of the event matrix may vary (although it must be consistent with the SAM and the method of calculation). The formal structure of the calculation, and the approximations it entails are discussed in Appendix B.

An important aspect of recovery programs is to reduce the vulnerability of the locality to further disasters. In terms of individual structures, this is dealt with, for example, through new building codes (e.g. Cuny, 1983). With respect to lifeline systems, various "systems" principles are recommended. For example, as Kameda and Shinozuka (1989) advocate, "The earthquake disaster problem of lifeline systems involve not only earthquake resistant constructions of individual components but also system recovery with the aid of network redundancy, back-up facilities, and restoration work, that are to be followed by reconstruction and improvement for the future earthquake." The same principles that apply to the design of a robust lifeline network also apply to the regional economic network as a whole. However, there may be economic trade-offs associated with this, for example, the dispersal of vulnerable activities may lead to a reduction in economies of scale (i.e. under normal conditions some goods and services may become more expensive, although the costs resulting from of periodic disasters is reduced). The cost of such insurance may be partially tested through the SAM methodology, adapted to take account of discounted costs and benefits. Although this is not considered further in this report, it appears to entail a straightforward extension of the method described in Appendix B.

3.9 How Accurate does the Model Have to be?

Uncertainty in the predictions arises from two sources:

i) Uncertainty from outside the model about the direct economic effects of the "event" (e.g. from an assessment of the physical damage and the translation of this into direct economic impacts, uncertainty as to the level of assistance, the future production capacity of the region, or uncertainty as to future trends in demand for local products).

ii) Uncertainty from inside the model because of rigid or inadequate data or assumptions in the relationships in the model, or how it is solved, which cause it to misrepresent the likely response of the economy to external shocks and policies. (For example, businesses may respond by adapting technologies or households change their consumption habits in a way not covered by the model).

Typically, a planning model may be used to provide a range of forecasts. For example, central, high, and low predictions based on alternative expectations about the i) - the direct consequences of the disaster and the recovery policies. Forecasting "errors" as in ii) may be in the form of random uncertainties (e.g. arising from sampling errors in the data base used) or systematic biases (e.g. the data reflect the historic, rather than the current situation). In either case, these may be accounted for providing their magnitudes are known and understood.

In the circumstances of a natural disaster, with considerable uncertainty as to the full extent of the immediate damage and the need to develop a workable recovery plan over a rather short time frame, it is impossible that any economic model could make "accurate" forecasts. What matters here, of course, is that the model should be "reliable" in the sense that decisions taken about the recovery strategy should not be rendered "incorrect" because of lack of precision in the forecasts. For example, the model may be used to estimate the total loss of employment in the locality as a whole as a result of the disaster, and then to prescribe the level of some new activity required to restore employment to the former level. This would then determine the amount of temporary assistance or re-investment needed. Clearly, the planning system and the economy have a certain degree of tolerance to uncertainty in these forecasts (for example, through built-in "network redundancy"), but beyond a certain level this unmanageable.

A low central forecast which proves to be correct, but with a very high upward uncertainty can be as unacceptable as a forecast with a small upward uncertainty which turns out to be too low, because both lead to wasted economic resources. For example, a lifeline system may be designed with a limited degree of over-capacity to take account of exceptionally high growth demand. Beyond this, it may not be possible to deal in a cost-effective way with the overload. In this case, there is a technological constraint on dealing with the inaccurate forecast.

In general, uncertainty becomes unmanageable when a society lacks the flexibility to deal with it, either technologically or institutionally, or both. In many cases, a response may be technologically feasible, but institutionally unacceptable. As indicated by Cuny, for example, it may be unacceptable to accept certain kinds of assistance from particular outside groups. Similarly, it may be quite feasible to convert religious facilities to commercial use, or re-locate a stricken community in another area. But if the populations are opposed to the re-use, or have historically been adversaries, these "solutions" may be politically infeasible. In this case, an alternative approach may have to be found. Provided the model can make forecasts which are reliable within the context and awareness of a knowledge about these factors it may be considered sufficiently reliable. These considerations are summarized in Figure 3-1.

3.10 Alternatives for an "Expert System"

The final consideration in this section is the possible eventual adaptation of the SAM method into an expert system approach. Both methods for constructing and applying the SAM are considered. Input-output tables essentially describe the network of flows and linkages in an economy in much the same way that other kinds of network representations are used to describe flows in an air traffic or water distribution system. These last networks are used to help understand how to improve the performance of transport or service systems, and have become the basis of some "expert systems."

With respect to the present project, there are two areas where the same adaptation of the tools considered here might be useful:

Application I):

> Adaptation of the social accounting matrix building system. Since this matrix building system has a well-defined algorithm at its core, and the matrix building itself requires a considerable degree of expertise (familiarity with data sources, accounting conventions, and the like), this is a good candidate for some form of expert system approach.

Application II):

> Integration of the event matrix with the expert systems developed from lifeline and other components of the disaster reconstruction program. From a technical point of view, this also appears to be a feasible goal - however, there are several considerations related to the institutional aspects of the recovery program - particularly the involvement of disaster victims themselves, as well as cooperation within the recovery planning team.

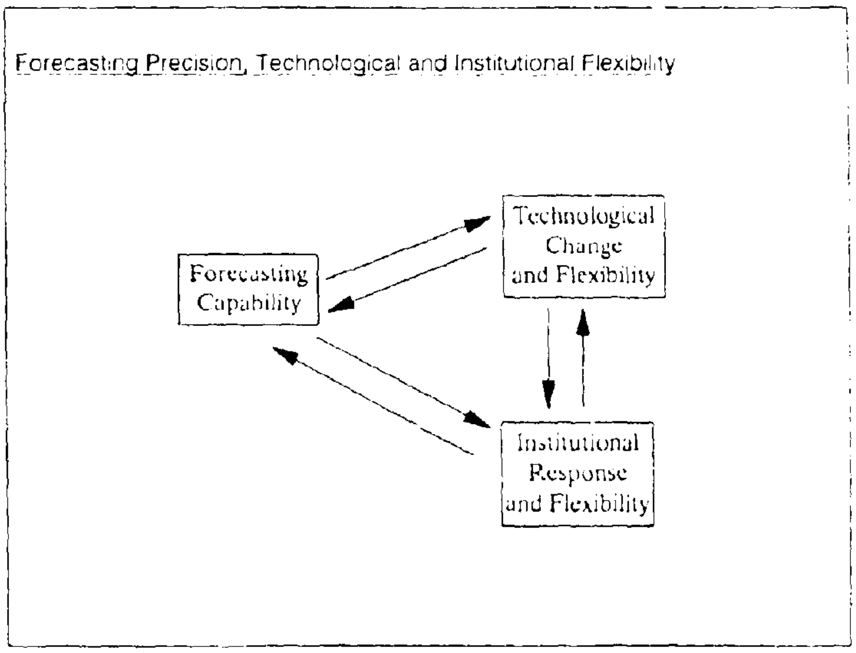


FIGURE 3-1 Uncertainty or Technological and Institutional Flexibility

Types of Intelligent Systems:

A recent review (Han and Kim, 1988) of the prospects for the application of "intelligent information systems," including expert systems, concludes that these artificial intelligence techniques are not a technology which solve urban planning problems by themselves. Rather, they are "a newly emerging and promising technology which can be incorporated or integrated into existing information systems to provide more intelligent and effective solutions to urban planning problems."

These authors sub-divide intelligent systems into four categories:

i) (DBMS) Data Base Management Systems which improve upon traditional data to computerize routine tasks in an efficient and accessible manner.

ii) (GIS) Geographic Information Systems which provide map-like access to data bases and allow some types of spatial economic modelling to be performed.

iii) (DSS) Decision Support Systems which access structured data bases using clear-cut decision rules including some modelling methods, 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.

iv) (ES) Expert Systems attempt to incorporate the judgement, experience, intuition and "rules of thumb" of human experts into problem solving, a heuristic rather than an algorithmic approach.

Depending on the state of the art with each type of intelligent system, these may each be useful in the area of disaster relief efforts. Although this project is not concerned directly with i) and ii), it is evident that efficient access to a large data base on the affected area could be an invaluable tool in identifying specific targets for relief, such as businesses, families. Such data bases take many years to develop (since they rely on detailed surveys and established planning institutions) and while these are now ubiquitous in disaster prone cities in countries such as Japan and the United States, they will be at best partial in disaster prone areas in developing countries. Similarly, the ability to overlay different types of information using a GIS approach provides an attractive capability. For example, the mapping of the propensity to flooding against the composition of residential structures, to prepare evacuation plans or assess potential damage in the face of an on-coming storm. Again, this capability rests on availability of the underlying data base. The applications considered here fall under iii) and iv) above.

Lastly, it should be noted that whatever these assessments for the future of artificial intelligence and expert systems, experience to date is limited, and "little is known about the impact of ESs apart from the economic benefits they have produced for a few large firms" (Jahoda et al, 1988).

Application I):

The construction of a SAM in principle falls under iii) since, given a sufficiently comprehensive and well-structured data base, the assembly and adjustment of the SAM may be reduced to a set of rules, which can be followed in a systematic and repetitive fashion. Unfortunately, even in industrial counties, at the local level, economic data are sufficiently "messy" (adopting different categories, based on surveys from different time-periods, and so on), so that a good deal of expert hands-on effort is required to construct an input-output table. Nevertheless, since the building of a matrix can, in principle, be reduced to a set of accounting identities and well-defined rules for assembly and adjustment, some of the principles of DDS can be applied. It is not difficult to conceive of a computer software package which would facilitate the rather rapid construction of local-area social accounting matrices 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 planners over a longer time-frame, as part of pre-event strategy development.

Although a number of software packages such as ECONIO are available for the construction of input-output tables for localities in the United States, the algorithms these systems adopt are rather rigid and not able to deal well with the paucity of data and variability of disaster prone local areas in developing countries (or even small areas in industrial countries). For these reasons, a heuristic, as much as an algorithmic system is required. Essentially, this 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). Within the present project, the aim is certainly not to construct such a system, but rather to see the possibility as a goal for guiding the work to be undertaken.

Application II):

Since most natural disasters are locality specific - or at least the most intense effects are felt by localized communities, it is unlikely that a suitable impact model will be available. What is needed, therefore, is a means for constructing a suitable SAM very quickly using expert system methods - similar to those for the sector-specific studies - and integrating the findings into a single evaluative tool. This would become the basis of similar expert systems to be used by planners and others assisting in the recovery efforts of small localities, especially those which cannot afford major pro-active efforts and analysis.

Although some proponents of expert systems see them as a way of bringing together and focusing the efforts of individuals and organizations concerned with the reconstruction program, it is questionable whether this would be effective for the circumstances described, for example, by Cuny (1982). It has to be recognized that the planning team may include a wide range of expertise, some of which may be non-technical in the formal sense. Jones (1989), in particular, has argued that "...it appears that best results are obtained when reconstruction planning is decentralized to the lowest appropriate level. Decision makers and populations within the stricken region are to some extent already aware of the nature of the changes taking place in the region and the appropriate ways to allocate resources...In addition, people within the locality will be acutely aware of why and how the system failed and how to reduce its vulnerability in the future."

Given this, any expert system must not attempt to replace the vital judgments made by the disaster relief teams involved, or because of its sophistication "exclude" people affected by the disaster from the decision process. Rather, it should aim to provide them with an additional tool for evaluating and testing alternative ways for coping with the post-disaster reconstruction. Thus, although the methods proposed might enable a "strike team" of economists and others might rapidly build a suitably precise impact model of the devastated area (to enable planners to assess the overall costs of the damage sustained and the priorities for reconstruction), the institutional context for its use has to be carefully appraised. All this suggests that any analytic tools should be intuitive (in the sense that they appeal to the "common sense" of the parties involved), and that they should operate in an unobtrusive manner (behind the scenes), in a manner which does not disempower non-experts, rather than be the focus of a complex negotiation.

Moreover, if the recovery program is to be seen as part of an on-going development process, and within the framework of a broader strategic plan for the future of the areas impacted by the disaster, then some of the analytic methods employed during the intensive recovery phase should (presumably) be designed in such a way as to be transferable and useful for the continuing planning functions. In this case, the same considerations also apply, but in addition, the analytic tools should be sufficiently simple to use and update.

If such institutional problems can be resolved, then the computer programs and user interfaces may be refined into a more readily usable expert system mode, which could then be tested on a number of pre-event representative scenarios. The overall framework for this integration of sector-specific expert systems and the SAM impact model would feed findings from the sector specific damage/response expert systems into the rapid-build/rapid-response macro-impact model, and hence inform the planning team in charge of reviewing scenarios and mapping strategies. Using the various expert systems the relevant event-map could be constructed, which would be evaluated together with the alternative recovery scenarios, and in this way, something approximating to an "optimal strategy" formulated. This would include, for example, the priority and sequencing of medical and housing and other lifeline reconstruction, as well as longer-term economic and infrastructure recovery.

SECTION 4
SOCIAL ACCOUNTING - THEORY AND TESTING

4.1 Social Accounting Matrices

The distinctive feature of a SAM is that it places more emphasis on the demand-side of the economy than does the typical input-output table. In particular, they take account of structural details such as the size distribution of economic activities, or the socio-economic and other variations across a community. The utility of this SAM approach for addressing a range of social and economic issues has been clearly established at the national and regional level in industrial and developing countries, as well as for small communities such as islands or villages. SAM's allow the interrelationships between structural change, for example, that will follow a disaster such as an earthquake, and the situation of particular social groups or economic sectors to be explored.

Since their innovation, input-output tables have been extended in many directions. The extensions which are directly relevant to the kind of system proposed here include the work of Richard Stone, whose proposals for internationally compatible social accounting laid the foundations for the social accounting matrix work of Pyatt, Thorbecke, Adelman and others. In addition to their application to localized small communities, the extension of the demand side of the models to include details of different kinds of household, by level of income or occupation or ethnicity is especially important because the distribution of impacts and the speed of recovery from disasters are closely related to the culture, and social and economic status of households. The new methods which have been developed to construct tables are necessary since there is unlikely to be an up-to-date (or any) table available for any given small locality which suffers a natural disaster. In this situation, what is needed is the ability to very rapidly construct a table which describes the essential details of the local economy as it was prior to the disaster, to assess the likely effects on the economy as a whole of the specific damages to activities, and to explore alternative strategies for economic recovery. For this last purpose, new methods of incorporating the impacts on an economy of dramatic change are relevant.

The most elaborate economic models available to planners combine input-output modeling (to describe the structural relationships) and econometric modeling (to describe dynamic relationships such as technical change and investment). However, such models tend to be very intensive of data and take many years to build (usually as part of general planning exercises). Although some attempts have been made to evaluate recovery strategies from earthquakes and other disasters, and that their construction may be cost-effective in the circumstances of a major city in Japan or the United States, few such models exist for disaster-prone areas in developing and many of the industrial countries. Because of this, the aim here is to enable post-event construction of pragmatic tools for aiding in the recovery process for these less fortunate areas.

4.2 Economy-Wide Impacts and Multipliers

Input-output models are primarily used to calculate the economy-wide impacts of changes to specific parts of an economy. The underlying theory behind this calculation is rather intuitive. It assumes that:

i) the economies of small regions are driven by the income they receive from outside, such as export earnings from trade or development aid, and

ii) the overall impact of this income on the region (or changes in income) depends on the extent to which income is recycled in the economy through transactions between producers, households and government.

These assumptions are illustrated by Figure 4-1 opposite which shows how income from outside the region is recycled many times within the domestic economy, through many different channels. For example, an initial boost in income to a particular household or population category leads to purchases from local businesses, taxes to local government, new income to workers and households and so on. This leads to the so-called "multiplier" effect. Since, at each recycling, a certain amount "leaks" back to the external economy (in payment for imports, etc.), the contributions from successive loops declines.

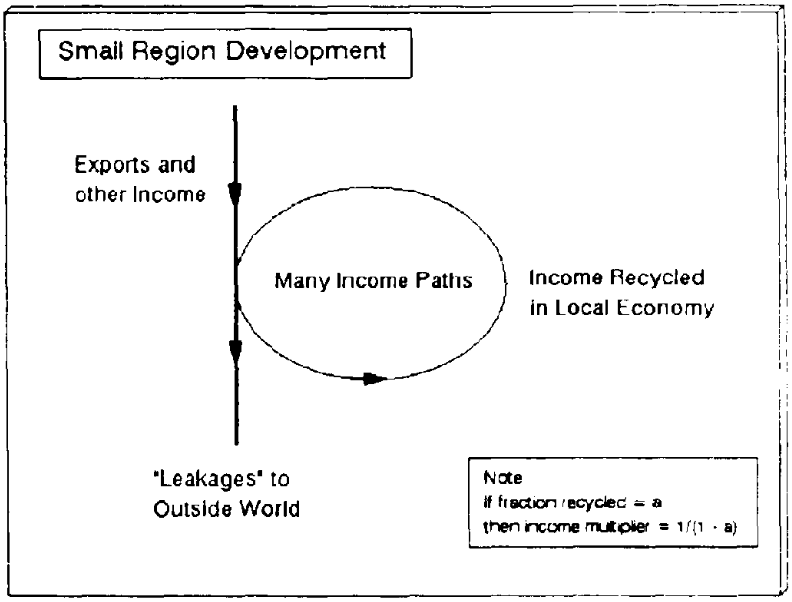


FIGURE 4-1 Small Region Development

If the economy is conceived of as a single sector, then an external or exogenous change, $\delta\mathbf{x}$, will lead to a total change of income to the economy of

$$\delta y = \delta x\ (\mathbf{1} + \mathbf{a} + \mathbf{a}^2 + \mathbf{a}^3 + ...)$$
$$= \delta x/(\mathbf{1} - \mathbf{a}),$$

where **a** is the fraction of the new income which is re-cycled in the local economy. Thus, the fraction **1 - a** "leaks" out of the local economy. The attraction of the input-output method is that this expression may be generalized to the multi-sector case, so that **Y** and **X** are vectors measuring the impacts on income, employment for each sector

$$\delta\mathbf{Y} = \delta\mathbf{X}/(\mathbf{1} - \mathbf{A})$$

and **A** is the matrix of expenditure propensities as measured in the input-output table. The technical difficulties in applying input-output analysis arise here because all economies are multi-sectoral so that the internal and external links in eve the smallest regional economies are quite complex. In addition, the smaller the economy, the less readily available are the data required to construct the table.

In most input-output analysis, it is necessary to decide what might reasonably be included as recycled income. Most calculations adopt a "Type II" method whereby local expenditures by businesses and households are included but expenditures by government and investors, and by extra-regional actors (such as national government) are not. These last expenditures are excluded because they are deemed to be 'unreliable." In any case, if all expenditures were recycled (i.e. **a = 1**) the multipliers would be unrealistically large. Importantly, Type II calculations are clear-cut and straightforward, and by closing the model in different ways it is possible to understand the contribution of different types of transaction in an economy to its overall behavior. Although the timing of the downstream impacts are not made explicit in these calculations, it is usually implied that the full consequences of an event would be felt by the end of the first year after the event.

This Type II approach may be insufficient in accounting for the effects of economic disasters because, i) in many cases it may be necessary to take better account of the role of public and other income and expenditures, and ii) the timing of events may be critical after an event. Both are especially important in order to "explain" the behavior of an economy following a disaster, and to account for the distribution effects within economies, especially when these are mediated by government (for example, through welfare and relief programs). Other types of models, in particular econometric models, do include temporal effects, but are generally considerably more complicated to construct and solve, and require a very detailed and precise empirical situation. Moreover, their primary use is to forecast economic trends rather than the impacts of one-off events, which is the special forte of input-output models.

4.3 Transaction Lags and Delayed Impacts

The above input-output theory has been extended in a way which takes account of the time it takes for actors to adjust their expenditures to changes in their income (usually called transaction lags). This allows the behavior of all actors to be included and also allows the timing of events associated with a disaster and recovery program to be more easily introduced into the model. With this lagged input-output method, the increase over time in the impact of a single event or of series of events (comprising the disaster and recovery strategies) may be estimated. In this case, the impact up to a time horizon T is given by,

$$\delta \mathbf{Y}(\mathbf{T}) = \delta \mathbf{X}(\mathbf{T})/(1 - \mathbf{A}(\mathbf{T}))$$

where **A(T)** is the marginal vector of expenditures. One aim of the project is to show that this elaboration can improve the forecasting of the impacts following a major disruption to an economy.

Since the goal is to achieve the simplest useful method, several approximations will be tested. For the "full" method, the events leading up to the disaster, the disaster itself and the post-disaster recovery are fed into the model in a sequential fashion. This is usually on a year-by-year basis, although increments may be monthly for exploring the more short term effects of a disaster.

Thus, events in the first year T_1 contribute to a stream of events in following years, which are combined on an annual basis with the stream of events from the second year T_2 and so on, to provide the net impact in some future year T. Schematically,

$$\delta Y(T) = \delta X_1(T_1)/(1 - A(T_1)) + \delta X_2(T_2)/(1 - A(T_2)) + etc$$

The results presented later show that this approach may be necessary for a useful empirical prediction of the year-by-year impacts of a disaster.

The results will also show that, for some predictions, this expression may be approximated further. For example, to calculate the combined impact of the disaster and recovery at a given time horizon, the impact may be found as the sum of events taking place at some specified time before the horizon. In other cases, it may be sufficient to simply attribute the same horizon to all events. In the later empirical studies, the impacts calculated by each approximation are compared with each other and with the standard Type II method. In some cases, the approximated methods are used simply because the data are insufficient to test the more elaborate methods.

4.4 Application to Natural Disasters

The most frequent use of input-output methods is to assess the impact of one-off exogenous changes to the economy, such as a loss of demand for an industry. In the situation of natural disasters, the technical problems of calculation are compounded because the direct damage to the economy may be distributed across many external and internal links, thus making analysis more difficult than with conventional input-output studies.

The lagged method offers a useful way of addressing this complexity since it allows both the extent and the time phasing of the disaster and recovery strategy into the input-output table. In the event of a disaster such as an earthquake, a proportion of both the external (or exogenous) and internal (or endogenous) links of the economy will be dislocated temporarily or permanently. An event may be totally exogenous. Clearly, if only external damage is sustained, say, the loss of an important food export industry through flooding or pestilence, then **A** will be relatively unaffected. This reduces the level of economic activity throughout the region, even in those sectors not directly affected by the event as indicated by Figure 4-2. Even with an endogenous event, there may be only a temporary interruption in a particular endogenous exchange process (say, the rupture of a pipeline), whereby the effects of this event will ripple through the economy long after the damage has been repaired. If there is more extensive damage within the local economy, then feedback and local multiplier effects will be greatly reduced. With $\delta\mathbf{X}$ negative and **A** reduced, the entire local economy may spiral into decline as a result of feedback processes in the economy. Schematically, this may be represented by,

$$\delta \mathbf{Y}(\mathbf{T}) = \alpha\delta\mathbf{X}(\mathbf{T})/(1 - \beta\mathbf{A}(\mathbf{T}))$$

Here, the α and β represent the event matrix which describes the level and timing of the exogenous and endogenous changes during the disaster and recovery. In the most general case, the event matrix will be a set of tables corresponding to entries in the original input-output table which specifies i) the extent of damage to internal and external components, ii) the goal for recovery, and iii) the time scale for recovery. The details of how α and β are specified will obviously depend on the situation under investigation.

A tacit assumption in input-output modeling is that the economy is initially at or near "equilibrium" and that after a disturbance it will return to a new stasis with all accounts in balance in the current year. Since economies are constantly changing, in reality the events in any one year will always depend on the spill-over from the events of previous years. In effect, the "initial" situation is always disturbed. This problem of model initialization becomes explicit in lagged models. For this reason, the model tested in this report will be based on data from a

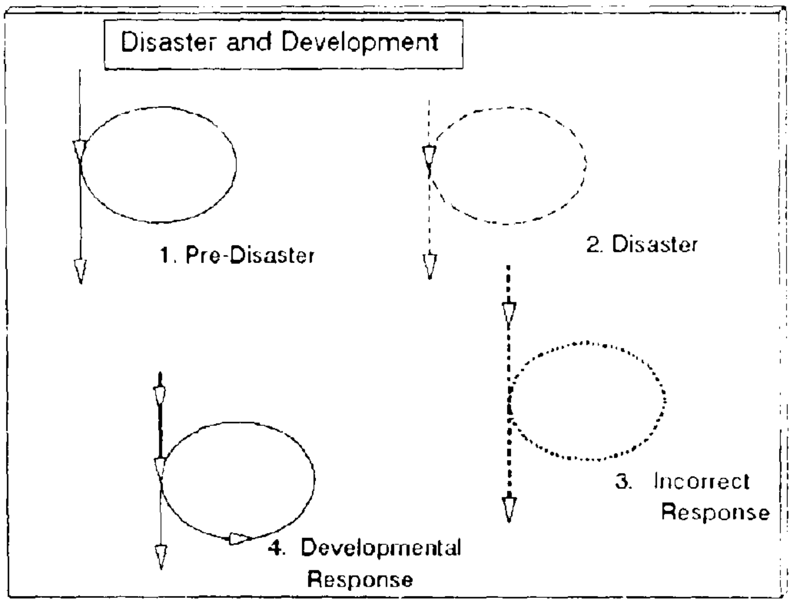


FIGURE 4-2 Disaster and Development

period of relatively steady and balanced growth, and the major disturbances (or events) will be introduced after a pre-event "settling down" period.

In most input-output analysis, the structure of the economy (as measured by **A**) is assumed to be fixed over the period of the disruption (for a period of as much as five to ten years). Thus, the multipliers calculated from **A** also are assumed to be unvarying. Often this is satisfactory even when the composition of the economy is changing. There may, nevertheless, be circumstances arising from disaster, or other on-going changes which must be accounted for in estimating the outcome of a plan. For example, the disaster may provoke untypical or rapid technical changes in sectors formerly using traditional production techniques. Again, one merit of the lagged method is that it permits these effects to be accounted for.

The main use of the model is to assist in the planning of appropriate recovery strategies. It is not unknown for inappropriate recovery strategies to contribute little to the inflicted society, or to lay the ground for a new disaster. For example, strategies which focus only on short term recovery may leave the region more dependent on external suppliers of raw materials, goods or capital (even reducing **A** further) or leave the economy with regional export earnings which are insufficient to support long run recovery. A more appropriate strategy would seek to balance the short term recovery against the long run need to strengthen and replace external income sources and rebuild and enhance linkages within the local economy. In other circumstances, a strategy may target particular economic goals but ignore social needs, or be too short term, or even too successful so that the society overshoots its capacity to deal with the pace of change, or sectoral and regional economic and demographic restructuring.

4.5 Overall Approach to Model Testing

The basic adopted approach for testing the model has been:

i) to construct a SAM model for the situation prior to the disaster using available data or adapt the previously constructed input-output table,

ii) to construct an "event matrix" which maps the damage caused by a disaster "scenario" onto the SAM in such a way that its implications can be assessed,

iii) to construct and apply a similar event matrix for the recovery program.

Since the ultimate aim of the project is to provide an easy-to-use planning tool, it is necessary that the model, and its data requirements and use are as simple as possible. Thus, two additional goals are:

iv) to demonstrate the utility of the matrix building and solving algorithms,

v) through repetitive building and testing to define the set of "expert rules" needed for the final system.

For present purposes, testing a modeling technique involves several steps:

i) showing that the model can represent the data, structure and behavior of the economy and track a known set of historical trends or scenarios,

ii) showing that the model can make useful plausible predictions of the outcome of planned or hypothesized future events,

iii) showing that detailed disasters such as the failure and repair of specific activities whether industries or lifeline systems (such as water supply) can be adequately represented.

From an empirical standpoint, the testing of the model therefore involves five considerations:

i) the empirical quality of the input-output table - for example, the table may be "full survey" (based entirely on statistics with minimal adjustment) or a mechanically updated table (based on aggregate surveyed accounts but with many details scaled using minimum information loss procedures) or a regional table (estimated using various location theory methods).

ii) the quality of the information about the "events," for example, the extent of the direct damage to the economy such as the fall in production capacity or its utilization in particular sectors or lifelines, the purpose and amounts expended by government and private agents during the recovery program, temporary or permanent changes in the technology or organization of the economy after the disaster.

iii) the quality of the empirical evidence against which the model is to be tested - including time series data both for the inputs to the model (such as earnings from exports, tourism, or development assistance) as well as the outputs (such as employment trends) which should be measured consistently over time. Further, the measures used should be consistent with each other and with those in the input-output table.

iv) the method used to solve the model - for example, whether events are combined on a monthly, annual or total basis, multipliers are calculated using conventional comparative static or lagged input-output methods.

v) the statistical or other criteria used to test the model - there are several mechanical and graphical tests which may be applicable, including a straightforward "eye balling" of the results.

vi) the details included in the table - if the model is to be relevant to the specific needs of natural disaster planning it must contain relevant details even though there may not be adequate empirical data to test these aspects of the model.

Each of these considerations requires some judgements to be made as to the quality of data or the satisfactoriness of the forecasts, none of which are unambiguous.

SECTION 5
THE "LABORATORY" DEMONSTRATION - ARUBA

5.1 Crisis and Recovery in Aruba

Aruba is small island 20 miles long by 6 wide situated 19 miles from Venezuela (see Figure 5-1). The Island today has a population of over 70 thousand, comprising people from over 40 nations. Formerly part of the Netherlands Antilles, Aruba achieved "status aparte" in 1986. Compared to most of the Caribbean, Arubians enjoy a relatively high standard of living.

While Aruba is seldom impacted by the earthquakes and hurricanes which regularly wreak great devastation on neighboring Caribbean Basin islands and countries, in recent years the Island has experienced "near misses" from hurricanes leading in 1990 to a fatal mud slide on one of its extinct volcanoes. The Island also lies on the edge of the earthquake prone region along the Boronoco Fault. Consequently, Aruba has an active Disaster Preparedness Committee which has identified a number of vulnerable locations, and has prepared a region-based emergency evacuation plan. The regional organization of the planning system is shown in Figure 5-2 and Figure 5-3, which also shows the location of the main regions, towns, and roads in Aruba.

Despite her relative good fortune with respect to natural disasters, over the last decade Aruba has suffered a dramatic economic decline of disastrous proportions. This situation followed from the close-down of her major industry - the Lago oil refinery. This oil refinery, a subsidiary of the Exxon Corporation, had been the principal source of income for Aruba since 1927. Before this time, the population had been relatively poor, eking out little more than a subsistence livelihood. At its peak during World War II, the refinery was considered the world's largest, employing some 8,000 immigrants from all over the world, attracted to Aruba along with many others by the prosperity on the Island. Figure 5-4 shows how the growth of employment in Aruba increased in tandem with the employment at the refinery. Even though this direct employment fell steadily as the refinery automated many of its operations after the war, the high salaries and taxes paid

FIGURE 5-1 Aruba Hurricane Tracking Chart

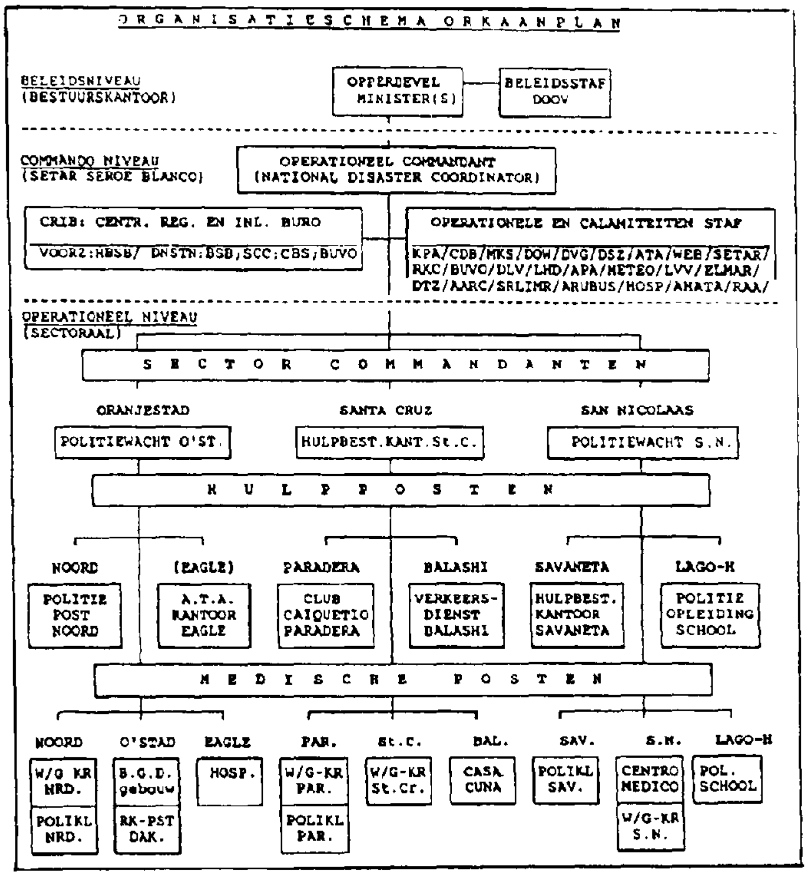


FIGURE 5-2 Aruba Disaster Preparedness Committee Organization

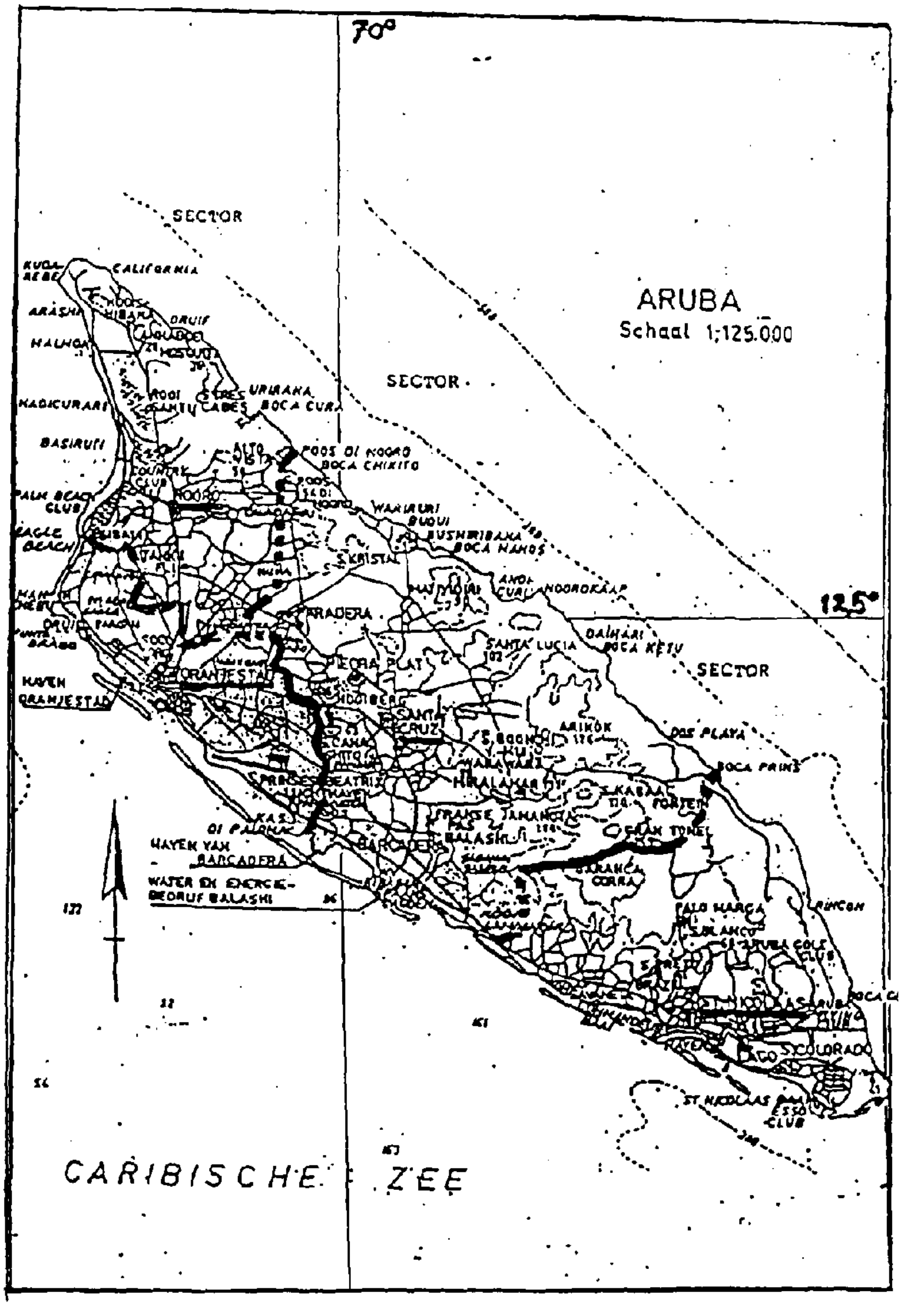


FIGURE 5-3 Aruba Disaster Preparedness Regions

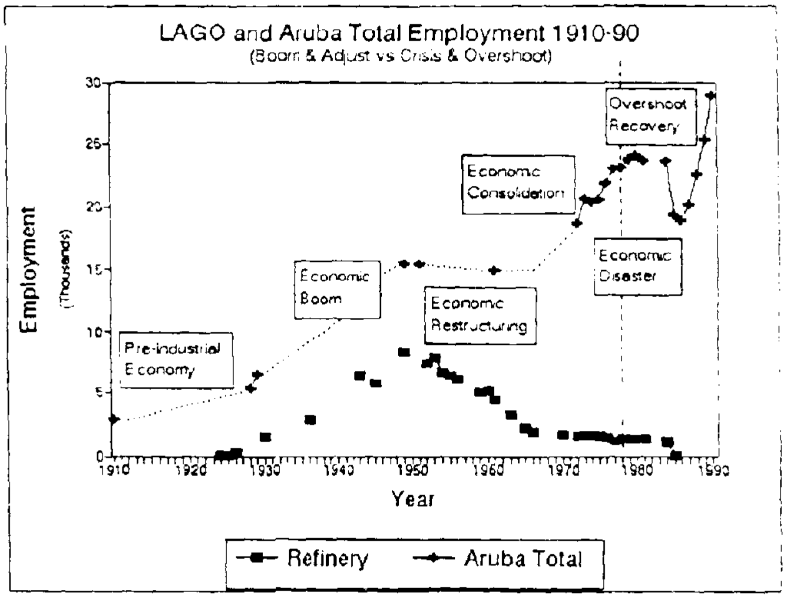


FIGURE 5-4 Aruba and Refinery Employment 1910-1990

by the refinery ensured its continuing importance to the Island, and Arubians enjoyed one of the highest living standards in the Caribbean.

Although, new activities, especially tourism, had begun to flourish in Aruba, when the refinery closed permanently in 1985, the Island lost her most important single economic activity, leading to disaster-level consequences for the entire economy. The importance of this multiplier effect in Aruba is seen from Figure 5-4. Even though the refinery employed less than 1,300 people directly at the time of its closing, about 6-8,000 jobs were lost overall. Unemployment on the island rose from a previous 5 percent of the labor force. The total loss in employment directly and indirectly arising from the refinery was 27 percent with a widespread expectation that total unemployment would reach 40 percent. It was speculated that a "spiral of decline" would lead to half the population leaving the Island (Croes 1986).

In the wake of this economic collapse, it was obviously important to create replacement jobs. The principal means available to Aruba was to accelerate tourism development. An over-riding initial planning question was simply, by how much would tourism have to be expanded to offset the lost employment? Because tourism has a much lower job "multiplier" than oil refining, in order to replace the lost jobs, the recovery plan aimed to double the size of the hotel sector above its 1985 level by the year 1990. This goal was more than fulfilled and the Island experienced a remarkable economic recovery.

While the disaster itself was obviously quite different from a natural event, its suddenness, the results for the economy, and the recovery planning undertaken were not dissimilar. As Figure 5-4 shows clearly, the sudden shutdown of the refinery led to a very rapid decline in employment. This stands in contrast to the stagnation brought about in the post-war period when the refinery steadily reduced employment over more than a decade, and a decline in overall employment on the Island was offset through the growth of other industries (primarily tourism). The relative magnitude of the disaster for the economy was as great as that experienced in most natural calamities and, indeed, the refinery close down could well have resulted from a natural disaster. Obvious differences are the specificity of event - the total close-down of a single activity rather than the distributed impact across many activities as is usually the case with earthquakes and hurricanes - and the somewhat longer notice provided - months rather than days or minutes. In both cases however the full impacts are felt directly or indirectly across the entire economy, and there is insufficient time for adequate proactive efforts. Finally, it should be noted that, although a human-made event is used to illustrate the approach, many external economic events are little better predicted than natural disasters - certainly, at the time, the Island Government professed great "shock" at the shutdown.

The results of such spontaneous recovery plans are also unpredictable, and sometimes bring problems as severe as the disaster itself. Most commentators considered the Aruba recovery plan to be extremely ambitious. IBRD86, for example, notes that "it must be recognized that the targets are highly ambitious in terms of achieving so large an increase in visitor numbers, of attracting from abroad the capital required for the expansion of visitor capacity, and being able to construct this capacity in so short a period" and "reducing unemployment to 15 percent by 1995, about half the present level, would be a considerable achievement." A special survey of tourism prospects in Aruba (by Panell, Kerr and Foster) was equally pessimistic, pointing to the high cost of labor on the Island. The subsequent recovery was therefore quite remarkable. Unfortunately, it may have been actually too successful, and today, because of an unforeseen economic "overshoot," there are many emerging post-recovery complications, not least a massive wave of new legal and illegal immigration to the tiny island, and instability in the balance of payments and public sector expenditure programs. Such imbalances are not untypical of the aftermath of a natural disaster, and Aruba's experience lends credibility to the argument that disaster preparedness planning should be seen as part of the ongoing development process and be especially sensitive to the needs of sub-populations, sectors and regions.

Despite her small size, Aruba has well defined geographic regions, which might be expected to be differently affected by most foreseeable disasters. This was certainly the case with the closure of the oil refinery. Nevertheless, there are also strong dependencies between the various regions of the island in terms of lifeline systems (such as water, electricity) and a good deal of daily commuting along the length of the Island. Depending on the circumstances, applications of the

SAM for disaster management would focus on the specific region impacted by the disaster, or sub-divide the island into the distinct regions in order to account for the inter-connections and dependencies between them. To address these issues is also to tackle the problem of how to construct disaster planning models for small districts within larger regions or countries.

The Arubian population comprises people of many nationalities and backgrounds. Again, this is very often true of areas impacted by natural disasters. Moreover, the literature shows that it is necessary to account for such divisions in planning for areas subject to natural disasters. Typically different economic groups, because of the areas in which they live, the type of buildings they live in, the work they do, or their access to supportive social networks or public relief, are all affected differently by disasters and the recovery effort. In order to understand these mechanisms, the present project has investigated how different populations in Aruba responded to the disaster and recovery, and the outcome for the Island's demography.

As with any "disaster technology" some experimentation is needed away from the site of an on-going trauma. On balance, the circumstances of Aruba offered a relatively straightforward set of events and policy responses against which to test the SAM methodology. In fact, it is often difficult to test economic models precisely because a "clean" situation where the trends one is attempting to explain in terms of a particular event, are not also perturbed by many other changes. Beyond this, the required data may simply not be available, especially since monitoring economic and social developments is not the foremost priority during a natural disaster. Even in Aruba, the data are far from ideal. For example, public concern with both the economic crisis and recovery process contributed to two changes of government, which in turn led to discontinuities in the collection and processing of statistics. This situation was exacerbated by the Island entering into a pre-independence "Status Aparte" with the consolidation of Central and Island administration in Aruba. With each change, crucial data and other valuable information was lost. On the other hand, the new arrangements, in conjunction with missions from international agencies (World Bank, IMF, UNDP and UNESCO) and the Central Bank of Aruba, have led to a general improvement of the quality of island based data and analysis in Island Government Departments.

Since tourist-dependent economies are especially vulnerable to natural disasters (witnessed, for example, by recent events in St. Croix), the safety of this industry is now a primary concern of the Arubian Disaster Preparedness Committee, as indeed it is to many islands and disaster-prone regions. Consequently, special attention is focussed on the situation of this industry in the present study.

For the various tests, several versions of the SAM based on 1979 and 1990 data are used to re-calculate the impact of the disaster on the Island, and to re-estimate the resources required for economic recovery, as well as current post-recovery plans. As far as possible, the forecasts from each of the models is matched against the relevant disaster-recovery scenario experience of Aruba over the last decade. Although disaster preparedness in Aruba is organized on a regional basis - in general - in Aruba and elsewhere - the appropriate way to evaluate the impact of a natural disaster will depend upon the type of disaster and the community affected. It may be most appropriate to evaluate the impacts from any one of several perspectives - regional, sectoral, social, or cultural. The present project shows that it is possible to construct models with all of these subdivisions rather rapidly for Aruba using the available data.

Overall, Aruba has provided a valuable opportunity for testing the SAM techniques in view of i) the recent history of the Island, ii) the relative availability of data, iii) an expressed interest in the project by the Disaster Preparedness Committee, and iv) the project team's familiarity with Aruba including the construction of a SAM for the island.

5.2 The 1979 Aruba SAM Model

The 1979 Aruba SAM model was constructed in 1982-3 but was based on data for years around 1979, this being the most suitable at that time. The method used to construct this model are described elsewhere - it is relevant to observe that the quality of the data are, on balance, comparable in quality to that used for most of the region-level input-output tables in North America and Europe which are used in practical policy making.

The supply side and factor cost entries of the 1979 SAM were based on the 1979 and 1980 Surveys of Business by the Central Bureau of Statistics of the Netherlands Antilles. This covered most large firms (more than 10 employees) and a 10 percent sample of small firms. The principal inter-industry transactions, between the oil refinery and public utilities and the tourism sector and local industry, were based on company records and the 1980 Aruba Tourism Plan. Demand side entries were based on the 1973 Household Survey updated by Consumer Price Index data, and Public Expenditures were based on budgeted accounts of the Island and Central Governments. Trade and financial flows data were provided by the Central Bank of the Netherlands Antilles (Aruba). Other data were provided by the Labor Department and the Department of Economic Affairs.

By the standards of regional input-output model construction in metropolitan countries, the Aruba social accounts correspond to a "full survey" input-output model even though some entries were imputed from other Caribbean islands, and not all data were surveyed in a single year. In general, it is obvious that since data come from different sources or are collected at different times, they will not all agree. For example, the income declared by households to the Tax Department, or reported in the Census of Population is unlikely to equate with what is recorded in the Survey of Businesses, even if each was available for the same year. In general, it is necessary to "reconcile" the various data to match the most credible data for a given year. It is emphasized, therefore, that despite the desirability of using surveyed data in the table, the uncertainties which remain may lead the model to over- or under-estimate the impacts of a disaster and subsequent recovery. The possible magnitude of these uncertainties is now briefly considered.

First, there are errors which arise in reconciling the data within a given year. For example, the 1979 Survey of Businesses sought a 100 percent sample of large firms (10 or more employees) and a 10 percent sample of small firms. Since the large firm sample was reckoned to be complete, the small firm sector was scaled to bring total employment figures by activity up to the official totals, as shown in Table 5-I. Typically, this involved increasing the number small firm samples by between two and five, a considerable amount. The degree to which this affects the final results depends on how different are the technologies used in the small and large firm

TABLE 5-I Variations in Wages Shares by Sector and Size of Firm

Variations in Wage to Output Ratios by Sector

Variation	size of firm			scaling method		over time		
Private		1979					1980	
Sector	Large	Small	Survey	Official	Informal	Large	Small	Survey
Farms/Industry	4.5	19.6	6.3	5.5	5.9		8.8	8.8
Oil Refining	1.7		1.7	1.7	1.7	1.4		1.4
Utilities	19.3		19.3	19.3	19.3	21.0		21.0
Commerce	41.4	38.5	41.2	40.0	39.7	40.0	38.2	40.0
HORECA	8.4	5.6	7.4	7.2	6.8	8.1	6.4	8.0
Communications	28.1	13.0	26.6	27.0	26.6	31.5	41.6	31.8
Services	42.5	21.5	37.2	30.5	28.6	31.0	33.2	31.1
Total	4.6	9.2	4.8	5.3	5.7	3.0	17.0	3.1
Employment	12539	4018	16557	19814	23420			

Variations in Wage to Output Ratics (Relative)

Private		1979		Total			1980	
Sector	Large	Small	Survey	Official	Informal	Large	Small	Survey
Farms/Industry	0.8	3.6	1.2	1.0	1.1		1.6	1.6
Oil Refining	1.0		1.0	1.0	1.0	0.8		0.8
Utilites	1.0		1.0	1.0	1.0	1.1		1.1
Commerce	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
HORECA	1.2	0.8	1.0	1.0	0.9	1.1	0.9	1.1
Communications	1.0	0.5	1.0	1.0	1.0	1.2	1.5	1.2
Services	1.4	0.7	1.2	1.0	0.9	1.0	1.1	1.0
Total	0.9	1.7	0.9	1.0	1.1	0.6	3.2	0.6
Employment	0.6	0.2	0.8	1.0	1.2			

Note: Based on 1979 and 1980 CBS Survey of Business sectors, since this will determine how much income is recycled in the local economy, and how many people will be employed for a given increase in output. In Aruba, the ratio of wages to output (a crude measure of the share of income which is recycled) and the employment output ratio both vary by up to a factor of two between the large and small firm sector. Because of this, scaling the data to the official employment figures changes sector wide technologies by up to 10 percent. Since the actual size of the small firm sector in Aruba is not well known (because it overlaps with the informal sector), the errors in aggregate technologies are likely to be of similar magnitude.

Second, comparing samples between years also gives some indication of the possible error arising from table construction. In Aruba, the Survey of Businesses was repeated in 1980. There are differences of around 20 percent between the measures of technology in the 1979 and 1980 samples, despite the fact there were no major changes in the Island over this period. The differences arise from variations in the actual firms sampled, year-to-year shifts in the fortunes of individual firms, and in some cases the movement of firms between size categories. Obviously, then, the structure of an Aruba table constructed from the 1980 sample would differ from the 1979 SAM and would provide somewhat different results. It should be noted here that input-output calculations usually assume that the structure of an economy is fixed over the period that the impact is measured, and assumes it to be initially in "equilibrium."

Despite the above, the key structural characteristics of the Arubian economy are unambiguous. The SAM for Aruba presented in Table 5-II shows that in Aruba, as in most islands and regions with "open" economies, there are relatively small feedbacks via the production side of the economy. The major contributions are the mutual purchases between the lifeline sectors - electricity is generated using fuel from the refinery, electricity is then used to distil sea water, and water and electricity are then purchased by the refinery. Since almost all industrial and domestic water used on the island is obtained in this way, this lifeline system is vital to the economic health of the Island. This lifeline system apart, most feedback from and expansion (or decline) of production comes through household and public expenditures being returned to the local economy.

TABLE 5-II Aruba 1979 Social Accounts

Social Accounts Aruba 1979 Amounts in AF million

Account		F1	F2	F3	F4	F5	F6	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total
		<-- Special Activities --->						Production Activities							Factors of Production						Households			Government		Investment		External						
F1																																		
F2																																		
F3	Lifeline Activity or Networks																																	
F4																																		
F5																																		
F6																																		
1	Agriculture/Industry							20	8	7	11	1	3	27							37	87		6		1	8	4	3					222
2	Oil Refining							4		34	8	2	1	7							3	7				16			3943					4025
3	Utilities							2	19	2		1	13	4							9	16		1										67
4	Construction							8	25	0	0	5	0	20							1	5		2	2	4	4							75
5	Commerce							36	5	4	6	0	2	16							67	163		3		0	1	28	26					358
6	Hotels and Restaurants							0	1	0	0	0	0	11							5	9				1		115						143
7	Services							17	9	6	5	7	24	38							17	53		39			1	29	34					279
8	Unskilled Labor							9	11	2	10	14	14	11								11		6				10						98
9	Midskilled Labor							7	26	4	11	21	16	21										26				4						136
10	Skilled Labor							5	32	6	8	12	8	43										57										171
11	Depreciation							3	38	6	5	8	7	13										2										82
12	Operating Surplus							11	16	8	5	158	19	58																				275
13																																		
14	Poor Households														62	35	7		26					7						3				140
15	Rich Households														31	95	156		139					18						26				465
16	Firms																	80	110															655
17	Government							9	3	-14	3	30	4	1	2	3	3				2	63	71				2							182
18	Households Capital																				-3	40					1							38
19	Firms Capital																						119	26		15				3				163
20	Government Capital																							-25		4				36				15
21	Tourism																				3	12								193				208
22	Imports/Exports							88	3551	4	2	101	31	8												123								3908
23	External Finance								281															13	49			16	-98					261
24																																		
25	External Lifelines																																	
	Total Expenditures							219	4025	69	74	360	142	278	95	133	166	80	275		141	466	190	181	51	164	17	206	3908	261				11501
	Employment by Sector							1087	1293	652	2500	4451	3271	5845										4589										23688

Note: Shaded area is reserved for details of selected activities such as lifelines or recovery programs

SAMIMP79 WQ1

Although some new and more reliable data for 1979 are now available for Aruba, the spirit of the present exercise suggests that only data which was available prior to the disaster be used. Therefore, for the initial demonstration here, few changes have been made to the original social accounts, primarily to reorganize the data into a form more easily compared to the data which is subsequently used to scale the model to the available 1990 data. The version of the 1979 model to be used in the initial forecasting exercises is shown in Table 5-II. The table shows the main activities for which data are more or less regularly available. The shaded area is reserved for additional information pertaining to specific sectors or recovery projects.

5.3 Pre-Event Forecasts of the Refinery Shutdown

The 1979 Aruba SAM was used to calculate the island-wide impacts of a hypothesized shutdown of the refinery and the necessary increased levels of tourism to facilitate economic recovery, as a part of the preparation for the First Aruba Macro-Economic Plan. (Because the results were judged by the Arubian authorities to be inauspicious for the forthcoming independence negotiations with Holland, they were presented only in the 1982 preliminary draft of NDP83). The results are shown in Table 5-III.

There was obviously no data available at that time to check the predictions, although post-facto it appears that the tentative calculations were reasonable, and in line with the actual loss in employment. In addition, the above findings suggest that it would be necessary to expand tourism by about 80 percent in order to compensate for the employment loss arising from a total shutdown of the refinery. This exercise showed that even the simple SAM model could give reliable aggregate results. The present project attempts to provide a more comprehensive and rigorous testing.

TABLE 5-III Aruba Plan Forecast of Refinery Shutdown (1982)

Item (NAF million)	Base Year	Refinery Shutdown	Tourism Collapse
Output	5711	1215	607
Wages	381	258	171
Surplus	595	211	111
Taxes	74	28	11
Investment	180	93	51
Net Income	660	377	176
Jobs	23994	17945	10316

Source: Aruba Long-Term Development Plan (Draft, May 1982), Tables 3.1, 3.2 and 3.3. Net income is receipts after repatriation.

5.4 Appropriate Testing Criteria and Precision

In beginning to demonstrate the model, this report focusses on the following:

i) using a modified version of the previously constructed Aruba SAM for 1979 to "predict" the employment and GDP data for the Island from 1979 to 1990.

ii) constructing a new SAM for the Island for 1990 by scaling the 1979 model against available more recent data,

iii) using this 1990 model to simulate the consequences of various plans and policies.

Although this agenda may appear straightforward, in practice it turns out to be very complicated, if not impossible, to fulfill in a conclusive way. Indeed, because of the difficulty in the practical situation of most small economies and regions of separating out the effects of individual economic events, there appear to have been no other such detailed efforts to test an input-output model, in Aruba or elsewhere. To this extent, the present project also serves to test the reliability of input-output models in general.

Standards of precision vary and "what is acceptable" depends on data quality and policy applications. Since the aim of the project is to develop adequate planning tools speedily and cheaply, this determines that the approach to construction and testing must be somewhat opportunistic and pragmatic. With respect to construction, the method must be flexible, and be able to incorporate the judgements and requirements of the policy makers, planners and disaster victims involved in the recovery process, even when these contradict "statistically significant" data. With respect to testing, the quality of the available data for Aruba does not justify using a statistical testing procedure, results will be evaluated simply by comparing the empirical and forecast trends.

While the present project does not require that the Aruba SAM constructed is of sufficient quality for policy purposes in Aruba, it is required to demonstrate that the method enables a satisfactory policy oriented disaster planning model to be built. Similarly, it is necessary to test the model against actual past and proposed policies and concerns, and to check its forecasts against those of other governmental and international agencies (such as the IMF), and to report any policy relevant results. This may be considered a minimal quid pro quo for the privilege of conducting research on the Island, and gaining the cooperation of the individuals concerned. The data used in the model and the findings presented here have been discussed with the relevant authorities in Aruba. One test of a "policy" model is that policy makers should express some degree of confidence in its results. The discussions with the Disaster Preparedness Committee and the Central Bank of Aruba have been especially encouraging.

It is evident that in the practical circumstances of constructing a SAM for a region in the throes of a natural disaster, there would be little time or opportunity to collect fresh data (except on the extent of damage). Further, model construction will be based on whatever statistical information is on hand and will have to depend on the judgements of local officials. As far as necessary, the construction of the new Aruba 1990 SAM has attempted to simulate the constraints on time and data in a disaster situation. In particular, the initial data collection and model construction for the 1990 SAM was deliberately restricted to a matter of weeks. In contrast, the testing of the model has taken several months.

Obviously not all circumstances of an ongoing disaster can be replicated. Generally, conditions are likely to be far more difficult. In some cases, however, it may be that the speedier model preparation would be facilitated. For example, under normal circumstances, government departments and private agencies may be hesitant to release data; but that following a disaster, some information may be more readily available as all groups rally to the recovery effort.

5.5 Relevant Social and Economic Categories

For many purposes, including especially disaster relief planning, it becomes necessary to incorporate details in order, for example, to examine particular structures, sectors or population groups, and their relationship with the rest of the economy, and how each might be mutually helped. Even so, since detailed models soon become cumbersome it is necessary to restrict detail to the essentials. The aim, of course, is to devise the simplest useful tool.

With respect to the predictive ability of models with different levels of detail, it is sometimes the case that very detailed multi-sector models do not predict aggregate trends (such as GDP, Gross Domestic Product, or total employment) any better than do aggregate macro-models simply because they are more detailed. However, the SAM model for Aruba might be expected to predict gross trends in Aruba better than the four equation IMF model currently used by the Central Bank, because the latter does not account for even such important details as the difference between the import requirements of hotel construction and government investment or household consumption.

For Aruba, in addition to the tests of the basic model, there are several possibilities for sub-dividing the economy and population beyond the categories originally included in the 1979 model, using data from the 1981 Census (most of which was not available until after 1983). In order to make results more relevant to the evaluation of natural disaster recovery planning, the industrial divisions of economy may be divided according to the size of businesses, the economy sub-divided according to its major geographic regions, or by the skills and background of each of its principal population groups. All are relevant to the aftermath of a natural disaster, and to subsequent re-structuring and development. The literature shows that the most important economic and demographic features of a region are correlated with its geography. Similarly, the informal sector is an important source of income, especially to low income and minority households who are often the most seriously affected by a disaster. For the present demonstration, the Island is sub-divided in each of the following ways.

i) **Basic Social Accounts (1979):** island-wide economy with standard sectors with households subdivided by income
ii) **Regional Accounts (1979):** four inter-linked regional economies with standard sectors and aggregated households

iii) **Cultural Accounts (1979):** island wide economy with sectors sub-divided by size of firm and households sub-divided by economic-culture

iv) **Social Accounts (1990):** island-wide economy with standard sectors with households subdivided by income

The most detailed tests will be carried out with i) and iv). The classifications of ii) and iii) are used to demonstrate the importance of alternative classification schemes. The additional information required to construct the Aruba Cultural Accounts Matrix (CAM) and Regional Accounts Matrix (RAM) were based on the 1981 Census of Population (published after 1983), information from the Aruba Chamber of Commerce and the Department of Social Affairs, and the 1987 Survey of Businesses by the (Aruba) Central Bureau of Statistics. Unlike the original 1979 SAM, the main aim with these models has been to develop and demonstrate the "mechanical" scaling methods to be incorporated in the expert system and illustrate a range of potential applications, rather than to establish detailed empirical models for the Island of Aruba.

5.6 Quality of Trend Data (1979-1990)

The possibilities for testing predictions of any model are limited by the available historic data. Indeed, the island of Aruba was selected as the laboratory demonstration because,

i) it offered a reasonably "clean" situation of a single disaster affecting the economy of a well defined region,

ii) Aruba is both and island and a nation, so more data are available than for most other similarly sized economies and populations

iii) the data in Aruba are relatively reliable and comparable in quality to other small nations, regions and islands.

Despite this, the principal problem in testing the predictive performance of this model has been to assemble a satisfactory historical record. The principal published sources used are summarized in Table 5-IV. Despite the apparent wealth of information, in order to provide a satisfactory data base, certain gaps in the historical record, ambiguities and biases had to be resolved.

Although there is no disagreement in these reports that the shutdown of the refinery was a "disaster," unambiguous information as to its impact are not available. It is not difficult to find comments such as "There are no reliable statistics on employment, labor force participation rates and unemployment.... the labor statistics may contain an error of as much as 5 percent (World Bank, The Economy of Aruba: Adjusting to Changing Conditions, May, 1986, IBRD86) or "Available data pertaining to the finances of the Island Government..are not uniform, they are sometimes based on cash, or the payable, or the transactions basis" or the "virtual absence of GDP data for Aruba" (IMF, Financial Balance of the Island of Aruba, June, 1985, IMF85). In practical terms, the assessments by the international and Island government agencies about the quality of official statistics in Aruba are certainly pertinent for the fine tuning of balance of payments and government deficits which is often the primary concern of these agencies. Despite these remarks, the recommendations for recovery in the reports were made on the basis of the data available at the time of the crisis and were used in formulating the Island's recovery plan.

While such comments paint a somewhat bleak picture, the annual data for Aruba are not worse overall than the national time-series statistics for many high income developing countries, nor worse than those for many small regions in metropolitan countries. For example, while employment statistics in localities in the United States are probably better than in Aruba, annual data on population flows are non-existent and detailed inter-regional trade and population flows data, are virtually unknown. For Aruba, a more pervasive complication is that there are often several seemingly contradictory measures for the same item, and during the last decade, some data for some years are simply missing.

These complications arise for a variety of institutional reasons. In particular, in 1986, one year after the shutdown of the refinery, the Island became independent from the Netherlands Antilles

TABLE 5-IV Published Sources Used in the Study

Table 10. Summaries of Principle Published Sources.

Acronym	Brief Summary
CBS72-	CBS (Central Bureau of Statistics of the Netherlands Antilles) reporting DOL (Department of Labor) statistics.
PlanDZ	Spatial Development Plan (1981-90) prepared by Fundashon Desaroyo Planea in 1981 in conjunction with DECO (Department of Economic Affairs) with regional employment data based on Tax Department records for 1979 and projections to 1990.
NDP83	The National Development Plan prepared by ITEO (Institute for Applied Economic Analysis) with DECO to coordinate development projects in preparation for independence negotiations with Holland. Estimates from 1972 to 1980 are largely based on CBS and DOL and the Aruba Tourism Plan. Some figures are based on preliminary 1981 Census of Population results. Employment (and GDP) trends up to 1990 were based on a 3 sector input-output model.
CBS83-	Census of Population from the CBS(NA) for 1981 detailing demography of the Island in that year.
DECO84	The first attempt by DECO to estimate the direct impact of the impending shut down of the refinery. Estimates of total employment and revenue impacts up to 1986 based on macro-economic model from the UNDP-UNDTC (United Nations Development Program - Office of Technical Cooperation).
DECO85	A short-term financial cost-cutting adjustment strategy based on the UNDP model with some projections to 1988.
IMF85	Balance of Payments impacts prepared by the IMF (International Monetary Fund) with the Central Bank of the Netherlands Antilles using a simple 4 equation IMF macro-model with estimates of economy-wide aggregate and public finances, and projections of possible tourism expansions and government and public enterprise cut-backs to 1988.
IBRD86	Similar and more extensive proposals from the IBRD (International Bank for Reconstruction and Development, or World Bank) on measured to deal with the crisis, in cooperation with DEACI (but rejecting their data).
NDP86	National Development Plan 1986-90 by DEACI (Department of Economic Affairs, Commerce and Industry, formerly DECO), with a revision of projections to 1990 for the proposed Tourism Plan.
DOL86	A one-off register by the Department of Labor (DOL) of unemployed by region and education.
DEACI87	An attempt to fill the gap in employment statistics for 1984 using Tax department data.
CBS87-	General statistics from the Central Bureau of Statistics (Aruba) omitting years from 1982 to 1987. Also a survey of businesses and employment by sector and region.
IMF88	IMF report noting the "dramatic" recovery warning of the danger of "over heating" of the economy and recommending urgent demand management measures.
DOL89-	Mini-surveys of by the CBS (for 1986) and subsequently by the DOL of employment in key growth sectors and work permits. Used as the basis for most recent employment forecasts.
UNESCO90	Data and projections concurring with IMF concerns.
IMF90	IMF report emphasizing dangers of inflation and bottle-neck in labor supply through immigration restrictions. Data to 1990.
CEP91	Government of Aruba (draft) Capital Expenditure Program designed to coordinate development projects with financial projections to 1995, proposing a moratorium on further tourism development.
CBA91	Annual Report of the Central Bank of Aruba (CBA) reporting data similar to the IMF.

(an island federation, now comprising Bonaire, Curacao, St. Eustatius, St. Martin, and Saba). Former Central Government functions in Aruba were consolidated into the Island Government. In this transition, ministerial responsibilities, personnel, survey instruments, and definitions were changed. Some data were simply "mislaid" or retained by the Central Government. A similar phenomena arises each time the party in Government in Aruba changes. This occurred twice during the period of crisis. Lastly, attempts by the various international agency missions to the Island to assemble or re-construct data usually lead to revisions of earlier estimates. Beyond this, a recurrent feature of small nations is that the best technically qualified public officials often move to the private sector or are recruited by international agencies. A considerable effort was put into gathering the information with the assistance of the relevant agencies, personnel, and ex-officials, and the Aruba National Library. Even in 1991, when this research was conducted, the data situation was unresolved and controversial. For example, a senior official in the Labor Department considers that the "employment data may be in error by as much as 25 percent," a view which is rejected by an equivalent official at the Central Bank of Aruba. (The fact that the more pessimistic view may be linked to a strong desire by the Labor Department to upgrade its computer facilities, while the Bank is obliged to make prescriptive forecasts, may provide some insight into these differences of opinion).

In practice, the major structural changes arising from a disaster could be forecast with relatively poor data. However, to demonstrate the detailed predictive abilities of the SAM demands a more reliable and extensive set of data. For example, in order to explore whether the model predicts well the trends in employment by sector, occupation or region, it is necessary to have regular survey data for the periods before and after the disaster. It is preferable, for example, that definitions are consistent between sources and across time periods. In most instances, for the Arubian economy as whole, it has been possible to reconcile employment data, and even to estimate the extent of unofficial informal sector activity and illegal employment, sufficient for the present exercise. Unfortunately, this has not been possible for regional employment estimates which appear to be quite inconsistent. Similarly, reliable data on the timing of event are also needed to clarify the relative merits of different possibilities for model construction and solution. This is necessary, for example, to help evaluate details which may add to model performance, but require a more elaborate calculation, such as the use of the time-lagged input-output method. In principle, this is possible on a month-by-month or even a day-by-day basis. The model has been tested to the limits of the data and time available.

5.7 Planning under Crisis - Models and Institutions

Although the broad outlines of the consequences of the shutdown and recovery are evident, a considerable effort is required to establish a usable data set against which to test the impact model. Some indication of the general sense of empirical chaos and economic uncertainty in Aruba immediately prior to, and after, the shutdown is seen from Figure 5-5 which shows all the available Gross Domestic Product (GDP) estimates and forecasts during the period 1979-1990. These data have been extracted from a range of reports by Arubian government departments and international agencies as described later. They are measured in Arubian Florins (AFl).

The uncertainty is especially apparent with respect to the forecasts for the GDP forecasts shown in Figure 5-6. Even after all GDP values have been adjusted to constant values (i.e. deflated to AFl 1979), there is still considerable variation in expectations during and after the crisis. The forecasts of employment shown in Figure 5-7 are less varied, but were essentially made incrementally for a few years at a time, following the constantly unfolding expectations for the recovery. All these forecasts (except NDP83) took into account the shutdown of the refinery. Obviously none were based on a precise knowledge of what the actual level of hotel construction and tourism revenues would turn out to be, although a general goal of "doubling tourism by 1990" was set, this appears to have been a moral boosting exercise and it is fair to say that most observers considered this target to be exceedingly optimistic. The GDP forecasts before, and immediately, after the closing of the refinery painted a very gloomy picture for the Island's future. The DEACI84 forecast, for example shows GDP falling to nearly Af 400 million in 1986, and even the IMF85 and NDP86 forecasts setting out the recovery plan predicted that GDP in 1990 would be below Af 550 million, still well below the 1979 figure.

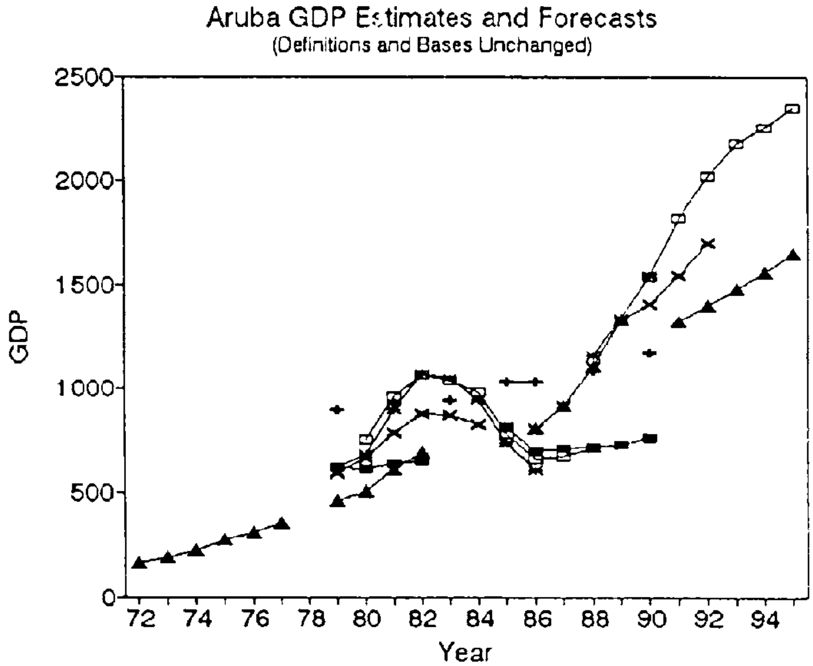


FIGURE 5-5 Aruba GDP Estimates and Forecasts

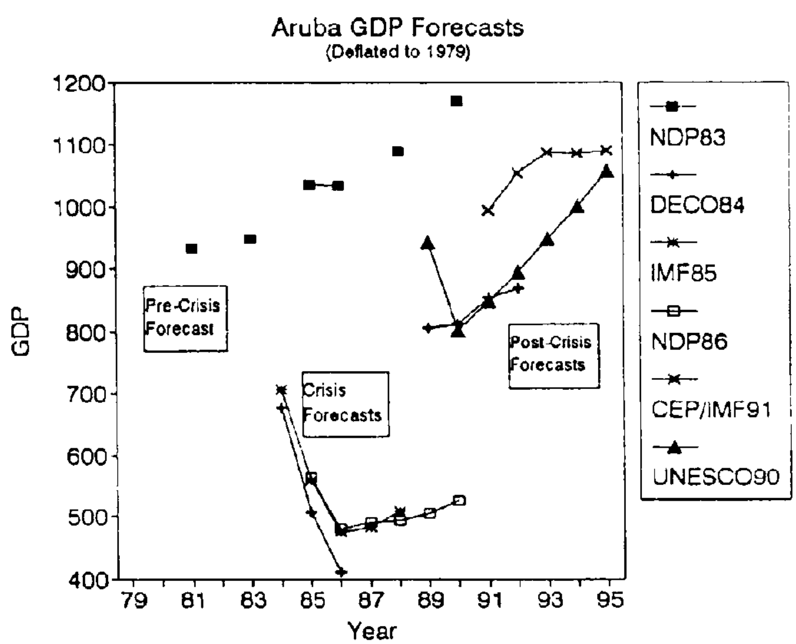


FIGURE 5-6 Aruba GDP Forecasts (Deflated)

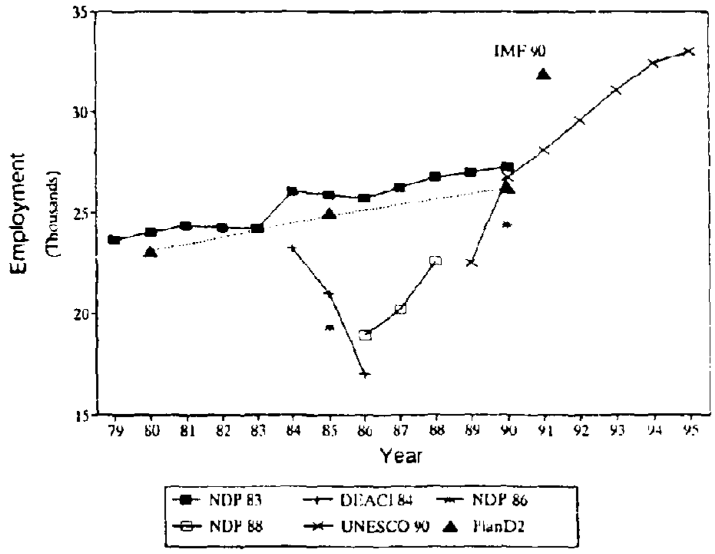


FIGURE 5-7 Employment Forecasts (1977-90)

The corresponding employment forecasts made during 1984-6 suggest the number of jobs on the Island could fall to as few as 17,000. The recovery plans deliberately sought expansion through tourism because it is a very labor-intensive activity. Projections for employment were therefore more optimistic than those for GDP. The NDP86, for example, suggested that employment might reach 24,000 by 1990. The IMF85 suggest that employment by 1988 would be 20,700, still some 2500 short of the 1984 level.

As noted above, the recovery was dramatic and well beyond the expectations of the forecasts. With support from the international lending agencies (most especially, the IBRD), and with tough marketing by ministers, but primarily by guaranteeing investors against loss, the successive Island governments persuaded international financiers to build new luxury hotels on the island. The key to their success appears to have been the tactic of claiming that Holland would underwrite the losses (whatever, the Kingdom's stated policy). With this Dutch connection assured, once the first major deal was struck, "the money kept rolling in."

By 1988 it became apparent to the IMF that the economy was moving rapidly out of recession and instead had looming problems of "overshoot." With a structural balance of payments deficit and a politically unacceptable level of immigration and change, the Government in power was voted out of office. Belatedly, by 1991, the new Government proposed a moratorium on new hotel construction in its Capital Expenditure Plan (CEP91).

The most recent forecasts for the Island beyond 1990 in CEP91 expect the Arubian GDP to increase from the present AFl 1,000 million, but level off at just below Af 1,100 million by 1995 when the moratorium on tourism expansion takes full effect. (By this time, according to the forecasts from the 1990 Aruba SAM model, the employment on the Island may well have climbed to 25,000 above the 1986 level).

Over the last decade, although at least four economic planning models have been developed for Aruba (by ITEO, UNDP, IMF and the CBA), none appears to have been used effectively to guide the recovery plan. Even so, only in part, did the lack of reliable empirical base contribute to the inability of the Island government to measure the effects of the crisis, or plan for a more balanced recovery. Equally important for explaining the failures of forecasting are institutional factors related to the process of independence, the crisis itself, and the internal workings of government, and its administration. Obviously, these are not variables of the disaster planning model, but unless a model can be well situated within the policy process, it is unlikely to be useful, whatever its forecasting capability.

SECTION 6

EMPIRICAL ISSUES - ESTABLISHING HISTORIC TRENDS

6.1 The Disaster and Recovery Scenario

The basic "scenario" used to evaluate the model is as follows:

- **Pre-Disaster:** In the period from 1979-85 the Island of Aruba received especially high corporation taxes from the oil refinery and Government spending increased steadily. In this period, tourism also was growing rapidly. However, in 1983, with problems in the neighboring Venezuelan economy, income from tourism began to fall, and by 1984 the Island's economy also began to stagnate - even prior to the shut down of the refinery.

- **Disaster:** When the oil refinery closed in 1985, Aruba lost its single most important economic activity. Although the refinery employed only about 1300 people directly at the time of the shut-down, some 6000-8000 jobs were lost overall and many people left the Island. Unemployment on the island rose greatly despite considerable out migration from the Island. To curtail this rise, rather than adopt IMF recommendations for reductions in public sector employment, the Government introduced wage cuts.

- **Recovery:** The Island Government's recovery plan required that the tourism industry on the Island should more than double by 1990. Against all expectations - especially since the tourism industry was itself experiencing a slowdown - this target was achieved. Largely as a result of a massive hotel construction program, the Island labor force has now grown to between 26 and 29 thousand with considerable (return) immigration of Arubians and others.

- **Post-Recovery:** Present plans and trends are now set to nearly double the level of tourism again by 1995, with the likelihood of further massive immigration. This has led to a widespread concern about the future "cultural identity" of the Island. A moratorium on major new tourism development is planned. There is also a concern that the Island is now overly dependent on tourism, and the repercussions should the industry be damaged through natural or other disaster.

As explained earlier, the approach used here to test the model is predicated on the basic assumption of input-output modelling that economies are driven by outside events. This is substantially true for Aruba - in the past the economy was driven by the income from the oil refinery; today it is largely driven by revenues from tourism. External development assistance too may be counted as a driving force to the economy. As the level of these revenues changes so does the economic activity throughout the economy. The approach to testing the model then is to feed variations in these items into the model and calculate the impacts on the economy as a whole. In this sense, the forecasts made by the model are not true predictions - since the principal events determining the changes to the economy, such as the shutdown of the refinery or the increase in tourism revenues - are fed exogenously into the model. Nevertheless, this test is consistent with the model's purpose which is to study the implications of given disaster or recovery scenarios, or any set of external economic changes.

6.2 The "Event" Matrix for the Scenario

In order to simulate the economic restructuring over the period covered by the scenario, the exogenous data are fed into the model via an "event matrix."

For the above scenario, the event matrix is simply a table showing the annual changes to the level of output of the directly affected sectors of the economy, in particular, the oil sector, tourism and hotel construction, and public spending. These changes roughly correspond to the four phases of the disaster and recovery scenario. Events are measured in constant 1979 AFl relative to the 1979 level of activity. This specifies:

i) an initial increase above the 1979 level in Government expenditures following an increase in corporation tax paid to the Island by the refinery,

ii) a decline in real tourism revenues after 1982 (relative to 1979),

iii) an end to refinery activities, predominantly in April 1985,

iv) an increase in tourist oriented infrastructure and hotel construction between 1986 and 1992,

v) a sustained tourism boom beginning in 1986 (and projected to continue beyond 1990).

In this case, the basic event matrix is relatively simple to construct since it affects only the total levels of output of each sector, rather than transaction entries within the input-output table. This simplified event matrix is given in the upper part of Table 6-1. This table also shows a number of adjustments to this basic scenario which take account of specific private and public policy choices with respect to employment - in particular, the choice of technology used in hotel construction and the decision by the Island Government to maintain public sector employment through the crisis. These adjustments are shown in the secondary event matrix. In addition to these primary events, there are other smaller changes, for example, exports (and re-exports) of goods not related to oil or tourism, and earning from off-shore financial services. The importance of each of these items will be considered separately.

For purposes of comparison with later results, these primary "events" also are shown in Figure 6-1 opposite. The corresponding total direct shifts in employment which will be used to adjust the initial forecast with the model are summarized by Figure 6-2.

6.3 Variables to be Predicted

As indicated earlier, an input-output type model can provide very detailed estimates of the consequences of economic change. In the case of Aruba, the impact of the refinery shut down and the recovery program may be compared with the available statistics at several levels of detail:

TABLE 6-I Base Event Matrix (1979-90)

PRIMARY EVENT MATRIX 1979-1990   Primary Events: Change in Annual Expenditures by Activity relative to 1979

Sector		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
PHASE	Year	Export	Refinery		Construction		Tourism											Government						
PRE-EVENT	79																							
	80	0	0		0	2	8	2										-16						
	81	-1	0		0	4	15	4										22						
	82	15	0		0	3	10	2										11						
	83	-5	0		0	-10	-39	-9										16						
	84	-10	[illegible]		0	-9	-35	-8										25						
EVENT	85	-4	-4025		0	-8	-32	-8										-20						
RECOVERY	86	61	-4025		26	-0	1	-0										-54						
	87	-4	-4025		83	11	43	10										6						
	88	-2	-4025		177	20	77	18										-10						
POST-EVENT	89	2	-4025		165	24	95	23										-15						
	90	7	-4025		151	29	116	28										-14						

TECHNOLOGY AND EMPLOYMENT ADJ   Hotel Technology and Public Policy: Annual Employment

PHASE	Year	Export	Refinery	Construction	Tourism	Public Sector
PRE-EVENT	79			0		4589
	80			0		4547
	81			0		4683
	82			0		4772
	83			0		5261
	84			0		4609
EVENT	85			0		4436
RECOVERY	86			271		4417
	87			271		4516
	88			2011		4200
POST-EVENT	89			2798		4400
	90			3361		4200

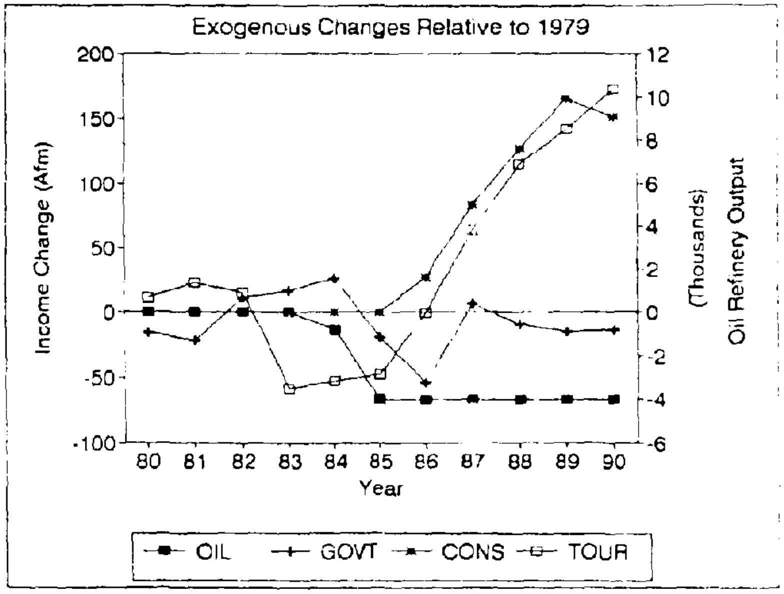


FIGURE 6-1 Exogenous Changes Relative to 1979

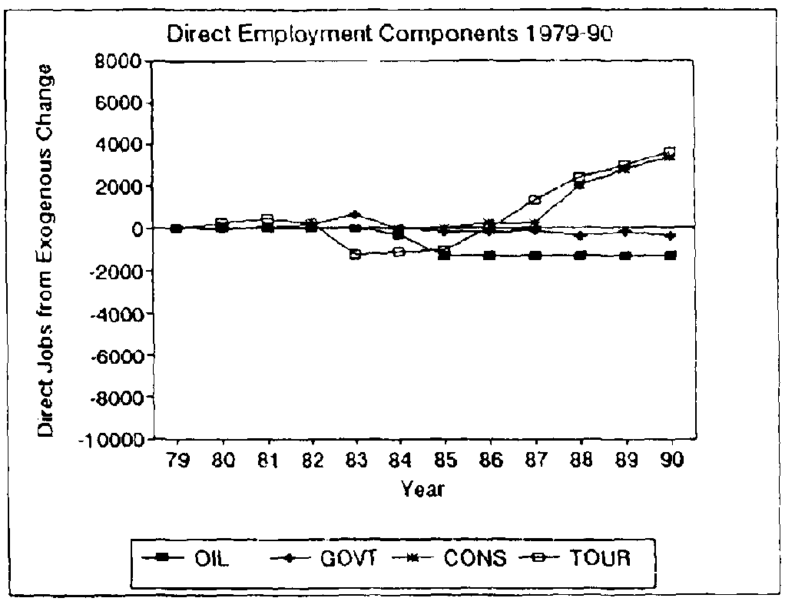


FIGURE 6-2 Direct Employment Components (1979-90)

i) economy-wide totals (e.g. employment, GDP or household income),

ii) sector or activity specific (e.g. employment in retailing, small businesses, government spending),

iii) social and regional (e.g. the income of selected households, or employment by occupation or education),

iii) marginal variables (e.g. balance of payments, investment or the government deficit).

The initial tests (described below) attempt to track the aggregate trend for employment and GDP between 1979 and 1990. The principal aim here is to match changes in the overall level of employment and GDP, and the timing of responses. These tests are designed to clarify whether the lagged input-output model used for the project performs any better than the conventional input-output method.

The testing of individual activities - which might also help to clarify further the relative merits of the lagged model and also help to estimate some of the lags, is considered later. It is to be expected, for example, that the expansion and contraction of the (downstream) consumer sectors (such as retailing and personal services) always lag behind the expansion and contraction of the driving sectors. Similarly (but more contentious), government spending might behave in a similar way.

Marginal items, such as the balance of payments, are clearly the least likely to be well predicted or tracked by an input-output model since they depend on factors external to the island economy. It is of interest nevertheless to test the model against the available data, especially this is a topical policy issue in Aruba, with some commentators debating whether the present recovery has not already sown the seeds for the next disaster!

In summary, five sets of tests are presented here.

i) A version of the SAM based on 1979 data is used to "track" aggregate employment and income trends in Aruba through the recession and recovery from 1979 to 1990. The predictions are compared for lagged and unlagged models.

ii) these are also tested against the available statistics on employment by sector for specific years, including a special survey of unemployment by region and level of education,

iii) the impact of the shutdown and recovery on regional employment (using the regional accounts) and on the occupational and ethnic populations (using the cultural accounts),

iv) a version of the model based on 1990 data is used to "backcast" employment growth from 1986 to 1991,

v) the trends are projected to 1999 on the basis of official expectations for tourism and proposed public sector capital expenditures. The consequences for balance of payments, and the possibility of a new "crisis" arising out of the recovery plan are reviewed.

6.4 Establishing Past Employment Trends

The growth and decline of employment by the refinery, and its long-run impact on total employment in Aruba were suggested by Figure 5-4 earlier. Unfortunately, for much of the Island's history over the last 50 years, satisfactory continuous employment data are available only for the oil refinery, with occasional surveys of Island-wide employment and the decennial Census. Even for the period of special interest for the present study between 1979 and 1990, there are several ambiguities to be confronted.

Several of the published historic data for this period are not based on surveys, but are prepared in the same manner as "forecasts" using economic models. As an initial exercise, therefore, it was essential to separate the primarily survey based estimates for these years from the interpolations and forecasts. Even for more recent years, the quality of the employment statistics for Aruba is uneven. In order to establish the most reliable data set, and to understand the limits of the data, all documented sources were consulted and a number of interviews conducted with government ministers, officials, managers and workers. The principle published sources of employment estimates and forecasts were given in Table 5-IV.

The employment trend statistics extracted from these sources is shown in Figure 6-3. After reviewing and comparing these data, the levels of employment in each phase were judged to be as follows:

For the pre-event phase, annual statistics from the Labor Department are available for years up to 1981, and for 1981 from the Census of Population. There are no reliable data on employment by sector for the key years between 1982 and 1985, although IBRD86 notes that "The unemployment rate between 1981 and 1983 is estimated to have increased from 9.4 percent to almost 15 percent." DEACI84 sets employment at 23,250 for 1984. Other data for this year given in DEACI87 based on Tax Department records indicates 26,800 full and part-time employees. To obtain interim data for these years and to establish levels of employment immediately prior to the shut-down, aggregate employment figures have been prepared:

i) employment in the years 1981 to 1984 has been (re)-constructed from the "IBRD86" estimates of value added by sector by scaling employment data by sector from 1981. The reliability of the employment figures so obtained for 1982 is questionable since the trend for earlier years shows excessive growth compared to the surveyed data presented in NDP83. It is possible here that the increased demand for labor (suggested by the increase in sector income) was satisfied in the then near-full-employment economy by increasing working hours rather than taking on new employees. By 1983 the economy had begun to slow down and for 1984 the method gives a total employment of about 23,500, which is close to the DEACI84 figure.

ii) the Tax Department data for 1984 given in DEACI87 also have been adjusted, to convert part-time employment to full-time - indicating a total of only 21,500 labor years. Since all four available estimates for 1984 are derived from the same survey, it is evident that differences in the definition of employment in the various statistics cannot be ignored. This is important for the present study since input-output models predict changes in the demand for labor on the basis of current (or assumed) productivity, following the definition of employment used in the model. Thus, a predicted increase or decrease in employment may be masked by short-time or over-time working or the unrecorded use of labor in both the formal or informal sector.

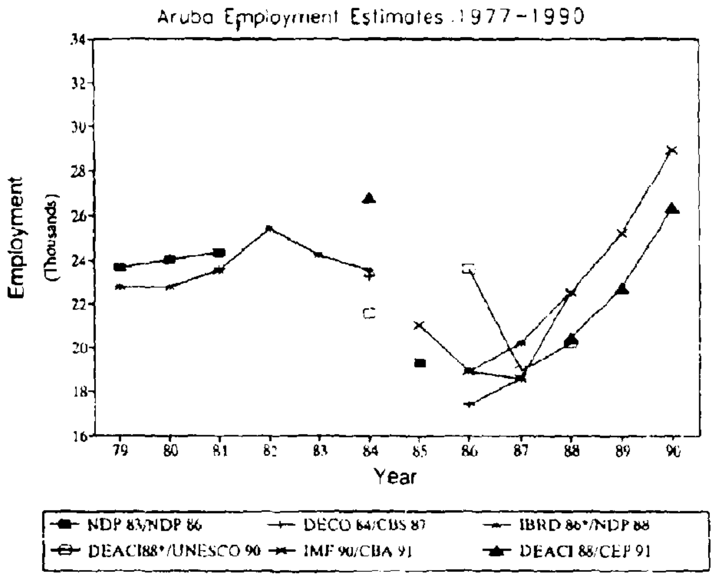


FIGURE 6-3 Aruba Employment Trends (1977-90)

For the event phase of the scenario, the published data for the depths of the recession from 1985 to 1987 also appear to be ambiguous. NDP86 gives a figure of 19,300 for 1985, considerably lower than the subsequent IMF90 figure of 21,000. CBS87 surveys for 1986 and 1987 record employment at 17,400 and 18,500 (after adding public sector jobs). There is also ambiguity with respect to unemployment. IBRD86 states this "deteriorated further with the closing of the Lago refinery, when the rate reached over 32 percent" (IBRD86). More recent official estimates put unemployment between 1983 and 1985 at 20 percent of the labor force (IMF90).

Most data suggest that the turning point to recovery from the recession appears to have begun in late 1986. The CBS87 survey shows a slight increase in jobs from 1986 to 1987. A registration of unemployed persons in 1986 (in preparation for the setting up of a Job Center) showed over 5,000 people to be without jobs (including "hard core" unemployed), whereas only half this number registered at the Job Center when it finally opened in 1987, again suggesting the recovery had begun. Immigration too began to exceed emigration in 1987-8. The IMF90 figure for 1987 may be overly pessimistic since it appears to omit 800 "recreational workers" or casino operators.

For the post-event phase, all sources show that the employment trend since 1986-7 has been strongly upwards with employment reaching 26,500 by 1990 according to CEP91. The IMF90 and CBA91 report an even higher figure because they include an additional 2,500 "self-employed" workers. Unfortunately, the "mini-surveys" upon which both sets of estimates are based sample only the leading sectors, leaving employment figures for other sectors unchanged for several years (or even omitted altogether).

Overall, the statistics for the years before 1982 and after 1986 are adequate for present purposes, although the several discrepancies noted require attention. In addition, there are incorrect allocations, for example, the data provided by UNESCO for 1986 appears to be taken from the pre-recession level for 1984. The employment data for the depths of the disaster, and for the increasingly rapid expansion after about 1989 are the least reliable.

6.5 Migration and the Informal Sector

Some of the variation in the unemployment statistics during the recession is explained by the considerable out-migration from the Island. Even after the Status Aparte in 1986, when Aruba became independent of Curacao, Arubian nationals are still entitled to full welfare benefits in the Netherlands and many Arubians preferred to "sit out" the recession in Holland. The official statistics given in Figure 6-4 show that net emigration of Dutch nationals was nearly 3,000 in 1985 alone, with net loss of nearly 6,000 people between 1984 and 1987 (after 1986 data records islanders as "Arubians" rather than "Antillians"). Some estimates suggest up to 25 percent of the population departed the Island. Since it is likely that up to half of the reported emigrants would be of working age, it is quite possible that while over 30 percent of jobs were lost only 20 percent of the remaining labor force was left unemployed. The past records are not totally reliable and in the past have badly underestimated emigration - one reason for this is that residents prefer to leave as "tourists" rather than emigrants, in order to avoid settling their taxes!. It is clear, nevertheless that with such a high level of outmigration, unemployment statistics alone cannot provide a reliable estimate of job loss.

For reasons noted above, it is desirable to take account of the informal sector. Unfortunately, the size of the informal sector and the "self-employed" sector, and the extent of illegal immigration poses several empirical ambiguities. For example, underemployment in the public sector in Aruba is commented on repeatedly by the international agencies, so it is not difficult, or uncommon, for public sector employees to undertake informal sector work on official time. The fact that the secure public sector job of one family member is often treated as the "insurance policy" of the extended family obviously becomes important in times of economic crisis. This is difficult to measure empirically, although the fact that the allocation of public sector jobs is an accepted component of the democratic process in Aruba, largely explains the government's decision not to heed IMF and IBRD recommendations to reduce the size of the civil service.

Equally ambiguously, both the formal and informal sectors in Aruba have always employed a fair number of illegal and unregistered workers. Illegal migration appears to have shown the same

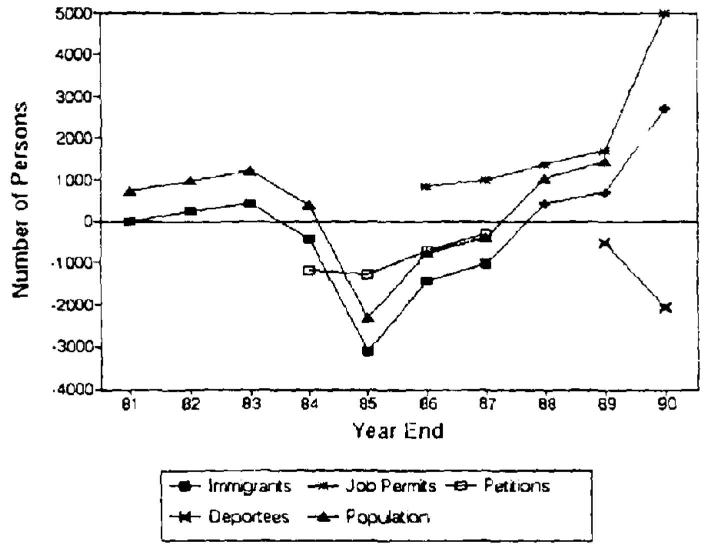


FIGURE 6-4 Net Immigration and Population Growth

pattern over time as legal migration. Nevertheless, while it is likely that some illegal and unregistered workers would have left during 1984-5, interviews suggested that the poorer immigrants from the Caribbean Basin feel that "however bad the situation in Aruba, it is worse back home." Thus, there is a strong incentive not to leave the Island, especially as it may be difficult and costly for them to return legally or otherwise. During the recession the informal sector is considered to have provided a cushion for many households, so the "subsistence" part of this sector is considered to have expanded during the recession.

Since the recovery, the rapid increase in formal applications for job permits (see again Figure 6-4), has been accompanied by an equally rapid increase in the number of unregistered workers. These are variously estimated at between 3 and 9 thousand (Zambrano, 1991). Some 700 illegal migrants were deported in 1989 and over 2,000 deported in 1990 alone. In view of its relatively high wages, Aruba is a very desirable location for workers throughout the Caribbean Basin and parts of Asia and the Pacific. Activities such as hotel catering and construction are known to employ illegal laborers. In addition, it is evident that other parts of the "non-subsistence" informal sector, such as gardening and construction, which depend on a healthy economy, have expanded greatly and also employ considerable casual labor.

Because the recession was marked by a fall in the hours worked and on-the-job productivity, the data for the recession probably underestimates the actual loss in productive employment. In contrast, by 1990 with rapidly increasing participation rates, some 50 percent of enterprises surveyed by the IMF report a "significant level" of overtime work. It is possible that, with so much informal sector activity, increased overtime, and a high level of illegal and unregistered workers, the actual level of employment in 1990 (measured in job-years) may be as much as from 3 to 10 thousand higher than the official figures.

It is evident then that, the official number of persons employed or unemployed, both during the recession and the recovery, may be a poor guide to actual productive employment. This poses some problems for testing the model since it accounts for changes in employment in the formal sector (whether legal or illegal), but takes no account of the informal sector itself. The above considerations suggest that a true comparison of the depths of the recession with earlier full-employment years would put the 1986 demand for labor lower than the official employment figures suggest, and that actual post-recession employment is likely considerably higher than the official figures. A working estimate based on interpolation of the official surveys, and a plausible adjustment to the official data is given in Table 6-II and Figure 6-5. This will be used as the basis for testing the model. Typical errors and uncertainties in these data are judged to be around 1,000 jobs. Such uncertainty suggests definite limitations on tests of "fine tuning" to improve the performance of the model, based on its demonstrated predictive power.

TABLE 6-II Annual Employment Statistics (1977-90)

EMPLOYMENT ESTIMATES														
Source:	77	78	79	80	81	82	83	84	85	86	87	88	89	90
NDP 83 (1)/NDP 86 (2)	22950	23049	23666	24039	24336				19300					
DEACI 84 (2)					23577			23250						
NDP 88/IBRD 86*			22771	22753	23550	25448	24225	23532		18900	20200	22550		
CBS 87										17406	18557			
CBA 90 (3a)											18600	22500	25200	28900
IMF 90 (3)									21000	18900	18600	22500	25200	28900
DEACI 88/CEP 91 (4)								26803				20454	22726	26370
CBA 91 (4)												22454	25226	28870
UNESCO 90/DEACI 88*								21573		23577	18900	20200		
INTERPOLATION	22950	23049	23666	24039	24336			23250	19300	17400	18550	20500	22700	26500
ILLEGALS														
Adjustment (5)	0	0	0	1	2	2	2	0	1	-1	0	3	3	9
ESTIMATION*	22950	23049	23666	24279	24728			23304	19149	17140	18592	21159	23276	28763

Note: * Scaled by author

NDP National Development Plan IBRD World Bank DOL Department of Labor
DEACI Department of Economic Affairs, Commerce and Industry
IMF International Monetary Fund CBA Central Bank of Aruba
UNESCO United Nations Education, Science and Culture Organization
CEP Government of Aruba Capital Expenditure Program
(1) DOL statistics adjusted by ITEO Institute for Applied Economic Analysis
(2) in conjunction with UNDCTD United Nations Department of Cooperation and Development
(3a) Central Bureau of Statistics Survey of Business (1986 and 1987) adjusted for public sector.
(3) based on CBS Central Bureau of Statistics (87) and DOL Mini-Surveys (88-90)
(4) revisions of IMF 90 and DOL mini-surveys
(5) percent net adjustment based on reported net migration of non-Arubans

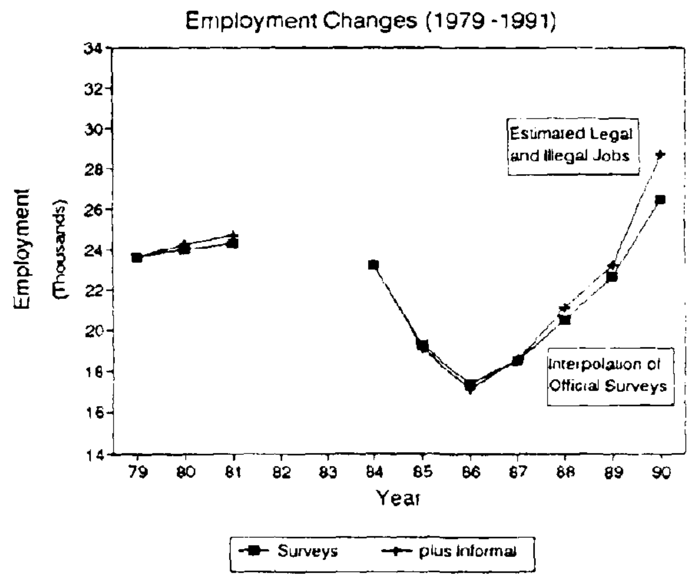


FIGURE 6-5 Adjusted Employment Trends (1979-90)

SECTION 7
TESTING THE MODEL

7.1 Tracking Jobs through Disaster and Recovery

The initial tests use the model to track total employment between 1979 and 1990. Two sets of forecasts are made:

i) "base" employment trends are calculated using the 1979 model after introducing only exogenous income data on the oil refinery shutdown and the growth of tourism and construction activity.

ii) "adjusted" forecasts to take account of specific employment policies in the public sector, and the known employment in hotel construction.

Base Forecasts: This forecast is made using the most straightforward application of the model assuming that changes in employment in all sectors are determined pro-rata by shifts in the income to the sector as shown in the primary event matrix. This "fixed technology" assumption leads to a predicted employment of about 18,000 at the bottom of the recession in 1986. Total employment in 1990 is predicted to have risen to over 30 thousand. This offers a satisfactory reflection of both the level and the timing of aggregate employment trends during and after the recession.

This forecast may be improved by taking account of the planned levels of employment associated with the major exogenous income changes. This modification is straightforward (and arguably quite reasonable in the context of model testing).

Adjusted Forecasts: The first adjustment to construction sector employment accounts for a specific choice of technology. In the base forecast, employment changes in the construction sector are determined by the average labor productivity in 1979. Typically, input-output modeling does not take account of technological change. Insofar as technical change is incremental, it is unlikely to affect results over short time horizons. However, in Aruba most hotel related construction during the recovery was carried out by international firms or larger local firms using technologies with labor productivity several times higher than the average for the Island. To adjust for this, the forecast for direct employment is replaced with the a-priori data given in Figure 7-1, reducing the estimate of employment in 1986 to about 16,500, and that for 1990 to about 28,500.

The second adjustment is to public sector employment. The base forecast assumes that the spending cuts induced by the recession lead to loss of jobs in the public sector. In reality, the government elected to maintain public sector employment and lower wages (rather than follow the IMF recommendations to cut jobs), as shown in Figure 7-2. In consequence, the model underestimates employment in this sector. To account for this policy, the employment forecasts for the public sector are replaced with the official data, thus increasing the mid-recession economy-wide employment back to about 18,500.

Since the first adjustment for hotel construction is based on the anticipated direct employment in this activity, it is more straightforward to apply than the second adjustment which depends on the effects of all exogenous changes on total public sector employment.

The off-setting effects of these two adjustments is shown in Figure 7-3. This improves the match with the surveyed data during the recession to the final forecast shown in Figure 7-4. The employment forecast for 1990 is higher than the official figures but is not inconsistent with the supposed level of unregistered workers, the apparent expansion of the informal sector, and the considerable level of overtime work in all key sectors of the economy (or the IMF estimates of "self-employed).

7.2 Comparison with Type II Forecasts

Part of the present exercise is to test the merits of using a lagged solution method for the SAM. While it seems fairly reasonable to expect that there would be delays associated with the

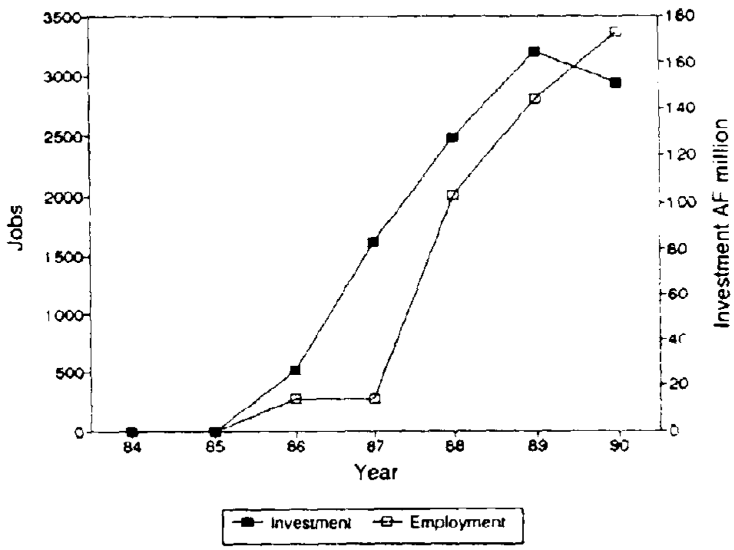


FIGURE 7-1 Hotel Construction Investment and Jobs

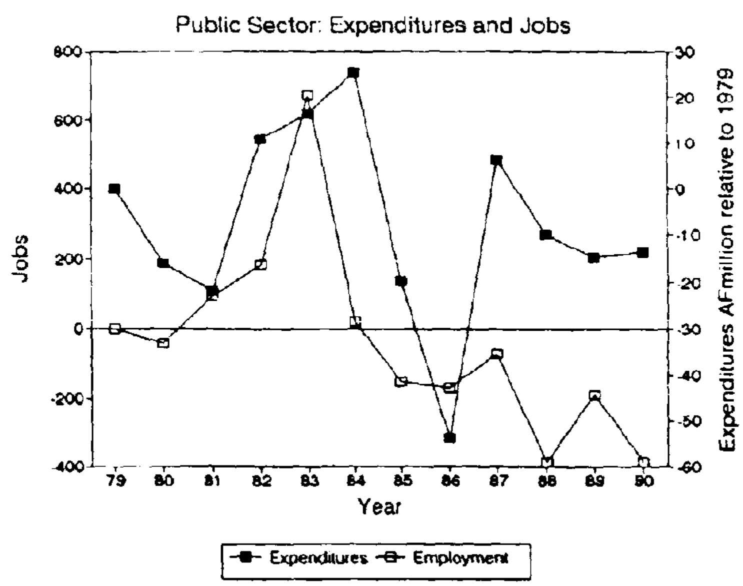


FIGURE 7-2 Government Spending and Employment

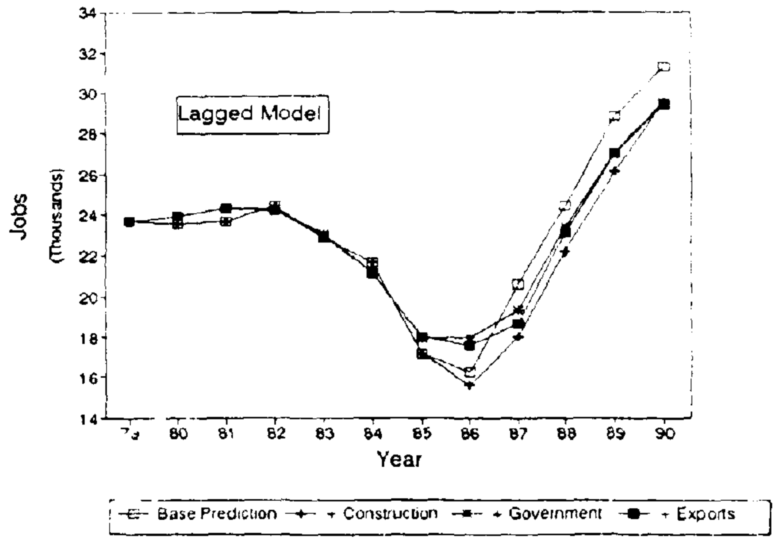


FIGURE 7-3 Predicted Employment Change (1979-90)

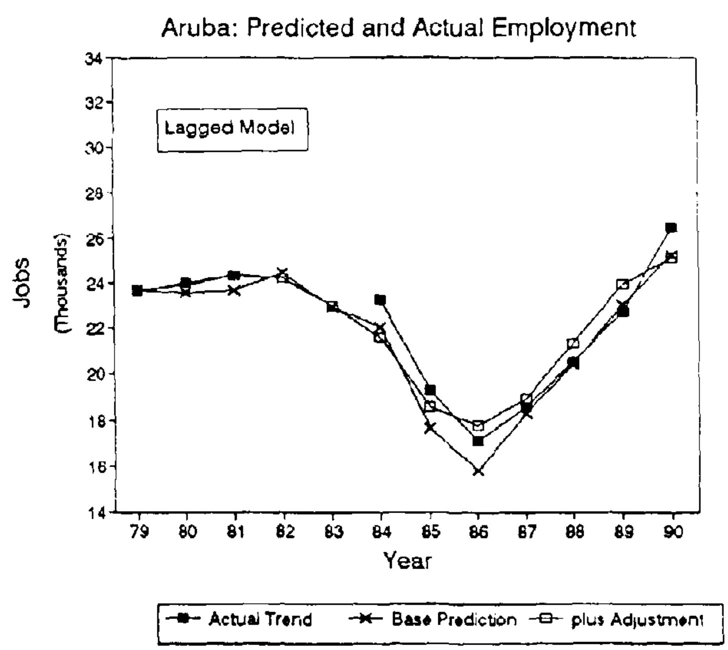


FIGURE 7-4 Final Prediction versus Actual Employment

restructuring, these delays are omitted from most input-output models (for the sake of analytic simplicity).

Th~ effect of omitting lags is explored by repeating the calculation with the same data, but using a standard Type II solution (with the model closed around households). This standard static model does not specify the time dimension but the implied assumption in Type II calculations is that the full impact of a given event will be felt within the first year.

Taking this assumption, the forecasts using the unlagged model must suggest that the bottoming out in employment would have been felt more immediately, and that the economy would have responded more rapidly to the increased revenues from tourism. For both the base and adjusted forecasts, employment falls to about 15,000 at the bottom of the recession. This greater job loss is predicted because the full impact is assumed to be felt before the new injection of government and tourism revenues began. In turn, the expansion is predicted to have taken off far more rapidly.

As shown in Figure 7-5, attempting to improve the Type II calculation by introducing a one year delay between the direct and indirect effects of events only partially corrects the level and timing of the forecast. Overall, the final unlagged model forecast shown in Figure 7-6 appears to be less satisfactory than the forecast from the lagged model, both with respect to the forecast levels of employment and the timing.

The differences between the results of the two methods become more apparent from a comparison of the total employment induced by each of the exogenous components separately, shown in Figures 7-7 and 7-8. For both the lagged and unlagged (Type II) models, the competing effects of the closing of the refinery and the increase in tourism construction and revenues are clearly seen. For the lagged model, in absence of the construction and tourism booms, it is calculated that over 9,000 jobs eventually would have been lost from the shut down of the refinery, compared to 6,000 for the Type II model. In both cases, the construction boom began before the full impact from the shut down was felt. For the recovery, both models

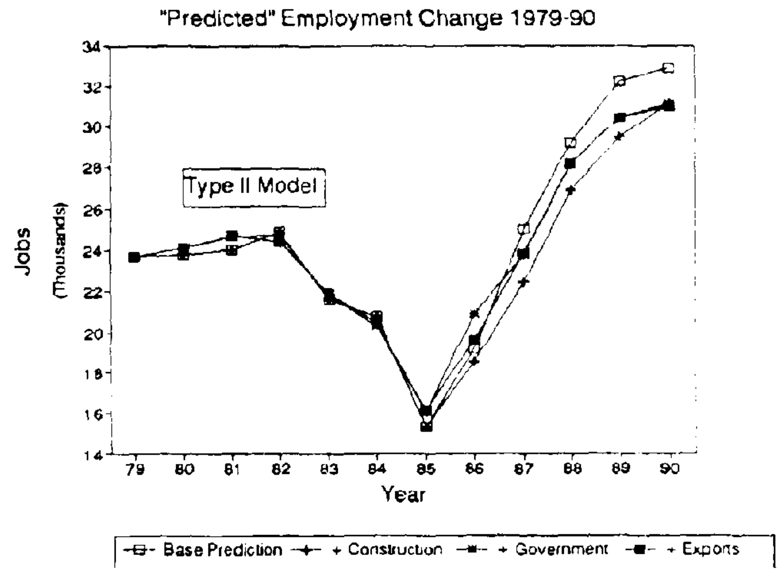


FIGURE 7-5 Predicted Employment Change (Type II)

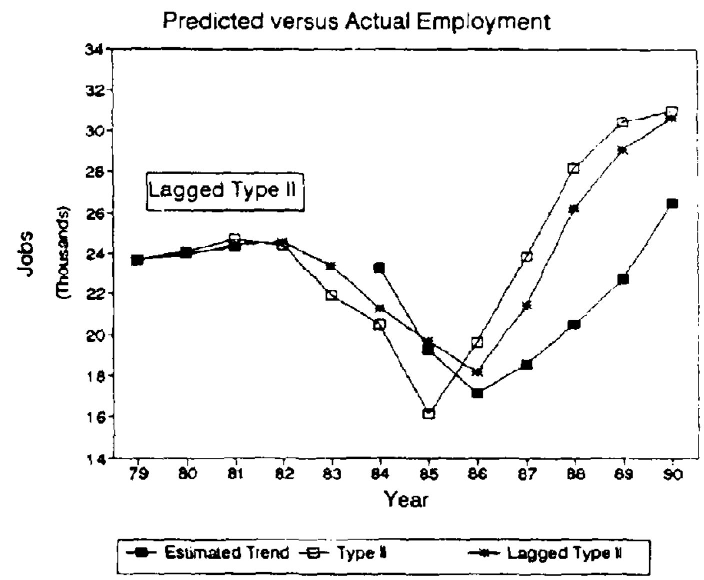


FIGURE 7-6 Predicted Employment (Lagged" Type II)

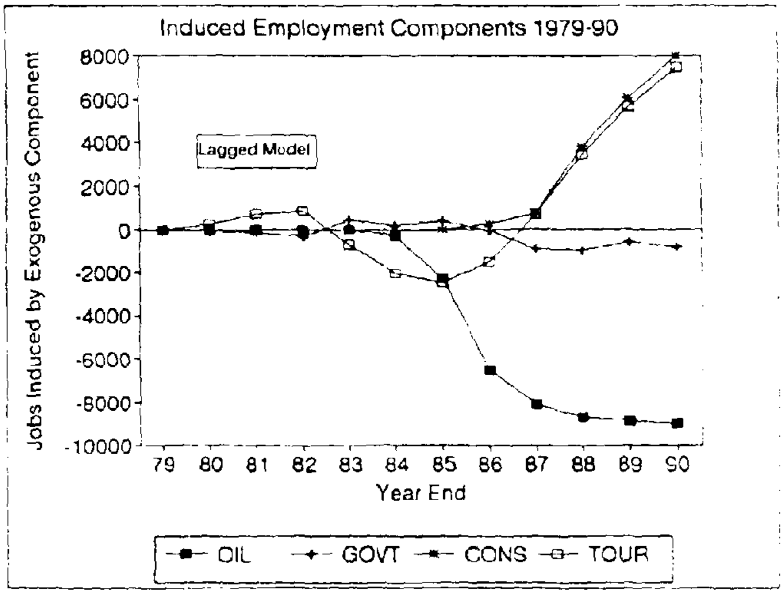


FIGURE 7-7 Induced Employment Components (Lagged)

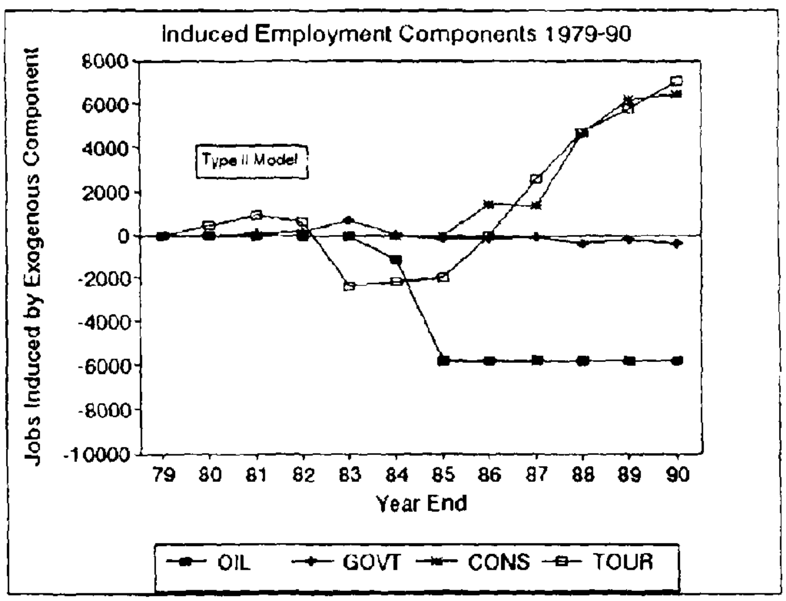


FIGURE 7-8 Induced Employment Components (Type II)

demonstrate that tourist related construction has induced nearly 8,000 new and replacement jobs in the economy as a whole by 1990, roughly equal to those induced by the increase in tourism revenues. The contrast between the lagged and unlagged calculations for the response to the economic recovery is less marked because construction and tourist expenditures both grow comparatively steadily between 1986 and 1990.

7.3 Transaction Lags and Responses to Crisis?

In the lagged model, each economic activity is assumed to have a characteristic distribution between the time when income is received and when it is spent. The average delays used to quantify the (gamma) distributions are based on the empirical observations in the literature that businesses tend to respond faster to economic change, than do households, who in turn respond faster than governments or investors. Heuristically, it is plausible to argue that since firms typically carry about three months of stocks of raw materials, they are obliged to make new expenditures rather rapidly (i.e. within a few months) following an increase in demand. Similarly, governments are tied to an annual budgetary process so are likely to have a response lag of about one year. Households typically take about six months to adjust their expenditures to changes in the level of income. In terms of calculating the impacts of changes on an economy, what matters is the extent of the lag relative to the time horizon used in the calculation. For short horizons, only those activities with rapid responses will have contributed significantly to recycling of income in the economy. Conversely, over a long horizon, most activities will contribute, and the overall multiplier will be limited largely by the real economic leakages (in particular, through trade and repatriation).

In Type II calculations, receipts and expenditures are equivalent over any given period. In the lagged model, by contrast, receipts are treated as orders (e.g. to a business) which anticipate expenditures (e.g. the payments to factors and suppliers). In setting up the tests of the lagged model it is necessary to know, in particular, at what point in the year the major event occurred (the shutdown of the refinery), whether the running event data (public expenditures and hotel construction) are actual expenditures or anticipated budgets, and whether employment series are annual totals or end-of-year statistics. Since the shutdown of the refinery took place in April 1985, it is evident that a considerable part of the downstream impact would be felt by year-end. In Aruba, most event data are presented as if they are annual expenditure totals, although hotel construction expenditures are based on inflows recorded by the Central Bank and public expenditures are calculated by the Bank from tax receipts and government borrowing. According to the Bank, the resulting picture does not necessarily reveal the underlying trend in Government finance. While the Labor Department collects statistics (up to 1980 and post-1987) on a continuous sampling basis, data from the Bureau of Statistics (1981, 1986 and 1987) by contrast are based on point-surveys. In the tests above, this has been accounted for by taking input data to be mid-year (i.e. expenditure evenly distributed over the year) and employment to be an end-year measure. This assumes a six month delay between the annual event and the measured impact.

In a crisis situation, neither the Type II nor the lagged approach used above may reflect well the behavior of particular actors in the economy. As was evidenced by the earlier discussion of immigration and temporary emigration, affected populations adopt a variety of atypical responses. This is also true of the business or government sector. For example, it is evident that the government responded by cutting expenditures in anticipation of a significant fall in revenues. Similarly, several suppliers to the oil refinery businesses closed down almost as soon as the shut down of the refinery was announced. As may be seen from Figure 7-9, the number of (legally required) lay-off petitions submitted by businesses increased markedly before the shut down of the refinery.

Even after adjustment, the final predictions from the lagged model appear to anticipate the employment trend data by about one year. This suggests that the lags used may be too short. However, it is equally likely that the income sources given in the event matrix is incomplete, for a number of reasons.

With respect to the delayed the impact of the shutdown of the refinery, the following may be important.

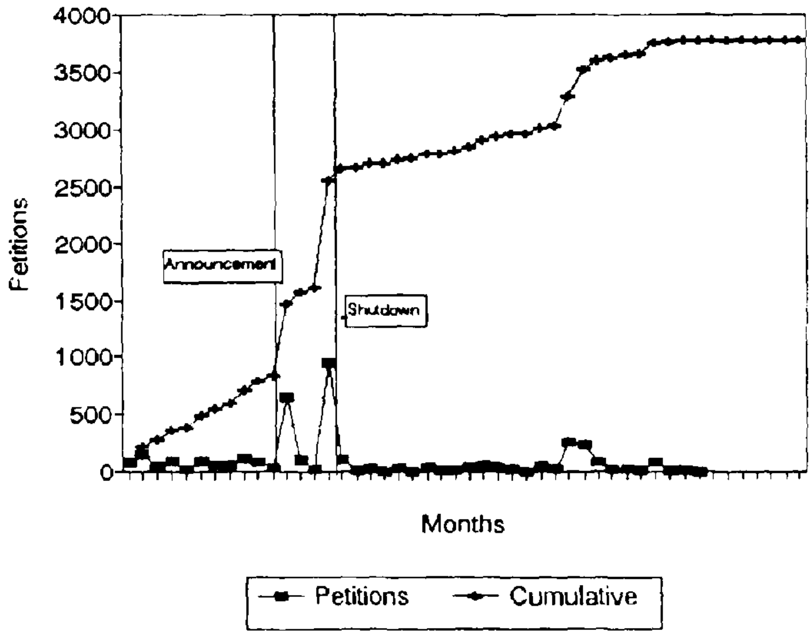


FIGURE 7-9 Aruba Lay-off Petitions (1984-86)

i) Many Arubian households maintain bank accounts overseas. IBRD86, for example, states that according to the US Treasury, Antillean residents held over one billion dollars in time deposits in US bank accounts at the end of 1985. The IBRD also notes the "large holdings" of foreign securities. In view of the international orientation of Aruba and relatively high per capita income (compared to Curacao), probably one half of this wealth would be owned by residents of Aruba. It is likely that some of this income was drawn upon during the crisis.

ii) All of the workers dismissed from the refinery received lay-off payments (DECO84 indicates a special retirement plan of AF 30 million about one quarter of the regular salaries for that year). In 1985, the private capital account balance increased by AF 10 million as a result of the shutdown (IBRD86). On the other hand, interviews with ex-workers from the refinery have indicated that some of the lay-off income was used to set up small businesses or to build and extend homes (through the small scale construction sector). Some ex-employees used the income simply to "live for the day" - because, for a time after the refinery closed, they remained convinced that the shut down was merely a ruse by the Exxon Corporation to re-negotiate its rate of taxation by the Island and that the refinery would soon re-open.

iii) The Island Government in office prior to independence had apparently "hidden" taxes received from the oil refinery in order to avoid paying over the legislated 25 percent due to the Central Government in Curacao. While the full amount has never been adequately accounted for, and contributed to the sitting Government being voted from office (Croes, 1986), some is considered to have "trickled back" to the Island.

iv) In 1985 the Island Government was able to finance its deficit largely by drawing on cash balances at the Central Bank of the Netherlands Antilles (IBRD86).

Although the authorities were aware of these various inflows of capital from overseas, and in 1986 their overall size was taken to be an indicator that the economy was reviving (according to the then Prime Minister), the sources were not well understood at that time. Indeed, the data still contain several ambiguities and omissions (not least that the Central Bank of Aruba records comparable data only from 1986 onwards).

With respect to the anticipation of the recovery, two issues are relevant.

i) There is a mismatch between the timing investment and the employment associated with the hotel construction program used in the adjusted forecast. Expenditures are based on Central Bank statistics (which record inflows of capital to the Island) while employment estimates are based on anticipated jobs creation (DEACI86 and 88). This was necessary because there is ambiguity in the available data. For example, a considerable share of the recorded financing for a major hotel construction project operated by an Italian company mysteriously "disappeared." In addition, analysis of the actual expenditures on the Island by this project were distorted by a procedure whereby equipment purchased in United States was transhipped via Europe (to take advantage of EEC subsidies), and the migrant workers employed on the project were housed and fed in the company compound. A similar problem arises with respect to the timing of public expenditures where there remains considerable confusion between budgeted, actual and recorded expenditures (IMF85).

ii) It is likely that in a crisis, all actors respond more quickly than under normal conditions. To assess the actual scheduling of the responses to the shutdown by the private and public sector, and by households, requires monthly series which are limited in Aruba. Nevertheless, for the oil refinery, the evidence from lay-off petitions by employers shows that some contractors to the oil refinery laid off workers one month after the shut-down was announced (i.e. before the closure in April 1985). The response by the Island government to the crisis also appears to have been relatively rapid, with a variety of tax raising and expenditure cuts beginning early in 1985 and extending to mid-1986).

7.4 Impacts across Sectors

An important test of the model is to match the forecasts of the non-oil industry - commerce and service sectors - since growth in these sectors is largely an indirect consequence of changes in the major exogenously driven sectors. Both commerce and service sectors rely for the bulk of their income on purchases by households. Unfortunately there are no official figures for employment in services and commerce for the years 1982 to 1986, and attempts to reconstruct these data from the estimates of sector contributions to GDP (in IBRD86) are not satisfactory. The comparisons of the adjusted forecasts with the surveyed data shown in Figure 7-10 show modest agreement during the recession and satisfactory agreement for the most recent years.

The fit is less good for the partially endogenous industry and agriculture sectors, shown in Figure 7-11. For these sectors, the problem again arises that in small economies like Aruba most changes result from the activities of individual firms undertaking specific projects, which have anomalous and unknown expenditures and behaviors. This is also the case with the large scale construction sector, public utilities and government sector in any small regional economy - see Figures 7-11 and 7-12. (Note that in Figure 7-12, the difference between the forecast and estimated trends for the public sector represents the adjustment to the aggregate forecasts given earlier).

Given better employment and other data on specific projects, it would be possible to "fine-tune" these forecasts further. For example, both the industry and commerce sectors have an export component (free zone re-exports and off-shore finance) which generates employment, in addition to the direct tourist expenditures (souvenirs and taxi tours) which have already been accounted for in the base forecasts. Unfortunately, it is not at all a straightforward matter to separate the re-export of commodities via the commerce sector from exports of local manufactures. Moreover, trade statistics in Aruba exhibit interesting anomalies arising from her proximity to South America. At one time, for example, Aruba was one of the largest exporters of coffee in the world, despite the fact that the Island neither produced or imported this item. The Island also

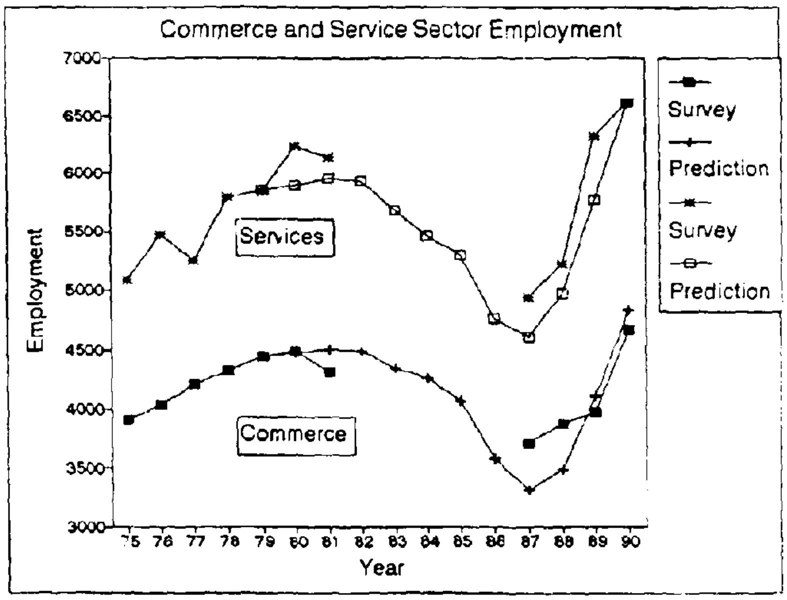


FIGURE 7-10 Commerce and Service Sector Employment

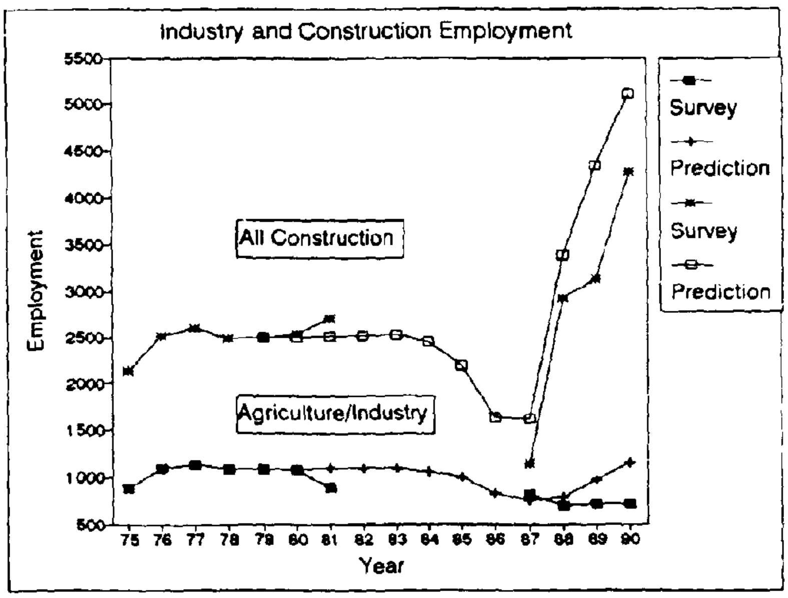


FIGURE 7-11 Industrial and Construction Employment

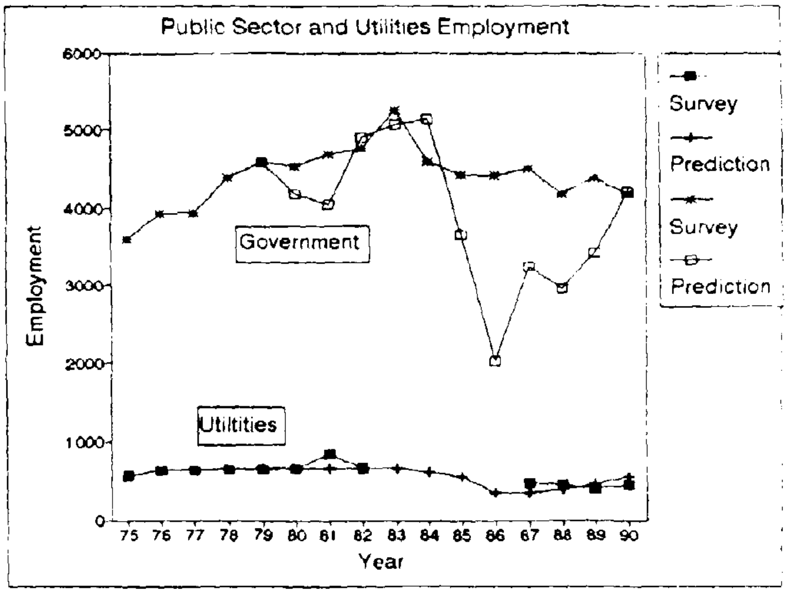


FIGURE 7-12 Public Sector and Utilities Employment

has an incredibly high importation of tobacco products, but nonetheless does not have an especially high incidence of lung cancer.

At this point, the tests have probably reached the limits of the annual trend data. There is in any case, another problem with attempting such fine tuning, that one simply stops the process when the results appear satisfactory, and so ignore other possible omissions which might cause the results to err once again!

7.5 Approximate Lagged Models

Since the goal of the project is to demonstrate that the model can provide useful results even when used in an approximate way, a less elaborate alternative solution method has been adopted to make forecasts by sector from the 1979 baseline to 1990. This "multiple horizon" forecast may be performed rather simply by combining the direct impacts the major events at appropriate time horizons as follows:

the 5 year impact of the refinery shut down

+

the 3-year impact of average level of hotel construction

+

the 2 year impact of the average increase in tourism

Figure 7-13 shows the contribution from each event in turn and the combined impact between 1979 and 1990. Comparison with the differences between the 1979 and 1990 survey data shows that the net changes are reasonably well predicted for commerce and service (the two sectors largely driven by indirect income). This may be viewed as a relatively severe test for any model given the major shifts arising from the opposing contributions of the refinery shutdown and the tourism boom.

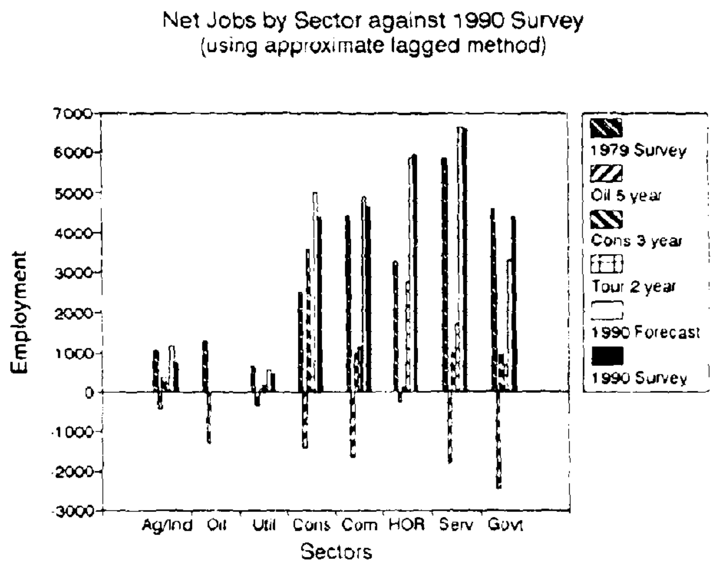


FIGURE 7-13 Sector Forecasts versus 1990 Survey (Approximate Method)

This last method may be compared both with the (unadjusted) results for the complete model (based on the summation of annual impacts), and with the further approximation of using a common 3 year time base for all events, and with the results of a Type II calculation. The comparison for all four methods with the surveyed employment data for 1990 is shown in Figure 7-14.

On balance, it is evident that the more complete the model, the better are the predictions, but that predictions are likely to be incorrect if adjustments (such as those for construction and the public sector are not made). This is not a difficult task provided the appropriate data are available.

7.6 Estimates of Gross Island Product

For GDP, GIP or National Income, the empirical situation in Aruba is even more fraught than for employment. The initial problem is shown by Figure 7-15 which shows GDP estimates and predictions for the Island between 1972 and 1990. Again, while in some cases data are missing, in many other cases there are multiple but contradictory data. Especially, for the period of interest from the collapse of the refinery to the bonanza of the tourism boom, the information is at first sight especially confusing.

The most obvious and significant variation in these trends arises because estimates are generally given in current values while forecasts are presented relative to some base year. While it may seem a simple matter to bring all values to a common base, a variety of price indices have been presented over the years and it is apparent that several adjustments have been used in preparing the estimates and/or forecasts, but these are not always made explicit.

The second variation arises from differences in definition. While there are standard definitions of GDP, most estimates for Aruba exclude particular items or even whole sectors. Some estimates do not include depreciation as a factor of production, while the oil sector (the largest industry) is excluded from others.

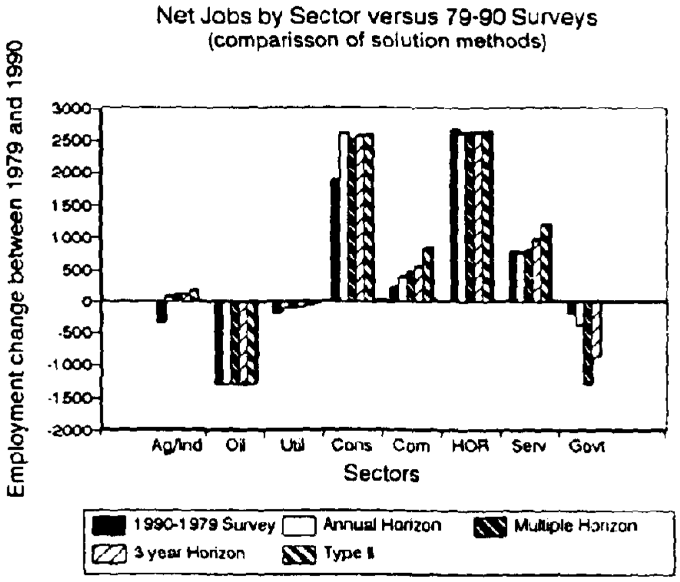


FIGURE 7-14 Comparison of Solution Methods

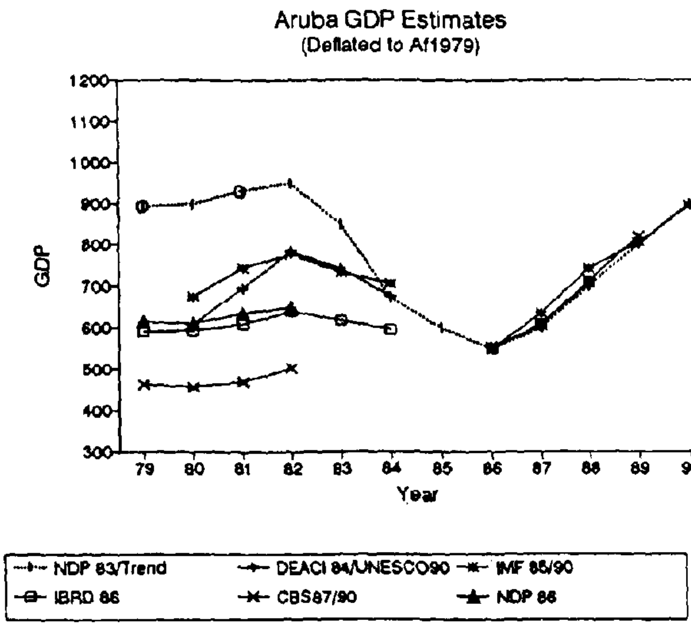


FIGURE 7-15 Aruba GDP Estimates

With respect to absent data, part of the problem is that the Island became independent from the Netherlands Antilles only in 1986 and although separate trade and financial flows were available, separate island "national accounts" were not. In addition, immediately prior to and after independence there was considerable disruption as the responsibilities of the Central Government (of the Netherlands Antilles) were passed to the new Central Government (i.e. the former Island Government) of Aruba. Unfortunately, this period also coincided with the closure of the oil refinery.

A variety of (usually unspecified) methods are used by all agencies to estimate past data and future trends and it is not always possible to distinguish between estimates and forecasts. Nevertheless, since what is required to test the model are estimates rather than forecasts, some considerable effort has been expended to separate the two, and reconcile the various "data." The ambiguity is greatest for the years 1983 to 1985. This is especially the case for estimates of the Island's GDP. For example, the 1985 IMF report preferred to use its own GDP estimates above those of Aruba, because "they are consistent with a more stable and theoretically more acceptable relationship between absorption and disposable income." (IMF85). This process also involves some unspecified "judgmental" adjustments by the officials of the Central Bank. Obviously, when estimates are prepared using standard model assumptions, there is a certain tautology involved in the testing process.

Estimates of GDP are shown in Figure 7-16. For this exercise, all estimates have been deflated to base year units (millions of 1979 florins) using the CPI (Consumer Price Index) as shown in Figure 7-17. This is somewhat unsatisfactory since the overall GDP shift between 1979 and 1990 is rather sensitive to the deflator, as will be sector specific prices to changes in import prices.

The pre-1985 estimates appear to fall into four distinct bands: i) NDP83, ii) IMF85 and 90, DEACI84, iii) IBRD86, NDP86, iv) CBS87. The explanation for the differences depends on the items included, and especially the contributions from the oil refinery.

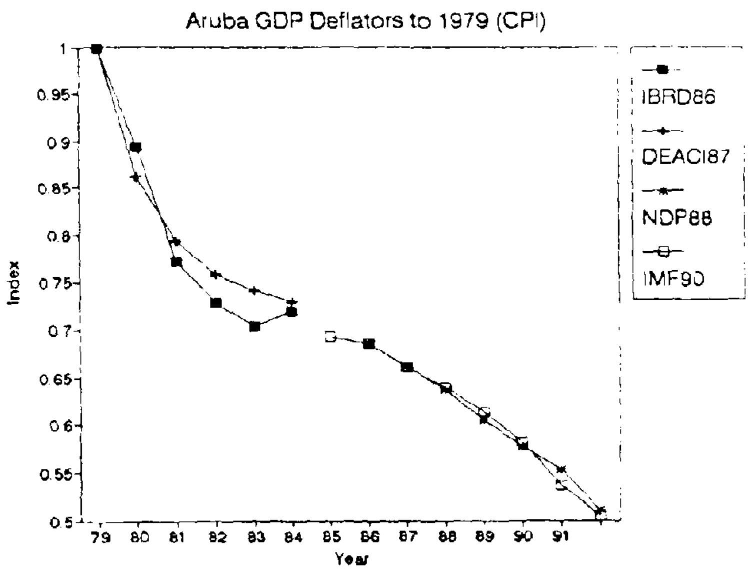


FIGURE 7-16 Aruba GDP Deflators

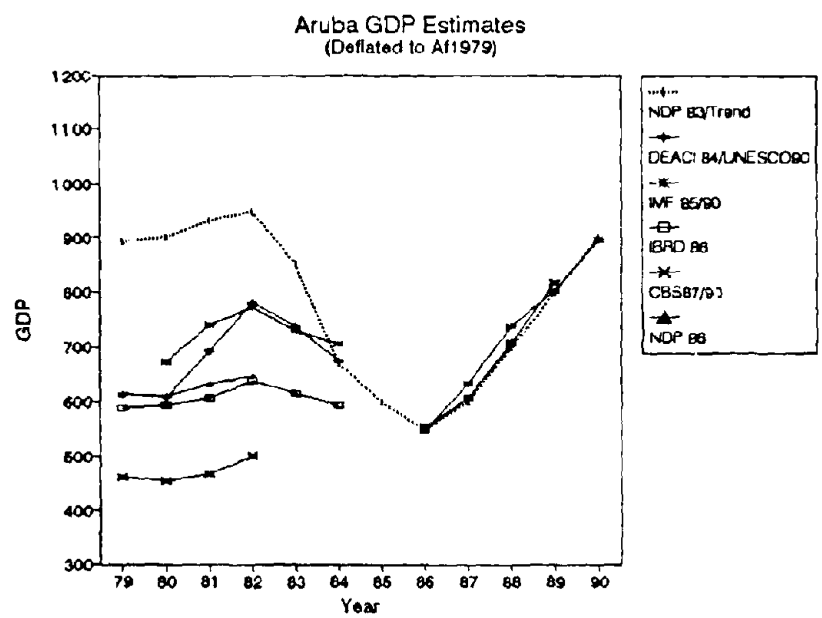


FIGURE 7-17 Deflated GDP Estimates

The variation in measures of "GDP" arising from differences in definition are illustrated by the following table based on data for 1979 given in NDP83.

TABLE 7-1 Definitions of National Income for Aruba.

Income Definitions for Aruba (1979)	Amount (AFl million)
Value Added by Firms (Factor Costs)	872
Sampling Adjustment in NDP83	58
Value Added by Firms (Factor Costs)	930
Value Added by Government	91
GDP at Factor Cost	1021
Indirect Taxes - Subsidies	33
GDP at Market Prices	1054
Net factor incomes from abroad	(294)
GNP (Market Prices)	760
Depreciation	82
Net National Income	678

These data are based on the 1979 CBS (Netherlands Antilles) Survey of Business for that year and were used in the construction of the Aruba 1979 SAM after adjusting private sector value added by AFl 54 million to account for the undersampling of small firms. The "NDP83" figures are therefore high relative to all other estimates, and because they include all factor costs including depreciation and indirect taxes.

Most other estimates explicitly exclude all, or part, of the value added by the oil refinery (about AFl 404 million in 1979), and this is responsible for much of the variation between estimates. The omission of this contribution seems quite unreasonable and potentially misleading, since the taxes, wages and local purchases of the refinery were central to the pre-1985 Arubian economy. The separation appears to have arisen largely for historic reasons - that for many years the Island's economy had been divided into its "Lago" and "non-Lago" components. Moreover, the treatment is inconsistent with that of other sectors of the economy. In particular, the major international hotels (such as the Hilton or Hyatt Regency) are treated as part of the domestic economy even though their relationship to the Island in terms of taxes and raw materials has always resembled that of the refinery.

If all value added contributions from the refinery and elsewhere are included, the varying estimates of the Arubian national income can be approximately reconciled with the estimated of GDP (at Market Prices) based on the 1979 data.

The principal adjustments required to reconcile the figures are as follows:

CBS: The comparatively low figure published by the CBS of Aruba (in CBS87) of Af 462 million for GDP at market prices in 1979 appears to omit the entire contribution of the refinery. Alternatively, these estimates are scaled on the basis of employment from aggregate data for the Netherlands Antilles, rather than on the survey data for Aruba. More recent estimates from the CBS are based on the those of the DEACI.

DEACI: The "NDP86" based on the survey also exclude the entire contribution of the refinery - even though the same government agency had previously included all contributions from the refinery in its "DEACI84" forecasts. (It is possible that the intention here was to provide a basis for comparison with the "new" Arubian economy).

IBRD: The IBRD86 data exclude the operating surplus of the oil refinery (AFl 298 million) and include various other adjustments (for example, a deduction of AFl 23 million as imputed bank charges and omits the considerable contribution of the small commerce sector).

IMF/CBA: It is not clear whether the IMF85 estimates of GDP (derived from a small Keynesian macro-model by assuming the domestic activity induced by Lago taxes, tourism revenues and government expenditures) also omit all or part of the value added from the refinery.

On balance, the most consistent estimate of trends in GDP for the period 1982-84 immediately prior to the shutdown are probably the series given in IBRD86 (suitably adjusted). Furthermore, this was the most recent effort to measure the state of the economy at that time. It is doubtful, however, whether this level of GDP (about AFl 780 million measured in AFl 1979) is known relative to the 1979 base level to better than 10 percent.

There is even greater uncertainty as to the level of national income at the depth of the recession. One contemporary estimate by Croes (1986) expected GDP to fall back 30 percent to the level of 1980. More recent official estimates of GDP in this period suggest that the combination of the refinery closing and the fall-off in tourism caused real GDP to drop by over one fourth from 1983 to 1985 (IMF90). However, the only "estimated" GDP figure for the depths of the recession is the IMF90 figure for 1986 (prepared in conjunction with the Central Bank using a modified version of the IMF macro-model).

Overall, the data suggest that by 1984, real GNP had fallen by about AFl 50 million (1979 florins) from the 1983 high, and then fell further by about AFl 200 to AFl 540 million by 1986, a total decline of about 30 percent. The data also indicate that, although the refinery was closed in early 1985, the greatest loss to GDP did not arise until 1986, even though the tourism upswing had already begun. Both the size and the timing of the recession and recovery are important for the testing of the model.

The only post-disaster GDP estimates of Aruba's GDP after the closing of the refinery are based on the IMF model. IMF90 and CBA91 suggest that GDP had risen to AFl 1550 million by 1990, increasing by about 18 percent annually (in nominal terms). Deflated to 1979 florins this puts 1990 GDP at nearly AFl 900 million, well above the 1986 level of AFl 500 million, and also above the commonly reported levels of 1979 to 1983.

Since there is no continuous data series connecting the pre-and post refinery era GDP data, and because the figures are deflated using the CPI index, and because the IMF model is ambiguous in its treatment of value added from the refinery, some considerable uncertainty remains as to the size of the 1990 economy relative to 1979. Moreover, as indicated earlier, the IMF estimates of GDP are derived from simple model from estimates of exports and government expenditures (neither of which are particularly well known).

7.7 Tracking GDP through Disaster and Recovery

Since the SAM model calculated wages and operating margins by sector, it provides a prediction of national income. The trend forecasts of GDP arising from the earlier adjusted forecasts are shown in Figure 7-18. These calculations suggest that by 1990 the Island GDP has more or less returned to the level prior to the shut down of the refinery, approximately AFl 900 million (in 1979 prices). While the general magnitude and timing of the recession and recovery again appear to be reasonably well predicted, it would be rash to signal the results as especially notable. In particular, the deflators used may entail a relative adjustment between the 1979 and 1990 figures of 10-20 percent. Nevertheless, it is quite possible that the predicted GDP figures are closer to reality than the current official statistics.

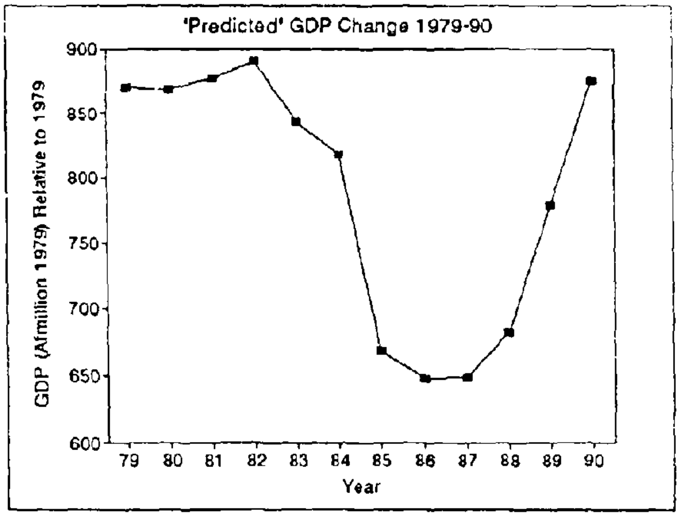


FIGURE 7-18 Predicted GDP Changes (1979-90)

SECTION 8
MATRIX CONSTRUCTION, SCALING AND UPDATING

8.1 Cost and Time Limitations

Input-output models are a detailed representation of the whole economy and as such are time-consuming and costly to construct. Most of the input-output models which have been produced at the national level (in Europe and North America) are based on extensive surveys of businesses and households and foreign trade. These very detailed tables are very expensive (sometimes running to millions of dollars), slow to produce (the 1985 table for the United Kingdom was published in 1990), and out of date (the latest surveyed United States table is for 1981). Despite this, these tables are widely used for policy formation, for example, to evaluate the outcome of budget proposals, or to review the implications of economic restructuring.

The input-output tables for sub-national regions, such as counties or states in metropolitan countries typically are based on the national tables. Only in a few cases have equivalent "full survey tables" been prepared for small areas. Apart from the expense, such exercises are usually complicated by "non-disclosure" rules for officially collected data. Regional tables are generally prepared by "reducing" the national table so that it matches whatever data are available for the area. This is also the starting point for the present study.

In some respects islands are fortunate with respect to data, especially when, like Aruba, they are also nation states. Information is available on trade flows in and out of the economy, and surveys of businesses and households and government are generally available. Despite this, as with most small areas and economies, there are many difficulties with much of the data in Aruba, and any SAM construction method must cope with these. In addition, these models may be expensive - the SAM model prepared for Aruba for the 1983 Macro-Plan required a considerable expense of time and effort. The aim of the present project was to demonstrate that this previously constructed table could be rapidly and inexpensively updated to account for the impacts of a major disaster and provide a useful instrument for recovery planning.

8.2 Construction of the 1990 Aruba SAM

The main objectives in constructing the 1990 Aruba SAM are:

i) to test the scaling procedures for matrix adjustment,

ii) to provide indicators to be built into the final expert system for matrix construction,

iii) to provide an updated matrix for projections and scenario simulations,

iv) to demonstrate that the final system is capable of being developed further into a practical policy instrument.

The objectives of the present project do not require that a "policy ready" model is constructed. Indeed, it is more important at this stage to test the flexibility and boundaries of the system. In engineering terms, these may be thought of respectively as equivalent to non-destructive and destructive testing of the model. For example, with respect to flexibility, it is necessary to know how much data, and what quality of data are required to build the model - i.e. how much can be left out, as well as what must be included? As explained elsewhere, the speediness of construction is as important as precision, given the circumstances of the proposed applications.

The scaling algorithm has been described in Phase One of the project and in Cole (1991). Although this method has been used to build models for other regional economies, the aim here is to streamline the exercise so that initial data collection and model preparation are completed over a short time span. This objective was met and the work carried out here was completed in less than one month with all programs, excluding model refinement and sensitivity testing. The latter has been used to test the "robustness" of the method - in other words to ask how bad the data may be, or how simplified a scaling method can be used without overly undermining the result, or leading to fatal problems in matrix construction. The conclusions from this can be used to provide information as to the relevant warnings and recommendations which should be built into the final expert system.

8.3 Scaling Algorithm and Application

The matrix construction procedure is based on a scaling algorithm which uses two sets of data - an initial SAM for the nation or region in which the locality suffering the disaster is situated, and an incomplete set of data for the region itself. The algorithm scales the first data set in such a way that it is consistent with all the locality-specific data. This procedure ensures that a minimum of information is lost. (For the case of Aruba, the scaling will take place between data sets for different time periods).

Generally, the locality specific data are aggregates, such as estimates of GDP, or total wages, and some structural data such as employment by sector or household income. The scaling procedure sub-divides these aggregates using the proportions indicated by the structural data, and then sub-divides these further to provide the same level of detail as in the national table.

The scaling procedure is iterative but usually begins by imposing the main structural details of the locality onto the national table. With the standard RAS scaling, for example, the entire national table may be "reduced" pro rata by income (rows) and by expenditures (columns) on the basis of the ratio of national to local employment by sector, with non-production activities scaled as the ratio of total employment. With the present method, in the case of Aruba, the 1979 table first is scaled to match an aggregate set of national accounts for 1990. These accounts include total factor payments, taxes, government expenditures and revenues, total imports and exports, financial inflows and outflows etc.

For the multi-proportional scaling, the matrix $A_{ij}(\infty)$ of dimension NxM defines the SAM to be constructed (for 1990). The i and j label the rows and columns of the accounts represented in the table (production sectors, households and so on). A base matrix, $A_{ij}(0)$, the 1979 SAM, is used as the starting point for the new table. If there are Z constraints, defined by the sub-totals B_z, then, after n adjustments, the Z constraints applied are given by:

$$\sum_{ij \in z} A_{ij}(n) = B_z$$

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

$$D[A(Z):A(0)] = \sum_{ij} A_{ij}(Z)\log[A_{ij}(Z)/A_{ij}(0)]$$

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,

$$D[A(n):A(n-Z)] = \sum_{ij} A_{ii}(n)\log[A_{ij}(n)/A_{ij}(n-Z)]$$

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

The details of the initial 1979 accounts are then systematically constrained using increasingly specific data. For example, in the case of Aruba, value added by sector, exports by sector, wages by sector, and the actual accounts of specific lifeline forms (water and electricity) are introduced successively. With each new piece of "target" data, all or part of the matrix is re-scaled. Finally, the table is "balanced" so that the total expenditure and total income of each activity are the same.

Since successive adjustments will change several entries, it is necessary to repeat the procedure (iterate) until all conditions are met. At this point the procedure has converged. Typically, it is sufficient to achieve consistency to within a few percent of the target data.

In general, the data will be underdetermined - that is, the total locality specific data available are not sufficient to fix every entry uniquely. Indeed, if this was so, there would be no need to refer to information from the national table at all.

For convergence to be possible, certain conditions must be met. The data must not be inconsistent - for example, in general the prescribed wages for a sector should not be larger than total factor costs (unless subsidies, or gross operating surplus is explicitly given as negative). In practice, many times the data used will come from different agencies (e.g. GDP from the Central Bank and wages by sector from the Labor Department); there are likely to be inconsistent data which as far as possible should be reconciled prior to scaling. It is also possible that specific pieces of data are over-determined (even though the table as a whole is underdetermined) so that a given entry may be successively expected to take two different values.

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). Like 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 that if the procedure converges, the result is unique. This means that only one final result can come from a given initial set of data, provided there is a systematic application of the minimum information loss principle. Thus, new data should not be added in mid-stream.

Once the accounts for the locality have been set up, further details of specific population groups or industries, beyond those shown in the national table, may be added either by sub-dividing existing entries (in smaller sectors), or adding new activities (for example, the informal sector which is not included in the official accounts).

The final precision depends on the amount of locality specific data available. In the case of the 1990 Aruba model, not all available data will be used. This is because it is useful to leave some actual data aside so that it may be used to compare with the equivalent "data" resulting from the scaling procedure. Since there is no fully surveyed recent table available for Aruba, individual entries can only be tested in this partial manner, and through the ability of the model to "track" other data in a reliable manner. Moreover, since the overall initial objective (during the crisis stage of the disaster) is to arrive at the most straightforward construction procedure, it is equally important to know what data can be left out, without its predictive ability being seriously undermined. The importance of particular pieces of data also may be tested by noting by how much the various multipliers calculated by the model are changed when these data are omitted from the construction of the SAM. If the shifts are large, then it is necessary to ensure that these data should be included precisely.

Beyond this, since the secondary objective is also to develop a procedure which could become a part of the on-going planning process for the locality once the recovery phase has begun, it is necessary that the model can be systematically updated as new data become available. For some localities, it may be possible to construct a table without applying some data from outside. However, even though a considerable amount of data were assembled for the 1979 Aruba SAM, it was still necessary to base some minor entries (in the inter-industry transaction table) on data from outside the Island. The available data for 1990 for Aruba are less complete than those for 1979, although this situation should change when present Census and Business Surveys are complete.

8.4 Details of the Table Building for Aruba

The overall procedure for constructing the 1990 SAM for Aruba is summarized in Figure 8-1. The data and results of each step are given in the accompanying Tables 8-I to 8-V.

Step One: The initial "national" SAM which is the 1979 Aruba SAM as presented in "NDP83." To facilitate scaling to the 1990 data and present situation of the Island, certain entries have been reorganized. In particular, the former Central Government and Island Government accounts have been consolidated. This table is essentially that used to "track" the 1979-1990 trends as reported earlier.

Step Two: The shutdown of the oil refinery in Aruba was a major economic disaster, at least equal to that which could arise from any conceivable natural disaster. The simplest way to obtain a first approximation to the impact of this event on the Island's economic structure is to scale the row and column entries of the 1979 table by the ratio of employment by sector before and after the shutdown. In addition, local oil purchases are re-allocated as imports.

The resulting table is unbalanced in that the income and expenditure of each account are not equal. This is relatively unimportant since the majority of entries will subsequently be re-scaled using sector specific data. Nevertheless, it is useful to include rough balancing items in the "Rest of the World" accounts (the block of entries 21-23 in the bottom right corner of the matrix). This provides a "first-cut" 1990 SAM for Aruba (in 1979 values).

Step Three: An aggregate matrix of national accounts for 1990 has been prepared from data in the 1991 Annual Report of the CBA. These data provide the overall "targets" to which all other data in the model must conform. Particular blocks of entries from Step 2 will be scaled to the totals shown here. In order to test the procedure, it is immaterial whether these data are correct. Indeed, since they are derived principally from the cash flows recorded by banks in Aruba, it is possible that they typically underestimate the level of activity on the Island.

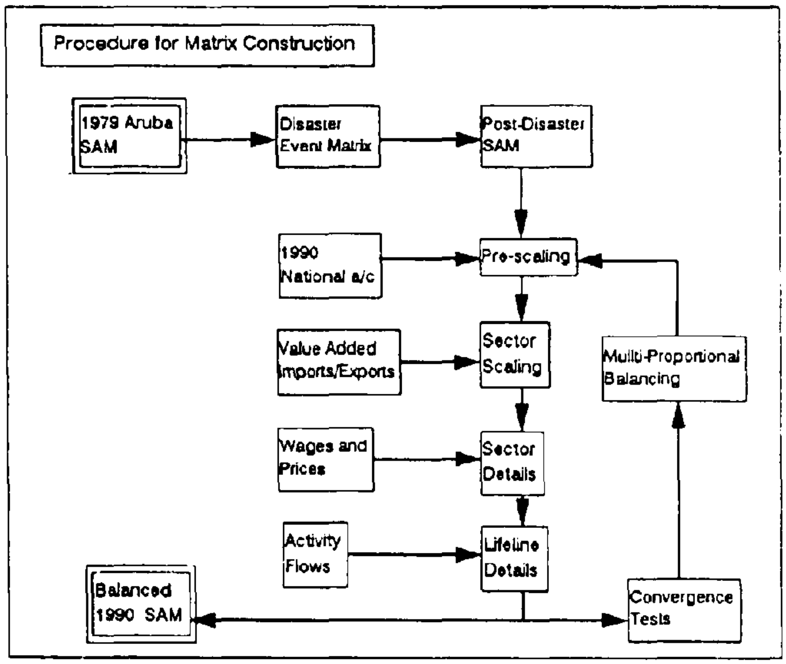


FIGURE 8-1 Procedure for Matrix Construction

TABLE 8-1 Aruba 1979 Re-Organized Social Accounts

Pre-Scaled Accounts (Re-organized 1979 SAM - 1979-90 employment changes, amalgamation of government and revised oil imports)

	PRODUCTION IND	OIL	UTIL	CON	COM	HOR	SER	FACTORS LO	MID	HIG	DEP	SUR	DOMESTC PO	RICH	FIR	GO	CAPITAL HC	FC	GC	OVERSEAS TO	TR	BO	TOTA
	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18	19	20	21	22	23	24
1	9		3	9	1	3	16						23	55		4		1	5	3	2		133
2																							
3	1		1		1	11	2						6	10		1							33
4	7		0	0	5	0	22						1	6		2	2	5	5				55
5	21		2	7	0	2	12						54	132		3		0	1	23	21		278
6	0		0	0	0	0	12						6	11				1		135			166
7	10		4	6	5	27	30						14	44		33			1	24	28		227
8	6		1	13	12	18	10							10		6				9			85
9	5		3	14	18	20	19									25				4			107
10	3		4	10	10	10	38									55							131
11	2		4	6	7	9	12									2							42
12	7		6	6	137	24	52																233
13																							
14								57	33	6		24				7							127
15								29	88	144		129				17							408
16											74	102											176
17	6		-10	4	26	5	1	2	2	3			2	58	66								165
18													-3	37									34
19															110	25						3	138
20																-24						33	?
21													3	12								[illegible]	305
22	68		28	17	90	47	22											123					395
23																13	49	50		16	[illegible]		128
24	146		47	91	314	177	250	88	123	154	74	255	106	375	176	167	51	180	11	213	51	324	3374

(Adjustment Needed)

MATRIX	Pro	Fact	Priv	Gov	Priv	Gov	Exp	Inflo	Total
Productio			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	395		15		123			288	821
OutFlows				13	99		16		128
Total	915	694	646	143	231	11	251	324	3216

TABLE 8-II Current and Target National Accounts

Current and Target National Account Aggregates

CURRENT	Pro	Fact	Priv	Gov	Priv	Gov	Exp	Inflo	Rows
Production			361	42	4	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			286	696
OutFlows				13	99		500		612
Cols	792	694	646	143	231	11	736	324	3577
Rows	656	575	711	165	147	9	698	612	3577

TARGET	Pro	Fact	Priv	Gov	Priv	Gov	Exp	Inflo	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				56	35
Imports	1117		72					626	1815
OutFlows				14	116		773		903
Cols	2645	1556	1521	319	494	35	1614	903	9287
Rows	2644	1556	1521	319	494	35	1815	903	9287

RATIO	Pro	Fact	Priv	Gov	Priv	Gov	Exp	Inflo	Rows
Production	0.00	0.00	3.00	2.53	42.68	3.09	4.42	0.00	4.02
Factors	2.85	0.00	0.00	1.91	0.00	0.00	0.00	0.00	2.71
Priv Cur	0.00	2.13	0.00	2.25	0.00	0.00	0.00	0.00	2.14
Gov Cur	4.31	12.63	0.72	0.00	0.00	0.00	0.00	0.00	1.93
Priv Cap	0.00	0.00	1.90	0.00	0.00	0.00	0.00	76.73	3.35
Gov Cap	0.00	0.00	0.00	0.96	0.00	0.00	0.00	1.74	3.72
Imports	4.11	0.00	4.80	0.00		0.00	0.00	2.17	2.60
OutFlows	0.00	0.00	0.00	1.08	1.17	0.00	1.54	0.00	1.47
Cols	3.34	2.24	2.35	2.24	2.14	3.09	2.47	2.79	2.60

TABLE 8-III Value Added, Wages and Trade by Sector

Sector GDP and Overseas Trade Details

Sector GDP

	1	2	3	4	5	6	7	Rest	Fut
Estimate				122	232	441		733	167
Matrix	94		10	155	641	253	375	479	167
								1.53	1.00
Ratio	1.53	1.53	1.53	0.79	0.36	1.74	1.53	1.53	1.00
Scale	1.53	1.53	1.53	0.79	0.36	1.74	1.53		

Source IMF90P24

Exports	Tou	Merc	Serv		Imports	Tou	Merc	Serv	Total
Estimate	625	241	175	1041	Estimate	72	1116		1188
Matrix	815	101	124	1041	Matrix	25	1117		1142
Ratio	0.77	2.39	1.41	1.00	Ratio	2.92	1.00		1.04
Scale	0.77	2.39	1.41	1.00	Scale	2.92	1.00		1.00

Source CBA91T13

Details of Financial Flows
Source CBA90Q4 Report

Sector Import Propensities

	Tour	Merc	Rest
Estimate	200	1116	916
Matrix	193	1117	924
Ratio	1.04	1.00	0.99
Scale	1.04	1.00	0.99

Source CBA91T13

Sector Wages

	1	2	3	4	5	6	7	Publ	Dom	Total	Aver
1990 Rate				1.90	1.30	1.60	1.90				1.68
Employm	738		460	4382	4673	5950	6617	4400		26022	
1984 Rate	1.30	4.66	2.71	1.93	1.33	1.44	2.10	1.77	1.00		1.70
Estimate	11		15	100	73	114	151	92			0.99
Matrix	41		24	104	117	137	191	163			
Ratio	0.28		0.62	0.97	0.63	0.83	0.79	0.56			
Scale	0.28		0.62	0.97	0.63	0.83	0.79	1.00	1.00	1.00	

Source IMF90P62/DEAE13A&B

TABLE 8-IV Details of Lifeline Accounts

Details of Individual Lifeline Accounts

	Energy/Water Lifeline Se					
	WEB	EL	TOT	Matrix	Ratio	Scale
Total	76	68	144			
1	17	4	21	21	1.0	1.0
2						1.0
3		8	8	2	3.8	3.8
4						1.0
5						1.0
6						1.0
7						1.0
8	11	6	16	36	0.4	1.0
9						1.0
10						1.0
11		4	4	18	0.2	0.2
12		11	11	24	0.5	0.5
13						1.0
14						1.0
15						1.0
16						1.0
17		35	35	-64	-0.5	-0.5
18						1.0
19						1.0
20						1.0
21						1.0
22	48		48	116	0.4	0.4
23						1.0
24			144	154	0.9	

Source: EDP91

TABLE 8-V Aruba 1990 Approximate Social Accounts

ARUBA 1990 APPROXIMATE SOCIAL ACCOUNTS — End Multi-Proportional Scaling

	PRODUCTION							FACTORS					DOMESTC				CAPITAL			OVERSEAS				
CODE	IND	OIL	UTIL	CON	COM	HOR	SER	LO	MID	HIG	DEP	SU	PO	RICH	FIR	GO	HC	FC	GC	TO	TR	BO	TOTA	TARGE
0	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18	19	20	21	22	23	24	0
1	19	0	7	32	2	4	27	0	0	0	0	0	73	177	0	9	0	39	19	6	27	0	441	440
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	3	0	8	0	3	31	7	0	0	0	0	0	31	56	0	2	0	0	0	0	0	0	142	142
4	8	0	0	0	11	0	22	0	0	0	0	0	1	11	0	2	52	171	10	0	0	0	289	289
5	31	0	4	16	0	3	14	0	0	0	0	0	120	301	0	4	0	4	2	38	214	0	751	750
6	0	0	0	1	1	0	32	0	0	0	0	0	29	53	0	0	0	114	0	506	0	0	736	732
7	26	0	10	23	22	54	61	0	0	0	0	0	54	175	0	90	0	0	4	71	175	0	767	763
8	5	0	3	35	22	43	23	0	0	0	0	0	0	14	0	11	0	0	0	11	0	0	166	165
9	4	0	5	37	32	47	42	0	0	0	0	0	0	0	0	48	0	0	0	4	0	0	218	218
10	3	0	7	27	18	24	86	0	0	0	0	0	0	0	0	106	0	0	0	0	0	0	270	269
11	11	0	4	7	5	57	51	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	135	135
12	61	0	11	10	133	231	335	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	781	777
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	102	58	12	0	124	0	0	0	17	0	0	0	0	0	0	314	315
15	0	0	0	0	0	0	0	43	129	218	0	547	0	0	0	37	0	0	0	0	0	0	973	977
16	0	0	0	0	0	0	0	0	0	0	135	106	0	0	0	0	0	0	0	0	0	0	240	241
17	38	0	35	5	19	37	4	20	30	40	0	0	1	29	61	0	0	0	0	0	0	0	319	318
18	0	0	0	0	0	0	0	0	0	0	0	0	-7	102	0	0	0	0	0	0	0	0	95	95
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	180	0	0	0	0	0	0	220	399	400
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-23	0	0	0	0	0	58	35	35
21	0	0	0	0	0	0	0	0	0	0	0	0	14	58	0	0	0	0	0	0	0	633	705	708
22	230	0	48	95	482	201	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1117	1119
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	43	73	0	71	702	0	903	910
24	440	0	142	288	750	732	762	165	217	269	135	778	315	977	241	318	95	400	35	707	1119	910	9797	9797
Jobs	738	0	460	4382	4673	5950	6617									4400							27220	

FINAL	Pro	Fact	Priv	Gov	Priv	Gov	Exp	Inflo	Rows
Production			1082	107	379	35	1038		2642
Factors	1376			166					1541
Priv Cur		1474		54					1528
Gov Cur	139	90	91						319
Priv Cap			274					220	494
Gov Cap				-23				58	35
Imports	1117		72		0			633	1822
OutFlows			0	14	116		773		903
Cols	2631	1564	1519	318	495	35	1812	910	9285
Rows	2642	1541	1528	319	494		1822	903	9285

TARGET	Pro	Fact	Priv	Gov	Priv	Gov	Exp	Inflow	Rows
Production	0	0	1083	107	378	35	1041	0	2644
Factors	1389	0	0	167	0	0	0	0	1556
Priv Cur	0	1467	0	54	0	0	0	0	1521
Gov Cur	139	89	91	0	0	0	0	0	319
Priv Cap	0	0	275	0	0	0	0	219	494
Gov Cap	0	0	0	-23	0	0	0	58	35
Imports	1117	0	72	0	0	0	0	626	1815
OutFlows	0	0	0	14	116	0	773	0	903
Cols	2645	1556	1521	319	494	35	1814	903	9287
Rows	2644	1556	1521	319	494	35	1815	903	9287

Note: Imbalance in aggregate accounts arises from mism [illegible] domestic service and private overseas transfers

Step Four: The magnitude of equivalent blocks as pre-scaled in Step 2 and the target table are shown and their respective ratios, typically between 2 and 3. In order to test the ability of the scaling procedure to deal with anomalous situations, some entries are arranged to be anomalous. 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). The first step in the scaling procedure is to multiply every entry from Step 2 by the relevant ratio. For example, all factor payments from production activities are multiplied by 2.8.

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.

This provides an approximate SAM for 1990, measured in current AFl million and consistent with the aggregate national accounts.

Step Five: Additional details are now added. Estimates of the contribution to GDP of tourism, commerce and construction have been made by the IMF. In addition, the CBA records data on tourism revenues and commodity and service exports. These are used to adjust the entries in the matrix. For example, the four entries for tourist expenditures (Column 21 from Step 2) which currently sum to 815 are each multiplied by 625/815 = .77. Information on imports by sector are not known. However, since it is desired later to compare results with those from the IMF model, the assumption of that model that tourism imports are 32 percent of revenues (AFl 200 million) is used.

Step Six: Again further details are added which sub-divide the data introduced by Step 5. Some data are available on wage rates by sector (construction and tourism) and information on relative rates for all sectors are available from earlier years, providing estimates of total wages by sector. These estimates are now used to sub-divide the factor payments by sector between their wage and non-wage components. Similar scaling could also be introduced at this point to modify household spending by sector using current CBS price indices for the "high" and "low" income households represented in the SAM. At this level of detail some possible inconsistencies in data are noted - for example, for the thriving construction sector the estimated total wage payments are only slightly less than their estimated contribution to GDP.

Step Seven: Preliminary details relevant to elaboration of lifeline systems are now added to the model by including information from 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. The former net subsidy to the utilities sector is reversed at this stage. The fuel sector (the re-opened transhipment and refining companies) will be added later. Because of the potential over-determination of wages (from the inconsistent data introduced in this Step and Step 6) wage payments are not re-scaled at this point.

Step Eight: Since data as to the total expenditures or income is not known for every account, these are now initially fixed by scaling the columns and then the rows of every account so that first the column and then the row totals each equal the current average.

The above adjustments have introduced information at several levels of detail. From the point of view of testing the model, no further detailed information need be entered.

Step Nine: The result of this "first round" of scaling is shown. At this stage, none of the required targets are met because the application of each new piece of data has disturbed the earlier adjustments. For example, even though the first scaling in Step 3 matched the SAM to the aggregate national accounts for 1990, the current bloc totals no longer conform to these data. The scaling procedure (from Step 3) is then repeated but with Step 2 replaced by Step 9.

Step Ten: 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. In general, the number of iterations required to achieve convergence will depend upon the desired precision, the number of entries, the degrees of freedom in the balancing of the data (essentially the difference between the number of entries in the table and the number of constraints applied), and the "tightness" of the remaining adjustments. If most of the "unknown" entries are nearly determined explicitly or implicitly (e.g. as a residual), then the adjustment process may take many recalculations.

The income and expenditure totals are in good agreement for all accounts, and the table conforms with all the target data which has been introduced. The final SAM for 1990 shown in Table 8-V also agrees with the aggregate national accounts data to well within 1 percent. (Note here that although there appear to be some remaining inconsistencies between the final matrix and the target matrix and between the row and column entries these are the result of various "dummy" payments - income to domestic servants from high income households and unrecorded tips to hotel workers by tourists).

SECTION 9

FORECASTING WITH THE 1990 ARUBA SAM

9.1 Backcasts and Forecasts for 1986-2000

It is obviously not yet possible to test forecasts with the 1990 SAM against actual future events. However, a "backcast" (retrospective forecast) of events from 1986-1990 can be evaluated. This is because the marginal impacts for a given exogenous impact are constant from year to year, since the coefficients of the SAM are constant over the horizon of the forecast.

The backcast consists of entering the historic (pre-1990) tourism revenues and related construction expenditures (hotels and infrastructure) into the model, as well as overseas income derived from other sources (such as commodity exports and re-exports), summarized as an event matrix in Table 6-I.

The forecast consists of entering the expected revenues and planned expenditures (CEP - Government Capital Expenditure Program) from 1991 to 1995 with an extrapolation to the end of the century.

The direct employment provided by these exogenous expenditures from 1986-1990 are shown in Figure 9-1. Hotel and public infrastructure construction are largely complete by the end of 1992 and 1995 respectively. Tourism revenues and other inflows are expected to grow until 1995. Beyond this, a no-growth scenario is assumed. Figure 9-2 shows the total employment induced by each of these components separately.

The employment increase due to the above factors between 1986 to 1990 is calculated about 18,000. Again, the results suggest that much of the employment growth in Aruba over this period has arisen from the construction boom, rather than the growth in tourism itself. Note, however, that the delayed effects from the shutdown of the refinery are not included in this

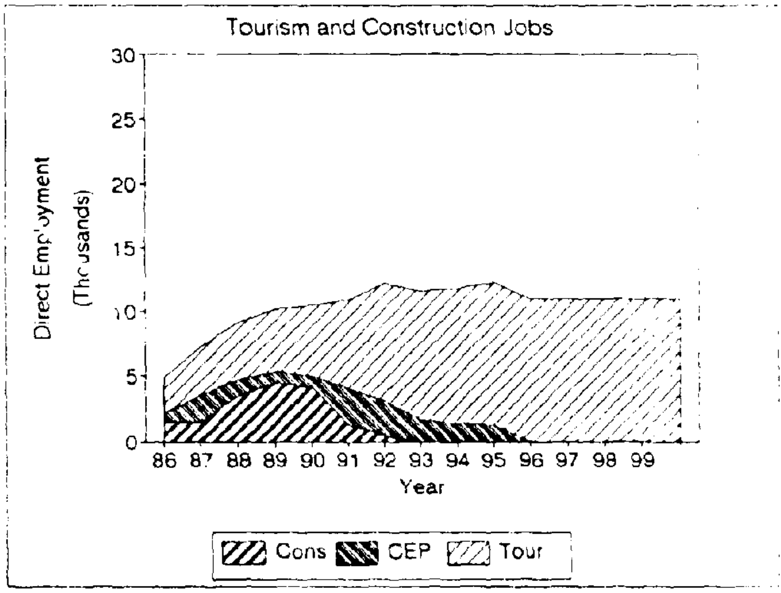


FIGURE 9-1 Tourism and Construction Jobs (1986-99)

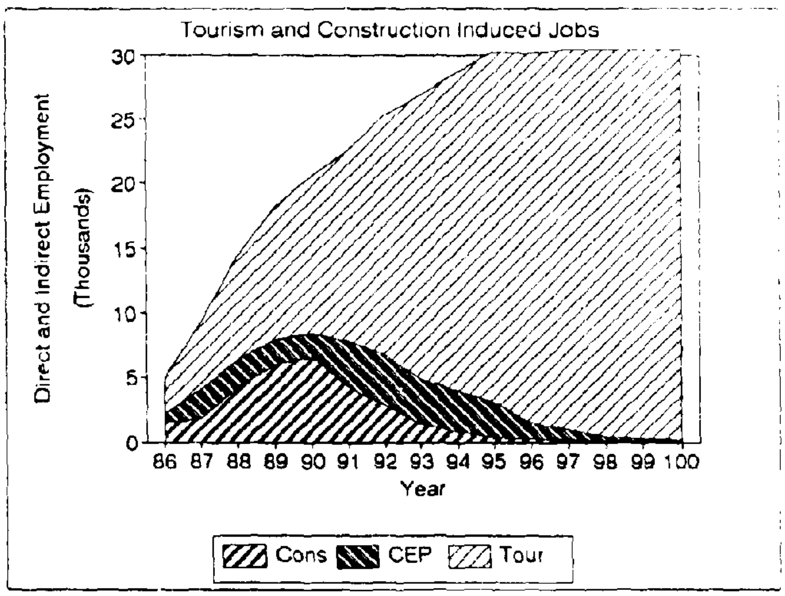


FIGURE 9-2 Tourism and Construction Induced Jobs

calculation. This backcast with the 1990 model is in reasonable agreement with the combined forecast for construction and tourism revenues made using the 1979 model given above.

The forecast from 1991 to 1995 - based on expectations for tourism and government capital expenditures, suggests that the increase in tourism and the "front-loaded" CEP may be sufficient to offset the end of the construction boom. It is also possible that delays in the hotel construction program will smooth the levelling-off in total employment. Beyond this, growth in exports suggests that by 1995 about 20 thousand jobs in Aruba will depend directly or indirectly on tourism. Less than 5 thousand will depend on income from other external sources. The downstream effects of the construction boom and the current CEP will by this time be rather small. Nevertheless, extending the horizon to the year 2,000 - assuming no further increase in tourism - suggests that by this time, without further diversification of the economy, the Island will be very dependent on the tourism sector for more than half of all employment.

9.2 Sector Specific Forecasts

The backcast/forecasts between 1986 and 2000 have been calculated for two sectors, construction and commerce, using the 1990 model. For each sector, the impact is sub-divided into the direct and indirect employment arising from different sources of income.

For the construction sector, Figure 9-3 shows that the direct employment arises from the hotel construction and the CEP takes place prior to 1995. Neither activity has a substantial downstream impact on other domestic and private construction. The indirect employment in construction (largely private housing and businesses) comes from tourism and other foreign earnings. Obviously the type of construction required and businesses and employees involved is likely to be very different between the hotels and private dwellings. It is likely that these projects underestimate the effect of the present bottle-neck in housing starts.

For the commerce sector, Figure 9-4 shows that the direct employment arises from tourist purchases and re-exports (primarily retail and wholesale respectively). Both stimulate significant

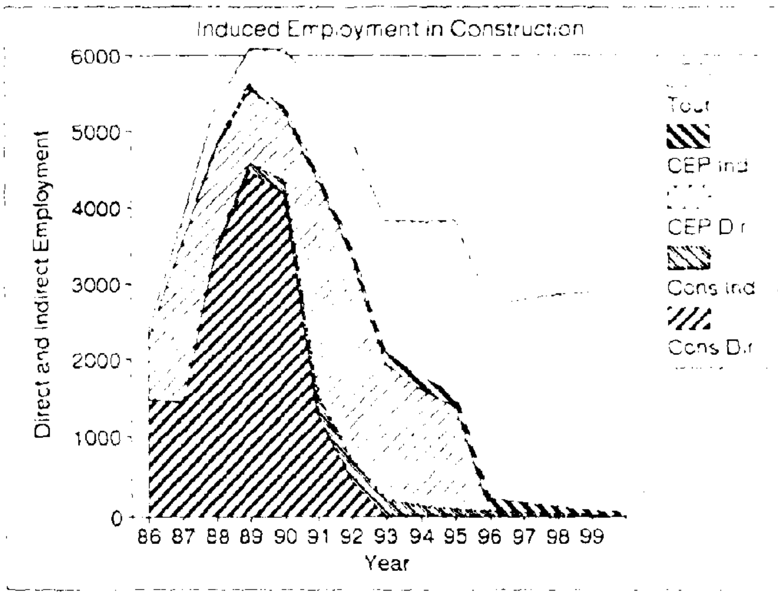


FIGURE 9-3 Composition of Construction Jobs (1986-99)

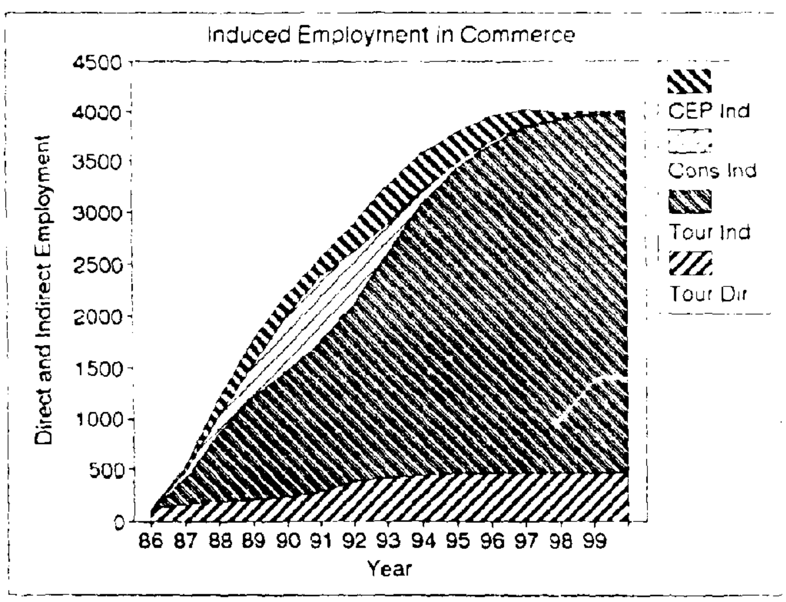


FIGURE 9-4 Composition of Commerce Sector Jobs (1986-99)

downstream employment in the commerce sector. Again, the type of commercial activity is quite different for the different components of demand.

Together, the charts indicate a considerable restructuring of jobs and job characteristics in the years ahead even when the total level changes steadily.

9.3 "Disastrous" Changes in the Level of Tourism

The tourism boom clearly has brought considerable income and employment to Aruba, and "rescued" the Island's economy from a potentially disastrous situation. Figure 9-5 shows the income accruing the private and public sectors of the Island's economy over a ten year period from a doubling of the level of tourism, essentially an additional AFl 620 million of tourism revenues, the 1990 level.

Tourism is, nevertheless, vulnerable to both natural and economic events. At the request of the Aruba Disaster Preparedness Committee, the model has been used to estimate the impact of a sudden decline in tourism, for whatever reason, whether damage from a hurricane or earth tremor, or an oil spill from a passing tanker. The latter is increasingly possible since the part of the refinery re-opened as a transhipment terminal (operated by Wickland), and scaled-down oil refining started up again in 1991 (operated by Coastal).

The Island is systematically improving its ability to cope with natural disasters such as hurricanes or tidal surges, and has identified a number of potentially vulnerable locations.

As an illustration of the potential impact of the loss of tourism, this section examines the impact of a sudden total collapse of tourist revenues. For this, the updated SAM model based on data for 1990 is used, with the expenditures by tourists eliminated. The results given in Figure 9-6 for employment, total value added (i.e. the change in GDP), and government revenues, show how the economic impact would increase with time. Total employment, for example, would fall from the present 26,000 to about 15,000 in the first year, and to less than 10,000 after about 5 years.

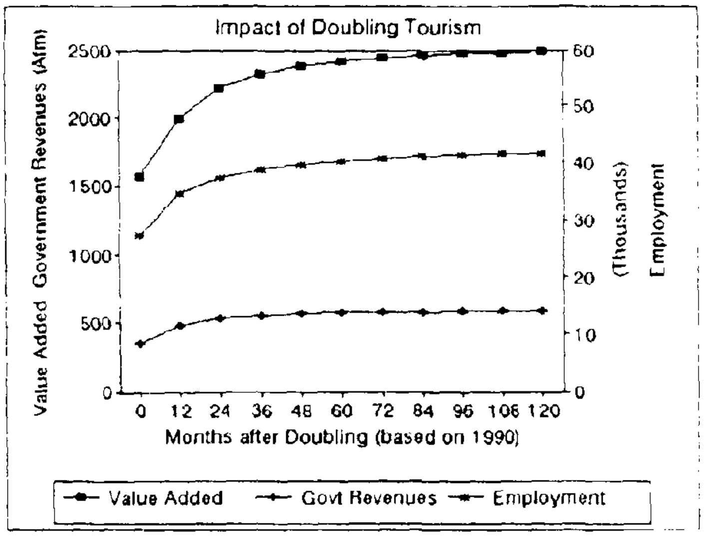


FIGURE 9-5 Impact of Doubling Tourism

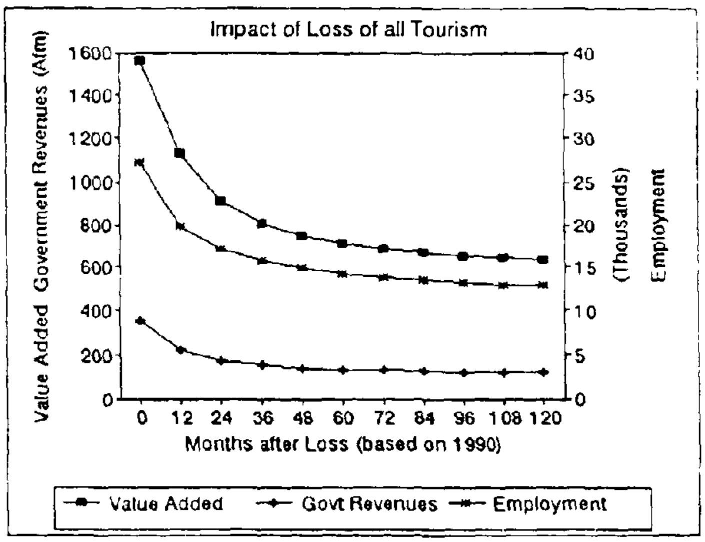


FIGURE 9-6 Impact of the Loss of All Tourism

The impact of this decline in employment in each of the production sectors of the economy (ten years after the event) is also shown. As might be expected, the impact is uneven, and depends only in part on the strength of the direct links to the tourist industry.

Unlike the former oil industry in Aruba, tourism is distributed across a wide range of individual hotels and other activities, so it is highly unlikely that a total collapse would occur. Nevertheless, it is not unknown in the Caribbean for a tourism industry to fail dramatically as a result of natural and other events. It should be noted, however, that the effect of doubling the size of the industry (the mirror image of this event) shown in Figure 9-5 is potentially equally dramatic since this would push overall employment on the Island to nearly 57,000!

9.4 Economic Overshoot and the Balance of Payments Trap

Since the Aruba SAM summarizes the economic exchanges between the various economic actors on the Island (such as tourists, hotels, shops, workers, households, and government) as well as their transactions with the outside world (via trade and overseas payments), it permits the total impact of a given change (or set of changes) to the economy to be calculated, including the estimation of total inflows arising from the expansion of the tourist industry.

In this section, the 1990 Aruba SAM is used to explore an important macro-economic policy for the future of Aruba - the possibility that the "dramatic success" of the tourism based recovery strategy has led Aruba into a "Catch 22" trap. The Island can achieve a balance of payments equilibrium only if it continues to expand its tourism sector, but if tourism is expanded further, the Island faces a politically unacceptable level of immigration.

DEACI have calculated that the tourism development which has taken place in Aruba over the last five years may have had an adverse impact on the Arubian balance of payments (Robles, 1990). Thus, while tourism has become the major export industry of Aruba, the total outflows required to support the industry so far have been greater than the foreign exchange inflows they have brought to the Island.

The suggestion obviously has worrisome implications for Aruba since future development, including a positive outcome for the balance of payments, are predicated on the continued growth of the tourist industry, and reports by the international lending agencies, such as the IMF, see this as a critical indicator of the Island's performance.

The use of an input-output model to measure balance of payments is a demanding test. Nevertheless, even though the model has been constructed as part of an exploratory study and the results are tentative, they lend support to DEACI concerns, since they show that both in the short-run, and in the long-run, the cumulative balance of payments impact of tourism on the Island's economy may be negative. In the short-run, this arises because of the start-up costs associated with tourism, and in the long-run because, even after tourism revenues have begun to level-off, private and public spending will continue to catch up with the effects of the boom. This may be the case even when the medium-run cumulative balance of payments is positive.

The calculations presented here are based on the average performance of the Island's economy. However, they suggest that, in general, the cumulative impact will depend on the precise details of (i) to (iv) above for each tourist related project - for example, the share of food imported by hotels or restaurants, the level of repatriated earnings or the rate of interest on infrastructure related development aid. In some cases, the long run net impact on the Island's balance of payments from individual projects is likely to be negative. In other cases it may be positive.

The calculation of DEACI is based on import-export data for the years 1986 to 1989. Since this was a period of rapid expansion of tourism in Aruba it might be argued that this "start-up" phase, which includes a good deal of construction, might be untypical and that eventually the situation would reverse to a positive balance. Thus the calculation may be correct but not apply to forthcoming years. This reversal appears to be the conclusion of the recent 1991 IMF report to the Prime Minister of Aruba.

The DEACI calculation assumes that the entire island economy supports tourism - in other words all imports to Aruba are ultimately tourist related. With the input-output calculation it is not necessary to make such a blanket assumption. Nevertheless, it is reasonable to suppose that outflows should include (i) the direct imports of the hotels and tourist related activities, (ii) the import requirements of the construction of hotels and related infrastructure, (iii) the import requirements of the labor force supporting the hotel industry, and the businesses they in turn depend upon, and (iv) the financial outflows of repatriated earnings by foreign workers and businesses. In other words, the calculation accounts for the full upstream and downstream import requirements arising from the tourist industry, excluding interest payments on borrowing by the government or private investors. Inflows are mainly the foreign exchange tourists bring to the island, but may also include development aid for tourist related projects and investment finance by businesses.

9.5 Balance of Payments Calculations using the 1990 Aruba Model

The event matrix corresponding to the proposed expansion of the tourism sector and the construction program so far announced (up to and including the Draft 1991-1995 Aruba Public Expenditure Program) is shown in Table 9-I. The BOP implications of the tourism boom are calculated from this table using the three approximations to the lagged model discussed previously when testing of the 1979 SAM.

Approximation One: Fixed Horizon Model

The first exercise reviews the cumulative impact on the balance of payments over a ten year period (a typical tax-holiday) for a fixed amount of tourism. The total inflows and outflows associated with the 1990 level of tourist activity (AFl 621 million), and the corresponding required tourist related construction are calculated. The latter is estimated to be a total of AFl 1692 million assuming a cost per room of about AFl 206 thousand (in 1990 florins), excluding other construction and public infrastructure.

The cumulative impacts given in Table 9-II show that over the 10 year period there is a net deficit of AFl 162 million, about 2 percent of total flows, a relatively small amount. This

TABLE 9-I Base Event Matrix 1986-2000

BASE EVENT MATRIX 1986-2000 — Primary Events: Change in Annual Expenditures by Activity relative to 1990

Sector		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
PHASE	Year	Exports			Construction		Tourism										Capital Expendatures Program							
	1985																	(mainly construction)						
CONSTRUCTION	1986	2			98	18	282	35										52						
	1987	3			94	25	385	47										139						
	1988	4			226	30	459	57										86						
TOURISM BOOM	1989	4			295	33	504	62										63						
	1990	4			273	38	573	71										58						
	1991	6			82	47	715	88										186						
CAPITAL PROGR	1992	7			29	62	949	117										176						
	1993	8				68	1035	128										114						
	1994	8				71	1081	133										96						
	1995	9				75	1150	142										85						
CONSOLIDATION	1996	9				75	1150	142																
	1997	9				75	1150	142																
	1998	9				75	1150	142																
	1999	9				75	1150	142																
	2000	9				75	1150	142																

Note: Amounts are deflated to AP1990

TABLE 9-II Tourism 10-Year Cumulative Impacts

10-Year Cumulative Income and Employment by Activity from AFI 620 million in Tourism Revenues

Activity	Income	Jobs
Industry	2108	3978
Utilities	907	2939
Construction	2542	34005
Commerce	3681	22039
HORECA	6424	48760
Services	4548	25200
Value Added	9757	
Households	8009	
Government	2038	17811

Note: income in AFI 1990 prices, employment in job-years.

suggests that whether the net balance is positive or negative is likely to depend on the actual costs of infrastructure and details of hotel operations. For example, a more clearly net positive outcome obviously would arise if less income was repatriated. A much worse situation could arise if the Island bears the full cost of hotel and infrastructure construction and there is a high level of imports and repatriation of income.

Approximation Two: Multiple Horizons Model

This first approximation does not take account of the scheduling of events. However, as indicated above, the cumulative balance of payments is affected by the timing of the construction and operations phases of the expansion of tourism. To clarify this, the calculation is repeated assuming an initial two-year construction phase followed by a sustained operational phase. Figure 9-7 shows that the income from tourists which rises from year to year as occupancy increases (from 70 immediately after construction to 80 percent). The graph separates the outflows associated with construction from those arising from the continuing operation of the hotels. Thus, while the cumulative outflows from construction level off after a few years, those from hotel operation rise steadily as their imports over successive years accumulate.

The net impact on the balance of payments (the difference between outflows and inflows) is seen to be negative for the first three years, reflecting the conclusion of the DEACI calculation.

The cumulative surplus then becomes positive for about another five years as predicted by the IMF model (see below). However, again the balance is marginal and, since the rapid expansion of tourism is planned to continue for several more years, it is possible that the cumulative deficit will continue.

There is a suggestion in both Table 9-III and Figure 9-8 that the net surplus may be reversed after some time as consumer and government spending throughout the economy catches up with the increased income earned from tourism. This might indicate that a deficit can only be avoided

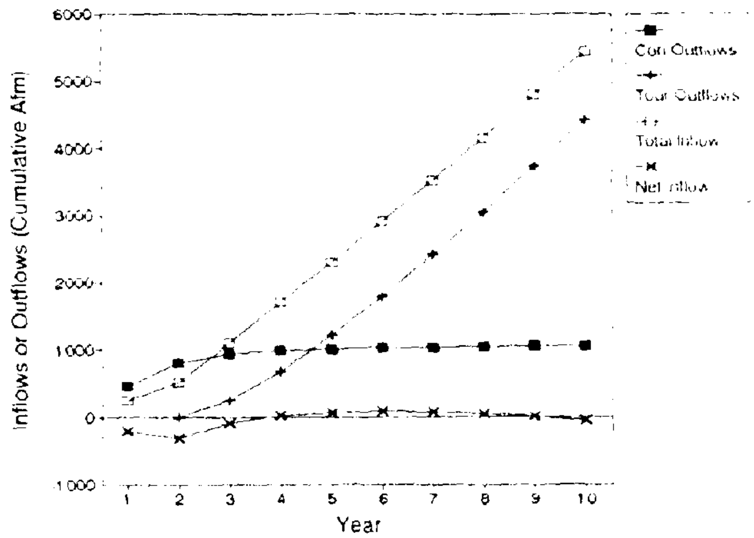


FIGURE 9-7 Tourism Induced Balance of Payments

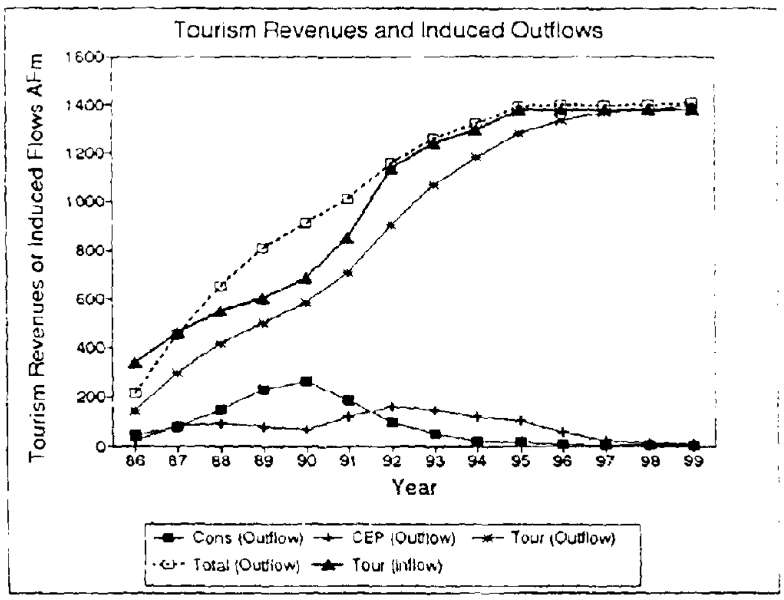


FIGURE 9-8 Tourism Induced Inflows and Outflows

TABLE 9-III 10-Year Cumulative Balance of Payments

10 Year Cumulative Balance of Payments
AFl 620 million of Tourism Revenues

Inflows	AFLm	Outflows	AFLm
Tourism	7165	Goods and Services	7050
Investment	483	Other	751
Total	7639	Total	7801
Balance	-162	(about 2 percent of inflows)	

Note: measured in AFl 1990 prices.

TABLE 9-IV Impacts According to the IMF Model

Impact of 1000 Extra Rooms according to IMF Model.

Year	1991			1995	
Rooms	M	X	Rooms	M	X
5600	1275	1286	7800	1875	1835
6600	1481	1438	8800	2018	2011
Change	206	152		143	176
Net	-54			+33	

by constantly expanding tourism, at least up to the level that the infrastructure share of construction becomes greatly reduced.

Approximation Three: Annual Horizons Model

The third and most elaborate calculation here attempts to track the tourism related balance of payment components over the entire period between 1986 and 1995. This calculation is based on the on actual and planned tourism revenues and construction. The results, shown in Figure 9-8, again suggest that both the short and long-run impacts on the balance of payments may be negative. In the short-run, this arises because of the setting-up costs; in the long-run because although tourism revenues are beginning to level-off, consumer and public spending is still catching up with earlier increases in tourism revenues. The need for new maintenance of hotels and infrastructure (not included here) could worsen this BOP trend (although in the past hotel chains in Aruba have tended to neglect properties towards the end of the tax holiday period).

Even without this, it seems that some of the statistics should be improved if the Island is to evaluate its tourism balance of payments correctly. For example, measuring tourism revenues as the amount of foreign currency deposited in banks monitored by the Central Bank of Aruba may seriously underestimate spending by tourists, income. Taking account of this should improve the BOP situation. Conversely, only hotel construction is included in this graph, but obviously there is a good deal of private and public construction which would not be undertaken but for tourism, which should also be included.

The data required to make a more precise calculation here are not available. Nevertheless, the tentative calculations suggest that, while the present moratorium on hotel development may be essential in order to adjust to, and consolidate, the on-going boom rapid phase of Aruba's tourism development, a new phase of tourism (or other development) will be required, if renewed BOP difficulties are to be avoided.

9.6 The International Monetary Fund Strategy - A Vulnerable Recovery?

The marginal nature of the balance of payments reversal is also suggested by calculations with the IMF model which takes into account the declining tourism related infrastructure expenditures planned by the Government. To demonstrate this, the IMF model of Aruba used in the 1985 report (IMF85) was updated so that its parameters matched data for the period 1986 to 1990. The IMF model was modified only slightly for the IMF90 report so should be expected to give similar results for the later period.

Table 9-IV shows the impact of an additional 1,000 hotel rooms on total exports (X) and total imports (M) in each of the years 1991 and 1995, according to this version of the IMF model. For 1991 there is negative net impact of minus AFl 54 million, but by 1995 the same addition is estimated to provide a net positive impact of AFl 33 million.

According to IMF85 the model played a central role in the preparation of the disaster recovery program for the Island, that was prepared by the IMF. However, the analysis of the IMF model in the present study has raised the following troubling points with respect to this use.

i) The results for the IMF model are very sensitive to the parameters used.

ii) According to IMF85, the parameters used by the IMF to make recommendations for the 1986-90 period were based on data for 1980-85. However, the parameters which would be needed to match the model to what actually happened in the earlier period appear to be quite different from those used to make the projections.

iii) Nor do the parameters used in the model provide projections of what would happen in the ensuing years, whether or not the known changes in income are fed into the model (as in the earlier tests of the SAM model).

iv) Because the IMF model does not distinguish between the import requirements of non-tourist activity, it is not possible to distinguish the impact of different phases in the

Island's recovery. For example, the balance of payments impacts of construction associated with tourism and infrastructure cannot be separated from other household and government related imports.

v) The Central Bank of Aruba (IMF91) notes that "Based on Fund staff advice, the authorities acted swiftly and decisively," and so credits the IMF with much of the success for the recovery. Even so, it is not at all clear to what extent the forecasts and recommendations deduced from the results of the model were actually used. Certainly, two of the key recommendations were not adopted (to raise taxes and to reduce public sector employment). Moreover, it has been suggested (by the Prime Minister of the day) that the Government knew that the IMF model was faulty but had to pay lip service to the analysis, in order to maintain the necessary IMF support.

These concerns notwithstanding, it appears that the tourism development which has taken place since the closing of the Lago refinery has rescued the Arubian economy from a potentially very damaging crisis, just as the proposed moratorium on major new tourism initiatives should enable the Island to consolidate the present gains. All the calculations suggest that, a new phase of tourism (or other) development may be needed once the adjustment phase is complete, and that it is reasonable to begin to plan for this now. The calculations also suggest that, in doing this, the Island should review more carefully the tourist related projects which it encourages and supports from the standpoint of their contribution to the balance of payments. Equally, they demonstrate that in reviewing tourist related projects (as it seems the Government is now proposing to do), consideration should be given to the balance of payments effects of projects individually and collectively, for example, using an input-output model somewhat more detailed than that employed here, as well as taking more precise account of the external financial flows such as interest payments, income repatriation as well as commodity imports specifically related to tourism. This should make it possible to distinguish those individual projects and strategies which stand a good chance of making a positive contribution to the balance of payments from those which probably can not.

SECTION 10
REGIONAL ECONOMIC IMPACTS

10.1 Regions, Disasters and Lifelines in Aruba

This section describes the construction and application of a regional economic model of Aruba.

Even with her small size, Aruba has well defined geographic regions, which would be differently affected by disasters and recovery programs.

Economically, the Lago oil refinery was located in the San Nicolas area, Oranjestad has remained the commercial and administrative center, tourism has developed in the previously sparsely populated Noord area, while the Santa Cruz has retained its primarily traditional local economy.

Demographically, San Nicolas has been populated by Caribbean and other immigrants associated with the oil refinery, Noord and Santa Cruz by the native (i.e. pre-oil refinery) Arubian population, and Oranjestad has been the cosmopolitan center.

The changing size and geographic distribution of the population over the last 60 years, indicated by Figure 10-1, has been driven largely by the level of employment in the refinery. Even though, historically, there has been a relatively high level of commuting between districts, the collapse of the oil refinery in San Nicolas and the rapid growth of tourism in Noord must be expected to bring about equally significant changes in the future demography of Aruba.

With such strong dependencies between the various regions of the island in terms of lifeline systems (such as water, electricity) and a good deal of daily commuting along the length of the Island, the highly localized character of the principle lifelines, and the vulnerability of transportation links between some districts, a regional model is necessary to assess the economic impact potential damage to this network. Clearly, such a model could also be used to forecast shifts in the distribution of economic activities on the Island, such as the level of commuting between regions, the pressures for new housing development or the level of employment and unemployment in different parts of the Island.

To develop such a model, for present purposes, it is sufficient to sub-divide the Island into its four principle districts: San Nicolas, Oranjestad, Noord and Santa Cruz. These districts correspond roughly to those selected by the Disaster Preparedness Committee (with Oranjestad and Noord combined).

The principle application here is to "predict" and "track" the impact of shutdown of the Lago refinery in 1985, and the subsequent tourism based recovery programs, on different geographic regions of Aruba. This exercise is simplified so as to consider only the final close-down of the refinery, and the speed-up of the tourism development plan to offset unemployment. Thus the total figures predicted will vary somewhat from those given earlier.

10.2 Construction of the Regional Model

The regional model is adapted from the 1979 Aruba model using data provided by the 1981 Census. Again, the aim is to provide a planning instrument suitable for assessing the regional economic impact of a natural or other disaster using readily available data. In the context of the present project, this exercise serves two purposes:

i) to refine the process for constructing regional-level models from the national economy,

ii) to estimate the importance of the inter-district networks.

The basic method of construction summarized by Figure 10-2 involves four steps:

Step One: Aggregation of the 1979 SAM.

For the present demonstration, labor and households are treated as single accounts in each region. Government, capital and firms are treated as Island-wide activities (recognizing, however, that

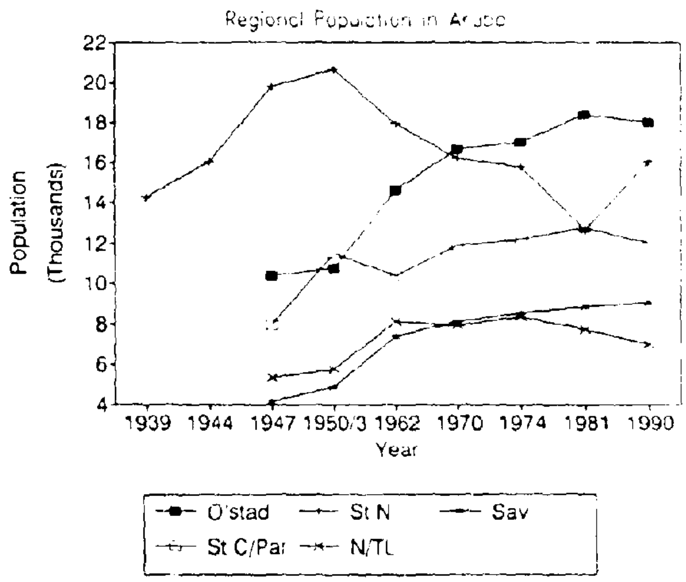


FIGURE 10-1 Regional Population Trends in Aruba

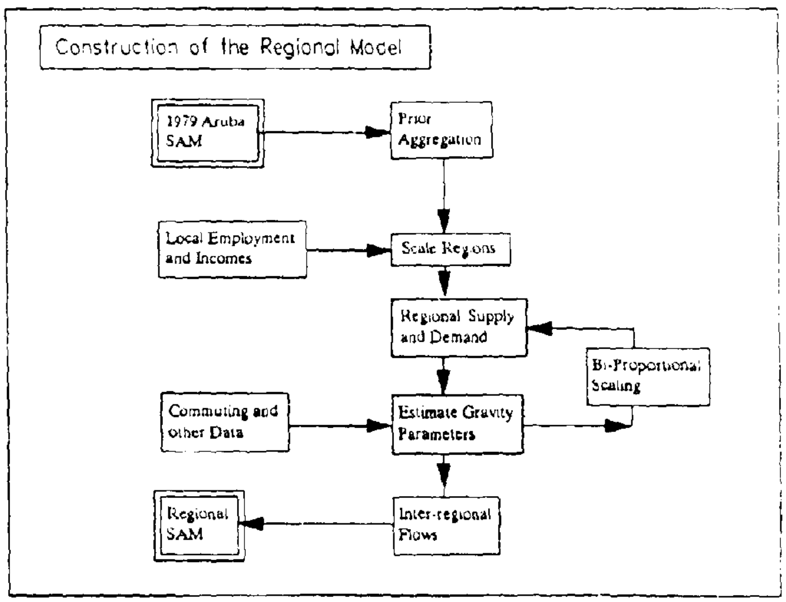


FIGURE 10-2 Construction of the Regional Model

these activities are largely centralized in Oranjestad). Although it is possible to construct a regional table with greater detail, this aggregation provides an input-output table of manageable size.

Step Two: Estimation of the local demand and supply of goods and services in each region of the Island.

The supply is calculated by reducing the production sector columns of the Aruba SAM pro rata according to the location of employment. This also gives the demand for intermediate goods by region and sector. Final demand by sector and region calculated by pro-rating household expenditures by regional household income (by location residence), and government expenditures by regional public sector employment. Total regional demand (excluding overseas exports) is then the sum of intermediate and final demand by sector.

This process provides unbalanced regional models.

Step Three: Estimation of inter-regional purchasing and commuting propensities.

These are calculated using the "gravity model" principle that the likelihood of purchasing a particular type of good or service falls off as the distance between the purchaser (household or firm) and the supplier (retailer or firm) increases and increases with the relative size of the supplier.

i.e. probability of purchasing between regions **i** and **j** is proportional to D_iS_j/d_{ij}^{α}

Data are available on the aggregate level of commuting between the four districts noted above and the gravity model parameter α has been fitted to these. The results given in Figure 10-3 show that a parameter $\alpha = 1$ provides a reasonable fit, whereas other typical parameter values do not. Since the model is relatively sensitive to variations in this parameter as shown by the alternative forecasts also given in Figure 10-3, it may be argued that the gravity model is revealing some significant behavior.

There are no comprehensive statistics for inter-regional purchasing habits in Aruba. However, the extent to which purchasing activities are localized (i.e. take place close to the point of residence) can be estimated by comparing the total supply in all regions with the total demand. For the oil and utilities sectors, the pattern is essentially pre-determined and the results are insensitive to shifts in the gravity model parameter since the supply is localized. Even though the number of regions and amount of data cannot be sufficient to provide a "statistically" reliable estimate, the results indicated by Figure 10-4 are judged sufficient for many purposes.

Step Four: Balancing the multi-regional model.

Intermediate and final local demand is distributed between regions according to the predictions of the gravity model. Overseas exports by region are pro rated according to regional supply. The income totals for each account are then balanced using the bi-proportional RAS method to match the column totals obtained in Step Two.

The regional accounts so obtained are shown in Table 10-I. The local economies of the four regions lie on the diagonal of the matrix (the shaded blocks), while the off-diagonal blocks detail inter-regional trade in goods and services, and commuting by employees. The outer blocks detail government expenditures, capital and overseas transactions. The lifeline system centered on production of electricity and water in the Oranjestad region is highlighted.

Because the regionalized model is based primarily on simple scaling of the national Aruba model, it does not display the regional variations in wage rates etc. which are apparent from the 1981 Census data. Such detail may be included using the multi-proportional RAS scaling as with the construction of the 1990 national model (described earlier). It is not necessary to demonstrate this again in the present project. The model may also be scaled to match the national 1990 social

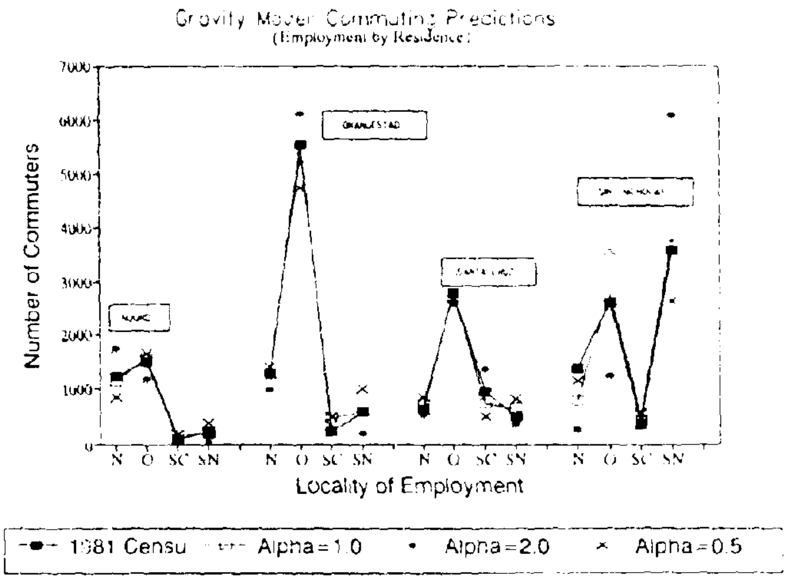


FIGURE 10-3 Gravity Model Inter-regional Commuting Predictions

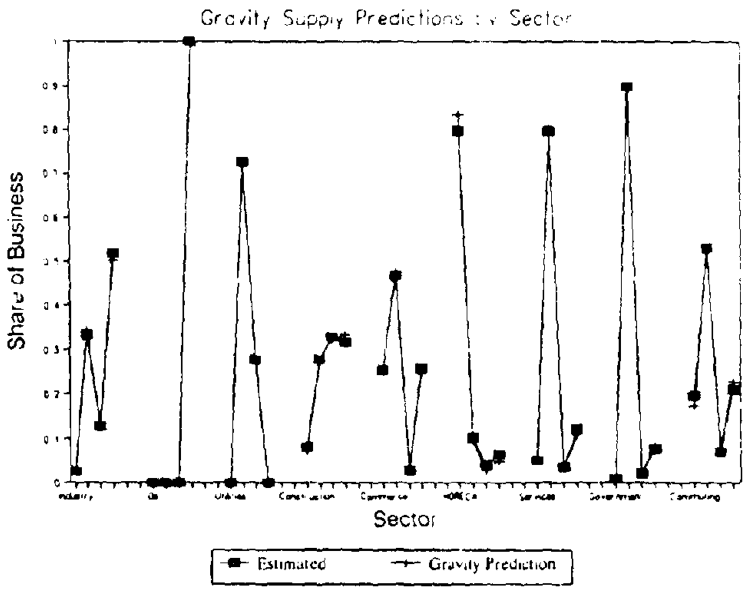


FIGURE 10-4 Gravity Model Predictions of Regional Supply

TABLE 10-1 Aruba 1979 Regional Accounting Matrix

ARUBA REGIONAL ACCOUNTS			NOORD	ORANJESTAD	SANTA CRUZ	SAN NICOLAS	ISLAND	OVERSEAS	
NOORD	1	Agr/industry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1
	2	Refining							2
	3	Utilities							3
	4	Construction	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4
	5	Trade	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5
	6	HORECA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6
	7	Services	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7
	8	Labor	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8
	9	Surplus	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9
	10	Households	[illegible]					[illegible]	10
ORANJESTAD	1	Agr/industry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11
	2	Refining							12
	3	Utilities	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13
	4	Construction	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14
	5	Trade	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15
	6	HORECA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16
	7	Services	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17
	8	Labor	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	18
	9	Surplus	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	19
	10	Households		[illegible]				[illegible]	20
SANTA CRUZ	1	Agr/industry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21
	2	Refining							22
	3	Utilities	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	23
	4	Construction	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24
	5	Trade	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	25
	6	HORECA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	26
	7	Services	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	27
	8	Labor	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28
	9	Surplus	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	29
	10	Households			[illegible]			[illegible]	30
SAN NICOLAS	1	Agr/industry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	31
	2	Refining	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	32
	3	Utilities							33
	4	Construction	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	34
	5	Trade	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	35
	6	HORECA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	36
	7	Services	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	37
	8	Labor	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	38
	9	Surplus	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	39
	10	Households				[illegible]		[illegible]	40
ISLAND	1	FIRMS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	41
	2	GOVERNM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	42
	3	CAPITAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	43
OVERSEAS	1	TOURISM	[illegible]			[illegible]	[illegible]	[illegible]	44
	2	IMPORTS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	45
	3	CAPITAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	46
NAF millions		TOTAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Job Years		JOBS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
REGAGGWC			1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3	1 2 3	

accounts. However, the data provided by the forthcoming 1991 Census will be a better basis for this updating.

The multipliers and impacts of the regional model in Table 10-II illustrate how impacts are distributed across the Island when a given exogenous change is introduced. In this case, each activity on the Island in each of the four regions is assumed to receive a fixed AFl 10 million. Because of the way the regional accounts have been constructed (i.e. without introducing region specific data on wage rates and technologies), the total island-wide effects of a type of change (such as an increase demand for tourism) will be the same whether the demand is in Noord or San Nicolas. However, the distribution of impacts across the Island will be quite different, because of the location of the activity and because of the pattern of the indirect effects. For example, Table 10-II shows that an increase of AFl 10 million in tourism creates 232 jobs directly and another 213 indirectly, a total of 447. When the tourism activity is located in Oranjestad, then a total of some 130 additional jobs are created there, but when the activity is located in San Nicolas, only 46 additional jobs are created locally. This is because a high proportion of the income generated in San Nicolas "leaks" back to the capitol Oranjestad, as purchases by households, firms and government.

10.3 Testing the Aruba Regional Model

In principle, the regional model should be tested empirically as with the 1979 Aruba model, by tracking employment and other trends from 1979 to 1990. Unfortunately, no annual regional data are available for this. However, data are available for a single period 15 months after the crisis. In order to assess the magnitude of the crisis, the Government in office set up Unemployment Registration Centers across the Island for a short period from May to July in 1986. In all some 5,235 jobless were registered. To ensure full registration, some 14 offices were set up for the first month, later to be consolidated into 4 regional offices (San Nicolas, Saveneta, Santa Cruz, and Noord) and one principal office in Oranjestad. Registrations in the four regions were 778, 2,238, 599 and 1,622 respectively, totalling 5,237, as shown in Table 10-III.

TABLE 10-IIa Pre-Event Standardized Regional Impacts

Scenario Sub-Totals 40 Months Pre-Event Impacts

Income	NOORD												ORANGESTAD							
Account	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Events	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
N WAGES	0.7	0.0	0.0	1.5	0.8	1.1	1.7	10.5	0.2	0.5	0.5	0.0	0.3	0.9	0.5	0.7	0.8	0.4	0.2	0.4
O	1.4	0.0	0.0	2.4	1.4	1.8	2.1	1.3	0.6	1.3	1.6	0.0	1.1	3.0	1.7	2.3	2.4	11.3	0.6	1.3
SC	0.8	0.0	0.0	1.3	0.8	1.4	1.1	0.8	0.3	0.8	1.0	0.0	0.6	1.7	1.0	1.3	1.5	0.8	0.3	0.8
SN	1.3	0.0	0.0	2.3	1.2	1.7	1.9	1.0	0.4	1.1	1.1	0.0	0.0	1.9	1.1	1.4	1.7	1.0	0.4	1.0
TOTAL	4.2	0.0	0.0	7.5	4.2	5.6	6.4	13.3	1.5	3.6	4.2	0.0	2.0	7.3	4.2	5.6	6.4	13.5	1.5	3.6
HH INCOME	5.2	0.0	0.0	8.7	6.2	6.7	7.9	14.2	4.4	14.6	5.2	0.0	3.9	8.7	6.2	6.7	7.9	14.1	4.4	14.5
GOVT	2.6	0.0	0.0	3.3	3.6	2.1	2.6	3.2	2.2	3.3	2.6	0.0	-1.1	3.3	3.6	2.1	2.6	3.3	2.3	3.4
Employment by Region																				
N JOBS	92	0	0	363	176	253	244	30	12	40	22	0	11	34	13	16	27	34	6	25
O	99	0	0	112	65	106	123	107	39	111	160	0	153	452	220	343	345	116	41	120
SC	10	0	0	17	11	15	25	16	6	16	18	0	9	17	11	16	26	15	6	16
SN	32	0	0	41	22	27	41	31	11	32	32	0	21	40	21	26	40	31	11	32
G	57	0	0	70	79	46	56	70	48	72	57	0	-23	70	79	46	56	71	49	73
Jobs	297	1	1	604	352	447	495	262	116	271	297	1	171	604	352	447	494	257	115	265
Employment by Sector																				
Direct	40	0	0	333	162	232	210	0	0	0	40	0	94	333	162	232	210	0	0	0
Sector	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Ag/Ind	76	0	0	25	10	12	19	10	6	19	76	0	11	25	10	12	19	17	6	18
Oil	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Util	4	0	0	5	4	13	7	8	3	0	4	0	100	5	4	13	7	7	2	7
Const	31	0	0	355	17	18	40	20	4	21	31	0	11	355	17	18	40	20	4	21
Com	65	0	0	70	196	41	58	72	23	74	65	0	33	70	196	41	57	68	22	71
HOR	6	0	0	8	5	239	17	11	4	11	5	0	4	8	5	239	11	10	3	10
Serv	58	0	0	70	41	78	290	64	24	66	58	0	33	70	41	78	290	63	24	65
Labor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Surplus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Govt	57	0	0	70	79	46	56	70	48	72	57	0	-23	70	79	46	56	71	49	73
Total	297	1	1	604	352	447	495	262	116	271	297	1	171	604	352	447	494	257	115	265

Income				SANTA CRUZ									SAN NICOLAS								ISLAND		
Account	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3
Events	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
N WAGES	0.4	0.0	0.2	0.7	0.4	0.5	0.6	0.4	0.2	0.4	0.4	0.04	0.0	0.6	0.4	0.4	0.5	0.4	0.2	0.4	0.1	0.7	0.0
O	1.2	0.0	0.5	1.8	1.2	1.4	1.6	1.2	0.6	1.2	1.1	0.12	0.0	1.7	1.1	1.3	1.5	1.1	0.5	1.2	0.4	2.5	0.1
SC	1.4	0.0	1.2	3.1	1.6	2.2	2.5	10.9	0.4	0.9	0.8	0.08	0.0	1.2	0.7	0.9	1.1	0.7	0.3	0.7	0.7	1.4	0.1
SN	1.2	0.0	0.8	2.0	1.1	1.5	1.7	1.0	0.4	1.1	1.9	0.22	0.0	4.1	2.0	2.9	3.3	11.3	0.5	1.3	0.2	1.5	0.1
TOTAL	4.2	0.0	2.8	7.5	4.2	5.6	6.4	13.5	1.5	3.6	4.2	0.45	0.0	7.3	4.2	5.6	6.4	13.5	1.5	3.6	0.9	6.1	0.3
HH INCOME	5.2	0.0	3.9	8.7	6.2	6.7	7.9	14.1	4.4	14.6	5.2	0.72	0.0	8.7	6.2	6.7	7.9	14.1	4.5	14.6	1.0	6.7	0.4
GOVT	2.6	0.0	-1.1	3.3	3.6	2.1	2.4	3.2	2.2	3.3	2.6	0.29	0.0	3.3	3.7	2.1	2.6	3.3	2.3	3.4	2.2	15.2	0.5
Employment by Region																							
N JOBS	21	0	10	22	12	16	22	22	7	22	17	1.4	0	19	11	14	19	17	6	18	2	36	1
O	100	0	55	113	64	106	122	107	38	111	84	7.5	0	100	60	42	105	90	34	93	15	102	8
SC	83	0	106	354	175	251	250	24	8	24	17	1.8	0	17	11	16	24	15	6	16	2	15	3
SN	36	0	23	44	22	28	44	35	12	37	122	7.4	0	148	191	279	209	65	28	67	4	25	3
G	57	0	-23	70	79	46	56	70	48	72	57	6.2	0	71	79	46	56	71	49	73	47	128	10
Jobs	297	1	171	604	352	447	494	258	114	266	297	24.4	1	604	352	447	494	259	116	267	70	485	26
Employment by Sector																							
Direct	40	0	94	333	162	232	210	0	0	0	40	3.3	0	333	162	232	210	0	0	0	0	216	0
Sector	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3
Ag/Ind	76	0	11	25	10	12	19	17	6	10	76	1.2	0	25	10	12	19	17	6	18	2	12	1
Oil	0	0	2	0	0	0	0	0	0	0	0	3.2	0	0	0	0	0	0	0	0	0	0	0
Util	4	0	100	5	4	13	7	7	2	8	4	0.9	0	5	4	13	7	7	2	8	1	4	0
Const	31	0	11	355	17	18	40	20	4	21	31	3.5	0	355	17	18	40	20	4	21	3	19	6
Com	65	0	33	70	196	41	58	69	22	72	65	4.2	0	70	196	41	58	69	23	71	6	39	3
HOR	5	0	4	8	5	239	17	10	3	11	5	0.6	0	8	5	239	17	10	3	11	1	7	0
Serv	58	0	33	70	41	78	290	63	24	65	58	4.5	0	70	41	78	290	63	24	65	11	76	4
Labor	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0
Surplus	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0
Govt	57	0	23	70	79	46	56	70	48	72	57	6.2	0	71	79	46	56	71	49	73	47	128	10
Total	297	1	171	404	352	447	494	258	114	266	297	24.4	1	604	352	447	494	259	116	267	70	485	26

Impacts from NAF 10 million

TABLE 10-IIb Post-Event Comparison of Regional Impacts

Scenario Sub-Totals 60 Months Post Event Impacts

Income	NOORD											ORANGESTAD										SANTA CRUZ									SAN NICOLAS										ISLAND		
Account	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3
Events	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
N WAGE	0.6	0.0	0.0	1.4	0.7	1.0	1.1	10.4	0.2	0.4	0.4	0.0	0.3	0.0	0.4	0.6	0.6	0.3	0.1	0.3	0.1	0.0	0.1	0.5	0.3	0.4	0.5	0.1	0.1	0.3	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	0.0
O	1.1	0.0	0.0	1.9	1.2	1.5	1.7	1.0	0.5	1.0	1.3	0.0	0.9	2.6	1.5	2.0	2.1	11.0	0.5	1.1	0.9	0.0	0.3	1.4	0.9	1.1	1.2	0.9	0.4	0.9	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.3	0.1
SC	0.7	0.0	0.0	1.0	0.4	0.8	1.0	0.6	0.3	0.4	0.8	0.0	0.5	1.4	0.8	1.1	1.2	0.6	0.3	0.6	1.2	0.0	1.1	2.8	1.4	2.0	2.2	10.7	0.3	0.7	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.2	0.3
SN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.15	0.0	3.3	1.4	2.3	2.6	10.6	0.2	0.6	0.0	0.0	0.0
TOTAL	2.4	0.0	0.0	4.3	2.5	3.3	3.7	11.9	0.9	2.0	2.5	0.0	1.6	4.8	2.7	3.7	4.0	11.9	0.0	2.0	2.4	0.0	1.5	4.6	2.7	3.6	3.9	11.9	0.9	1.9	1.3	0.15	0.0	3.3	1.4	2.3	2.6	10.6	0.2	0.6	0.6	4.1	0.2
HH INCOME	3.0	0.0	0.0	5.1	4.0	4.1	4.7	12.2	3.7	12.6	3.2	0.0	2.3	5.5	4.3	4.4	5.1	12.2	3.7	12.6	3.0	0.0	2.2	5.3	4.2	4.3	4.9	12.1	1.6	12.5	1.4	0.23	0.0	3.5	2.0	2.4	2.8	10.4	2.0	10.7	0.4	4.4	0.2
GOVT	1.8	0.0	0.0	2.1	2.9	1.3	1.5	2.5	2.0	2.5	1.9	0.0	1.7	2.2	3.0	1.4	1.6	2.5	2.0	2.6	1.8	0.0	1.7	2.1	2.9	1.4	1.6	2.4	1.9	2.5	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	14.5	0.4
Employment by Region																																											
N JOBS	88	0	0	357	173	249	243	35	11	36	18	0	8	18	9	13	22	20	7	21	17	0	7	16	9	12	17	18	6	18	0	0.0	0	0	0	0	0	0	0	0	2	12	1
O	78	0	0	80	46	85	94	87	31	90	148	0	137	422	212	324	318	97	34	100	79	0	39	82	47	83	94	86	11	89	0	0.0	0	0	0	0	0	0	0	0	0	12	63	6
SC	14	0	0	11	8	11	20	12	4	12	14	0	6	12	8	12	21	12	4	12	79	0	102	348	172	247	245	20	6	20	0	0.0	0	0	0	0	0	0	0	0	2	10	2
SN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	107	5.8	0	379	177	263	270	49	13	51	0	0	0
G	39	0	0	44	62	28	33	53	43	55	40	0	36	47	64	30	35	55	43	57	90	0	17	45	64	29	34	57	42	54	0	0.0	0	0	0	0	0	0	0	0	45	312	9
Jobs	219	1	1	492	289	373	390	187	89	193	220	1	114	499	294	378	396	183	88	189	213	1	110	491	292	374	389	176	85	182	107	58	1	379	177	263	270	49	13	51	60	418	18
Employment by Sector																																											
Direct	60	0	0	331	162	232	210	0	0	0	60	0	94	333	162	232	210	0	0	0	60	0	94	333	162	232	210	0	0	0	60	3.2	0	333	162	232	210	0	0	0	0	216	0
Sector	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3
Ag/Ind	66	0	0	10	3	4	7	8	2	8	67	0	5	10	4	4	7	7	2	8	66	0	4	10	4	4	7	7	2	7	45	0.2	0	0	2	2	6	6	2	6	1	4	0
Oil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.2	0	0	0	0	0	0	0	0	0	0	0
Util	3	0	0	3	3	12	5	7	2	7	3	0	90	3	3	12	5	6	2	6	1	0	90	3	3	12	5	6	2	6	0	0.0	0	0	0	0	0	0	0	0	0	3	0
Cons	20	0	0	343	10	9	31	11	5	11	20	0	4	343	10	9	31	11	5	12	19	0	4	343	10	9	10	11	5	11	6	1.0	0	136	3	2	14	3	1	3	2	11	4
Com	45	0	0	43	160	22	32	51	16	13	45	0	19	42	181	23	31	48	15	50	42	0	18	39	180	22	32	45	14	47	22	0.7	0	19	167	7	13	23	6	24	1	22	2
HOR	4	0	0	5	1	237	14	9	3	9	4	0	2	5	4	237	14	6	3	9	4	0	2	5	4	237	14	8	5	9	1	0.2	0	3	1	234	31	6	2	6	1	5	0
Serv	42	0	0	46	27	60	264	45	19	50	42	0	21	47	29	62	270	46	18	49	41	0	20	46	26	60	267	46	16	47	10	0.5	0	12	4	17	226	11	3	12	9	60	3
Labor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0
Surplus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0
Govt	39	0	0	44	62	28	33	53	43	55	40	0	36	47	64	30	35	55	43	57	90	0	17	45	64	29	34	52	42	54	0	0.0	0	0	0	0	0	0	0	0	45	312	9
Total	219	1	1	492	289	373	390	187	89	193	220	1	114	499	294	378	396	183	88	189	213	1	110	491	292	374	389	176	85	182	107	58	1	379	177	263	270	49	13	51	60	418	18

Impacts from NAF 10 million

TABLE 10-III Regional Unemployment 15 Months After the Shutdown

Regional Unemployment 15 months after Shutdown of Refinery

	HOME					
WORK	N	O	SC	SN	Net(1)	Model
N	88	92	45	97	322	322
O	197	727	367	342	1633	1633
SC	32	70	289	115	506	506
SN	101	256	217	1561	2134	2434
Govt	50	185	93	87	415	1115
Home	468	1330	1011	2202	5010	6010
Work	322	2048	506	2134	5010	
Register	778	2238	599	1622	5237	

Note: Adjusted for public sector employment policy
and Lago job finding policy (1)

UNEMP.WQ1

The predictions from the model of regional job loss after a 15 month time horizon have been matched to these figures. Since it is not known whether registration was predominantly at the place of work or place of residence, so predictions are shown for both. The comparison given in Figure 10-5 shows that the "place of work" prediction is closer to the registered figures, except in San Nicolas, which is the geographically most isolated township. For San Nicolas, the registered unemployment is rather less than predicted by the model. This may reflect the efforts by the refinery to find new jobs (generally overseas) for its own ex-employees.

10.4 Regional Impact of the Refinery Close-down

Since the above test relates only to the shorter-run regional impacts of the shut-down, a second exercise gives predictions of the impact of the close-down of the refinery on the four districts. These are calculated to a five year time horizon, together with the net impact of doubling the size of the tourism sector, calculated to a three year horizon. The impacts then are compared with the regional situation in Aruba as recorded by the 1981 census.

The results are given in Table 10-IV. The table shows the number of jobs provided in each region and the amount of wage income received in each region (after taking inter-regional commuting into account). The chart also shows the total level of household income (including non-wage income) and government revenues.

Briefly, the results suggest that had the full effects of the refinery shutdown been felt, by about 1990 some 64 percent of jobs would have been lost in San Nicolas, compared to 45 percent in Santa Cruz and 13 percent in Noord. In Oranjestad 36 percent of non-government jobs would be lost. The impact of this regional unemployment on household incomes in each region is muted somewhat because of commuting between regions. Households in San Nicolas would have lost 60 percent of wage income compared to 44 percent in Santa Cruz, 36 percent in Noord, and 41 percent in Oranjestad.

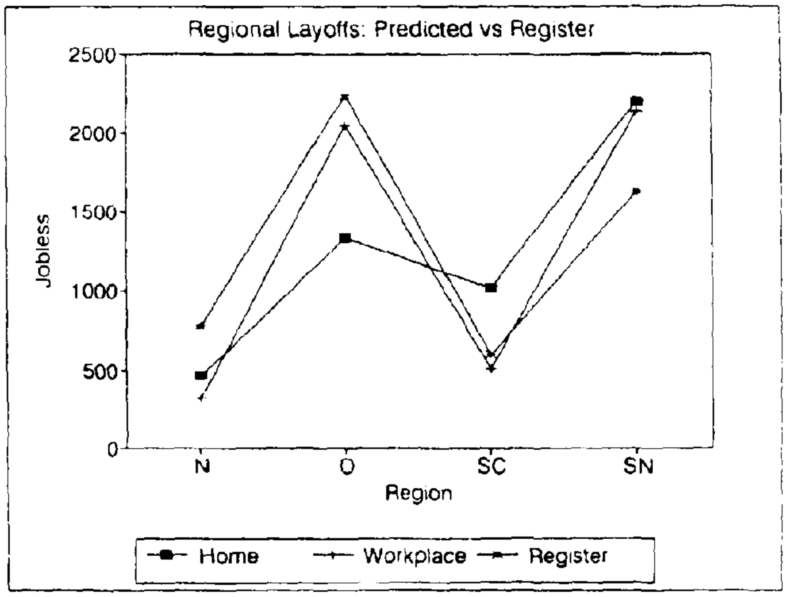


FIGURE 10-5 Regional Layoffs: Predicted versus Register of Unemployed

TABLE 10-IV Regional Impact of Refinery Shutdown and Tourism Boom

Regional Impact of Refinery and Tourism

Item	Original	Refinery	Refinery and Tourism
Jobs at Place of Work:		Loss	Net Change
Noord	4518	-609	5579
O'stad	8269	-2958	-398
S Cruz	1579	-718	-347
S Nic	4645	-2976	-2338
Govt	4535	-2466	-1224
Wages at Place of Residence (Af million):			
Noord	43	-15	11
O'stad	114	-46	-1
S Cruz	73	-32	-7
S Nic	144	-87	-46
Total	374	-180	-12

Note: variations in the total loss to the Island compared to other previous calculations arise because of adjustments to the data set.

As might be expected (and as on-site observation in 1986-87 certainly indicated), the impact on San Nicolas was significantly higher than in other parts of the Island. Even though the total employment in Lago was less than 1,300 workers of whom about half were residents of San Nicolas, nearly 2,500 non-oil jobs would have been lost to the town (including Saveneta).

10.5 Regional Impact of the Recovery

The primary initiative of the recovery strategy was to expand tourism as rapidly as possible, in order to reduce the high level of unemployment on the Island. However, since the new hotels were to be constructed in Noord, at the opposite end of the Island from the refinery, this was bound to create serious regional disparities. Indeed, the recovery strategy appears to be leading to a massive shift in the economic and demographic geography of the Island. One obvious question, therefore, concerns the future regional balance of work place and residence across the Island.

The model may be used to estimate the repercussions of this policy, such as the level of commuting between regions, the pressures for new housing development or the regional shift in employment.

The likely regional impact of this recovery strategy is calculated trebling the level of tourism in Noord is calculated (this is the amount of tourism required to bring the total Island employment approximately back to its former level). But although employment is restored overall, this does not, of course, restore the regional employment balance on the Island. Indeed, the results of the calculation, also shown in Table 10-IV, show that the San Nicolas economy would still provide only half the number of jobs prior to the close-down. Even in Santa Cruz, much closer to the new hotels, the number of jobs would still be reduced by some 22 percent. In contrast, employment in Oranjestad would be practically restored to its former level while in Noord employment has risen by 23 percent. On balance, household wage income in San Nicolas has fallen by about 30 percent, while in Noord it has risen by 25 percent.

10.6 An Alternative Regional Strategy

The results of the above calculation are a fair reflection of the present regional development in Aruba, as determined by the tactic of expanding tourism at one end of the Island in order to compensate for the shutdown of the major industry at the other.

The model may also be used to explore alternatives. As an illustration, the consequences for regional employment of locating all the new tourism constructed in Aruba since 1986 in San Nicolas instead of Noord are calculated. Not surprisingly, the results summarized in Figure 10-6 suggest that such an approach would have resulted in a considerable reduction in the regional imbalance of employment and residence.

The last results correspond approximately to the situation in 1989-90 and do not take account of the partial re-opening of the refinery with the Wickland oil terminal and Coastal oil refining activities. While these initiatives are likely to have an important impact on San Nicolas, they are unlikely to compensate for the loss of the Exxon refinery. The contractual arrangements with workers and the Government are very different: employment is small (with all construction carried out by workers temporarily imported from Turkey), and ten-year tax holidays have been granted.

10.7 A Regional Lifeline Event Matrix

The primary reason for constructing the regional model is to permit certain aspects of the "lifeline" systems to be investigated, for example, the importance of interregional water, power, fuel, and transportation links. As an illustration of the impact of a failure of the lifeline system, it is assumed that the town of San Nicolas is totally cut-off. As the earlier map of the Island shows, there is a significant possibility that this part of the Island could be disconnected for a short period through flooding or other disaster. The only paved road between Oranjestad and San Nicolas runs along the low lying coast, as do the fuel and water pipelines between the refinery and the public utilities stations.

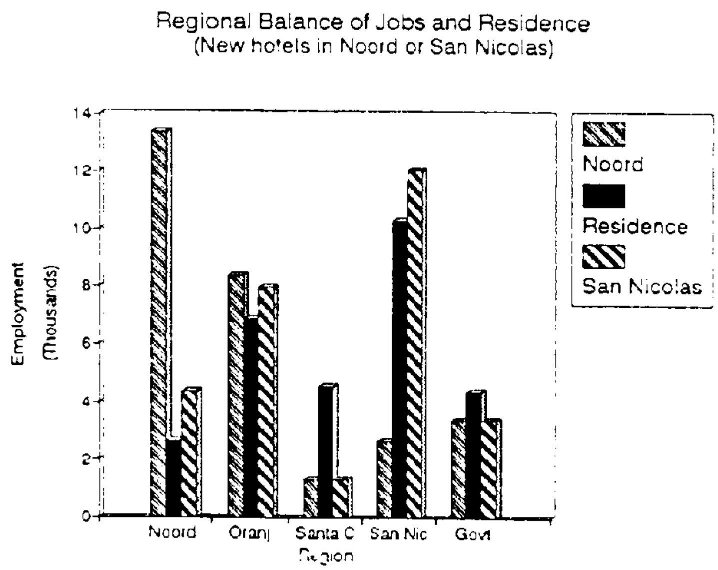


FIGURE 10-6 Correcting the Regional Imbalance of Jobs and Residence

To simplify the discussion and calculation here, all links between the San Nicolas district and other parts of the Island are taken to be disconnected for an extended period (i.e. several years), with each region maintaining its level of production increasing imports from overseas (to compensate for lost inter-regional trade). There are no changes to the proportion of expenditures between those parts of the economy which are not de-linked. Nor is any time scale given for recovery.

The event matrix corresponding to this assumption is shown in the Table 10-V, and is simply a matrix of zero and unit entries. In a more realistic case, entries would be based on estimates of the damage sustained by the different parts of the economy. For example, this matrix may account for the "survival rates" of the immediate post-disaster phase and the "recovery rates" of the post-disaster phase. Combined with the original regional accounts, these data provide the new set of regional accounts which then are used to evaluate and plan for the "post-disaster" situation.

The loss of internal linkages on the Island following the disaster means that many of the original feedback processes between the regions of the Island which contribute to the multiplier would be lost. The extent of this may be seen by comparing the impacts of a fixed AFI 10 million demand for each activity for the "post-event" situation, given in Table 10-VI, with the earlier results for the "pre-event" economy, given in Table 10-II. Now, for example, an additional demand for tourism in Oranjestad creates 232 jobs directly, but now only a total of 378 island-wide, and none in San Nicolas. The same new activity in San Nicolas creates a total of 263 jobs, all of them local since there can be no spill-over to other parts of the Island.

While the above example is artificial, it demonstrates how the approach may be used to address rather complex disaster and recovery scenarios. In particular, by setting up annual event matrices describing the current survival and recovery rates, a detailed planning strategy may be explored.

TABLE 10-V Event Matrix for Regional Dislocation

ARUBA EVENT MATRIX	Post Event Survival Rates	Noord 1	2	3	4	5	6	7	8	9	10	Oranjestad 1	2	3	4	5	6	7	8	9	10	Santa Cruz 1	2	3	4	5	6	7	8	9	10	San Nicolas 1	2	3	4	5	6	7	8	9	10	Island 1	2	3	Overseas 1	2	3
NOORD	1 Ag/Industry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	2 Refining	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	3 Utilities	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	4 Construction	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	5 Trade	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	6 HORECA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	7 Services	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	8 Labor	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	9 Surplus	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	10 Households	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ORANJESTAD	1 Ag/Industry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	2 Refining	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	3 Utilities	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	4 Construction	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	5 Trade	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	6 HORECA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	7 Services	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	8 Labor	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	9 Surplus	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	10 Households	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SANTA CRUZ	1 Ag/Industry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	2 Refining	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	3 Utilities	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	4 Construction	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	5 Trade	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	6 HORECA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	7 Services	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	8 Labor	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	9 Surplus	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	10 Households	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SAN NICOLAS	1 Ag/Industry																															[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]
	2 Refining																															[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]
	3 Utilities																															[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]
	4 Construction																															[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]
	5 Trade																															[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]
	6 HORECA																															[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]
	7 Services																															[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]
	8 Labor																															[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]
	9 Surplus																															[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]
	10 Households																															[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]
EXTR	1 FIRMS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	2 GOVERNM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	3 CAPITAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OVRSEAS	1 TOURISM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	2 IMPORTS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	3 CAPITAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Survival Rate	TOTAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Survival Rate	JOBS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
REFERENCE		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 10-VI Event Matrix for Regional Dislocation

ARUBA REGIONAL ACCOUNTS	Post Event Transactions		NOORD 1	2	3	4	5	6	7	8	9	10	ORANJESTAD 1	2	3	4	5	6	7	8	9	10
NOORD	1	Ag/Industry	0			0	0	0	0			0	0		0	0	0	0	1			1
	2	Refining																				
	3	Utilities																				
	4	Construction	0			0	0	9	0			0	0		0	0	0	0	1			0
	5	Trade	0			0	0	1	0			8	1		1	1	6	0	3			12
	6	HORECA	0			0	0	0	1			2	0		0	0	0	0	3			2
	7	Services	0			0	0	1	0			1	0		0	0	0	0	1			[illegible]
	8	Labor	0			1	3	4	1			0	1		1	1	5	1	2			0
	9	Surplus	0			0	6	3	0				0		1	0	5	0	3			
	10	Households							0	42	7											
ORANJE STAD	1	Ag/Industry	0			0	0	1	0			4	2		2	1	1	0	7			12
	2	Refining																				
	3	Utilities	0				0	4	0			2	3		1		0	1	2			3
	4	Construction	0			0	0	0	0			0	1		0	0	1	0	4			1
	5	Trade	0			0	0	1	0			7	7		2	1	0	8	8			32
	6	HORECA	0			0	0	0	0			0	0		0	0	0	0	5			1
	7	Services	0			0	1	18	1			6	5		3	2	7	2	26			23
	8	Labor	0			3	3	10	1			0	3		4	4	9	2	25			7
	9	Surplus	0			1	26	15	2				3		7	2	54	2	58			
	10	Households																	1	110	99	
SANTA CRUZ	1	Ag/Industry	0			0	0	0	0			1	1		1	1	0	0	1			4
	2	Refining																				
	3	Utilities	0				0	3	0			1	0		0		0	0	1			2
	4	Construction	0			0	0	0	0			0	1		0	0	1	3	4			1
	5	Trade	0			0	0	0	0			0	0		0	0	0	0	0			1
	6	HORECA	0			0	0	0	0			0	0		0	0	0	0	0			0
	7	Services	0			0	0	1	0			0	0		0	0	0	0	1			1
	8	Labor	0			0	2	5	0			0	2		2	2	5	1	[illegible]			1
	9	Surplus	0			0	1	2	0				1		1	0	0	0	0			
	10	Households																				
SAN NICOLAS	1	Ag/Industry																				
	2	Refining																				
	3	Utilities																				
	4	Construction																				
	5	Trade																				
	6	HORECA																				
	7	Services																				
	8	Labor																				
	9	Surplus																				
	10	Households																				
	1	FIRMS									17										236	
	2	GOVERNM	0			4	-					1	1		4	1	33	9				21
	3	CAPITAL									4	3									49	14
OVER SEAS	1	TOURISM										2										
	2	IMPORTS	2			2	14	44	1	0	0	21	29		32	5	21	5	43	0	40	64
	3	CAPITAL								1										4		
NAf. millions		TOTAL	5			6	67	136		45	25	67	60		49	27	125	16	209	132	366	219
Job Years		JOBS	28			307	1089	2015	25				157		413	692	1997	174	479			
REGEVENT			1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10

ARUBA REGIONAL ACCOUNTS	Post Event Transactions		SANTA CRUZ 1	2	3	4	5	6	7	8	9	10	SAN NICOLAS 1	2	3	4	5	6	7	8	9	10	ISLAND 1	2	3	OVERSEAS 1	2	3	
NOORD	1	Ag/Industry	0		0	0	0	0	0			0												0	0	0	0		1
	2	Refining																											2
	3	Utilities																											3
	4	Construction	0		0	0	0	0	0			0												0	1		1		4
	5	Trade	1		0	1	0	0	0			5												1	0	12	8		5
	6	HORECA	0		0	0	0	0	0			0													0	109	4		6
	7	Services	0		0	0	0	0	0			0												1	0	3	0		7
	8	Labor	0		0	1	0	0	0			0												4			0	0	8
	9	Surplus	0		0	0	0	0	0															0			0	0	9
	10	Households																								14	6	4	10
ORANJE STAD	1	Ag/Industry	3		1	2	0	0	0			4												2	0	2	1		11
	2	Refining																											12
	3	Utilities	0		0		0	0	0			3												2			2		13
	4	Construction	0		0	0	0	0	0			0												0	2		3		14
	5	Trade	2		2	1	0	0	0			11												1	1	13	10		15
	6	HORECA	0		0	0	0	0	0			0												0	0	8	3		16
	7	Services	2		1	2	0	1	1			6												33	1	25	18		17
	8	Labor	6		6	1	0	0	0			0												32			0	6	18
	9	Surplus			2	2	3	1	1															2			0	1	19
	10	Households																								1	2	9	20
SANTA CRUZ	1	Ag/Industry	0		0	1	0	0	0			2												1	0	1	1		21
	2	Refining																											22
	3	Utilities	6		6		6	0	6			3												0			1		23
	4	Construction	0		0	[illegible]	0	0	0			0												0	2		3		24
	5	Trade	0		0	0	0	0	0			1												0	0	1	1		25
	6	HORECA	0		0	0	0	0	0			2													0	1	8		26
	7	Services	0		0	0	0	0	0			1												1	0	1	2		27
	8	Labor	1		2	5	1	1	1			1												16			6	0	28
	9	Surplus	0		1	1	1	0	1															0			0	0	29
	10	Households							0	70	12																1		30
SAN NICOLAS	1	Ag/Industry											6	5		1		0	2			16				2	6		31
	2	Refining															0	0				3					1962		32
	3	Utilities																											33
	4	Construction											2	13		0	6	0	1			1					0		34
	5	Trade											16	1		-	6	6	1			25				3	9		35
	6	HORECA											0	1		0	0	0	1			4				0	5		36
	7	Services											3	1		1	0	1	2			8				1	4		37
	8	Labor											6	50		7	9	2	4			1					6	1	38
	9	Surplus											3	121		1	15	1	1								0		39
	10	Households																	0	139	45						1	0	40
	1	FIRMS									26													0			1002		41
	2	GOVERNM	3		4	1	1	0				10											66	69	12		22		42
	3	CAPITAL									5	5											30	27	4			14	43
OVER SEAS	1	TOURISM																										103	44
	2	IMPORTS	10		12	7	1	2	2	4	0	30	62	1025		12	41	7	16	0	127	129		19	133	0	0	103	45
	3	CAPITAL								1										5			381		36	14	99		46
NAf. millions		TOTAL	22		15	24	7	6	0	5	47	69	35	6019		24	66	10	32	144	173	194	466	216	271	206	402	346	
Job Years		JOBS	534		171	835	1261	149	196				516	1293		302	5507	231	663					4535					
REGEVENT			1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	1	2	3	

SECTION 11
SOCIAL IMPACTS AND TECHNOLOGY POLICY

11.1 The Impact on Economic Cultures

Many studies of the aftermath of natural disasters have shown that the impacts fall unevenly across populations. Moreover, many studies argue that the disaster-recovery process should be seen as part of the overall long-term development of the regions economy, taking account of the needs of various population groups, particularly with respect to their differing needs for training, education and public resources.

To examine these issues, another more culture sensitive sub-division of the economy is required. This "cultural accounting matrix" (CAM) sub-divides the Island's population according to their technology-related "cultural heritage." Although the categories are designed to illustrate how different segments of the population are integrated into the economy of the Island, they can be related to the sub-divisions adopted by American and Dutch anthropologists who have studied the Island. For simplicity, the four cultural-economic categories are taken to be:

Traditional-Arubians: The original Ameri-Indian population of the Island were essentially fisher-folk and small-scale agriculturalists who, for present discussion, might be characterized as sharing a "traditional" economic culture. The economic culture which evolved after colonization by the Spanish (and later the Dutch) among the Papiamento-speaking "Spanish-Indian" population was a peasant (or pre-industrial) economy based on small holdings and casual labor on the island and overseas in plantations and mines. The arrival of the American owned refinery in the late 1920's brought an abrupt transformation of the Island, which pushed the traditional economy of the island to the sidelines, so forcing the majority of the population into a dependent economic culture. Because of the handicap of an unorthodox language and poor time-keeping and unreliable work habits, the Indian descended Arubian group were largely left behind by the economic bandwagon created by the refinery. Despite this, the opportunity for hand-outs from the refinery (via the system of kinship with other native Arubians of Western descent) enabled the Indo-Arubians to experience a significant improvement in income even without acquiring corresponding industrial skills. This created an economic culture characterized by a mismatch between production and consumption skills.

While post-war education has enabled many younger Indo-Arubians to move successfully into the modern economy, in terms of economic and educational development, the group as a whole poses special problems. The rural population of Aruba, for example, suffer high levels of alcoholism (as did workers undergoing similar rural to urban transitions during the industrial revolutions in Europe). The characterization of this particular component of the present day Arubian population as "Traditional-Arubian" is therefore to suggest that this group continues to share many of the same difficulties in assimilating into a modern industrial economy that "traditional" populations have confronted worldwide, in and out of situations arising from natural disasters.

Migrant-Arubians: The Migrant-Arubian population also may be viewed as having a "dependent" economic culture. However, the mismatch between skills and consumption is the reverse of that which characterizes the Traditional-Arubians and, for purposes of present discussion, they are taken to be representative of a politically weak "minority" population. Many are regionally mobile within the Caribbean and or retain an "immigrant" social status even though they are born on the Island. This population comprises three groups - those descended from Africans who were brought to the island mainly by Dutch traders in the early nineteenth century; the "Windward Islanders" whose parents were recruited as skilled laborers to work in the refinery; and those arriving more recently as casual and domestic workers from other parts of the Caribbean.

To oversimplify, the three sub-groups in the Migrant population are drawn respectively from the Dutch, English and Spanish speaking Caribbean islands - and came for different reasons to Aruba. Because there were no large-scale plantations in Aruba, the economic skills of the original African population of Aruba were similar to the Indo-Arubians. However, the group had fewer kinship bonds, and - because, at the time of emancipation, land was distributed only to those "born free" on the Island (in an effort to encourage ex-slaves to leave), they had fewer ties to the land. The oil refinery workers in contrast were recruited for their specialized skills from the English speaking Caribbean. Although this group was eventually largely excluded from the better paid jobs in the oil refinery, many had already a culture of learning and benefitted further from the educational programs initiated by the refinery. Today, the descendants of these workers often occupy professional and technical positions in tourism and other service industries. Despite these apparently high skills, there are very few entrepreneurs in this group. Finally, the most recent Afro-Arubians are mainly women in extremely insecure domestic jobs, and other temporary (and sometimes illegal) immigrants in low-skilled occupations. While there are clearly distinct differences in the skills and experiences of the Migrant-Arubians, they share a history of the most socially destructive form of colonization, and, within the present division of labor, they are largely dependent on wage income.

Modern-Arubians and Expatriates: These two groups represent the "dominant" economic-culture of the Island, in the sense that the majority of economic policy of the Island government and the successive development plans prepared by Dutch and international agencies usually embody assumptions and values which this group dictates or shares. The original Modern-Arubian population is descended from the Dutch and Iberian settlers and refugees who arrived in Aruba prior to the arrival of the refinery, with later components drawn from the many immigrants of diverse nationalities who came to work in the refinery or the expanding economy and who then settled permanently on the Island. The native Arubians of European descent formed the social elite of the Island were able to adapt more readily than the Indo-Arubians to the rapidly expanding economy by building on astute commercial and political skills. Although the group is extremely heterogenous, comprising people of many nationalities, all have acquired the economic culture of metropolitan countries, in terms of entrepreneurial skills and lifestyles.

The Expatriate population share much of the economic culture of the Modern-Arubians, except that they are temporary residents with typically higher skills, incomes and occupational status. To some extent this is offset by their relatively weaker political connections and influence - economic development programs and subsidies, for example, are directed to promoting local business, while tax collection focusses on foreign-owned businesses and expatriate households.

In Aruba, the expatriate group comprises primarily Americans and Europeans (on temporary assignment to the oil refinery or international hotel chains and finance houses), or Dutch nationals (working in the public administration, education or small business), and South Americans in somewhat lower status occupations.

The labor force and corresponding households are categorized in this way to illustrate the cultural division of labor - i.e. the fact that different groups in most societies, including Aruba, have rather well defined occupations in specific production sectors, and have markedly different income levels and consumption patterns. As indicated earlier, such a division is also very important for peoples subject to natural disasters, because typically different cultural-economic groups, because of the areas they live, the type of buildings they live in, the work they do, or their access to supportive social networks or public relief, are affected differently by natural disasters, or indeed any kind of economic change. The CAM approach therefore also provides the possibility of setting the disaster into the "developmental" context advocated by Cuny (1983) and Jones (1989).

The Aruba cultural accounting matrix is shown in Table 11-1. As in the previous tables, the entries are amounts of money paid by different economic actors, production activities, household, government, and so on, to each other over the course of a year. In the table, the top-left entries are payments between production activities in the economy; the entries below this show payments to workers and entrepreneurs and owners; the adjacent entries show how this is distributed to households and firms (as legal entities); and so on. The row and column totals for each activity are their total income and expenditures in the course of a year, respectively. For present discussion, the division of households into cultural groups is the most important feature of the table. The total income of each of the population groups is shown in the household totals of the matrix as 165, 67, 317 and 90 AFl million respectively. Given the proportions of households noted earlier, this suggests that the income of Expatriate households is about three times that of Modern-Arubians, and about five times that of Traditional- and Migrant-Arubians. The table shows that the relative shares of income paid to each cultural group by the various production sectors differ markedly, reflecting both the vertical and the horizontal division of labor in the

TABLE 11-I Aruba 1979 Cultural Accounting Matrix

Aruba Accounts 1979 (sub-divided by size of business and economic culture)

Activities and Populations	2	3	4	5	6	7	8	12	15	16	17	19	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	Total
1 Agriculture																												
2 Industry	16	7	5	6	2	2	4	1	7	2	0	20				25	10	40	5	2	4		0	1	4	4		168
3 Oil Refining			33		0	0				0	0					3	1	5	1				16			3960		4019
4 Utilities	2	20	2		0	12	1	0		1	1	3				6	3	13	2	1								67
5 Construction	4	15	0	0	1	0	2	0	0	1	0	11				0	[illegible]	2	1	0	1	1	1	2				43
6 Trade	28	4	3	4	0	2	2	2	4	0	0	12				22	12	59	6	1	1		0	1	21	25		209
7 Hotels/Restaurants	0	0	0	0	0	0	1	0	0	0	0	3				3	1	[illegible]	1				0		115			132
8 Transport/Communications	4	2	1	1	1	5	1	0	1	1	1	8				2	1	17	5	13	1			0	28	21		113
9 Finance and Business																												
10 Other Services																												
11 Agriculture																												
12 Industry	1	1	0	1	0	0	0	0	1	0	0	2				3	1	[illegible]	0	0	0		0	0	0	0		13
13																												
14																												
15 Construction	3	11	0	0	1	0	1	0	0	1	0	8				1	0	1	1	0	0	1	1	2				32
16 Trade	4	1	0	0	0	0	0	0	1	0	0	2				22	2	11	1	0	1		0	0	7	1		65
17 Hotels/Restaurants	0	1	0	0	0	0	1	0	0	0	0	6				[illegible]	0	0	0				0					9
18 Transport/Communications	12	7	4	2	2	17	5	1	2	2	2	25				15	[illegible]	18	6	23	2			1	2	14		165
19 Finance and Business																												
20 Other Services																												
21 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	153
23 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	171
24 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	37	45	25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	165
25 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	67
26 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	54	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	317
27 Expatriate-Households	1		5	0	14	1	3	0	1	7	1	6	4	6	29	[illegible]	[illegible]	[illegible]	[illegible]						1		10	90
28 Island Government ,1	10	36	-12	3	52	8	7									11	5	27	10					12				169
29 Central Government ,1																[illegible]	2	10	[illegible]	46				2		21	2	93
30 HHold Capital																[illegible]	[illegible]	16	[illegible]					1				34
31 Firms Capital	3	38	6	5	8	7	13									[illegible]	[illegible]	[illegible]	[illegible]			23	16	26			19	163
32 Government Capital																[illegible]	[illegible]	[illegible]	[illegible]	2	34		4				15	55
33 Tourism																[illegible]	[illegible]	8	3								193	208
34 Exports/Imports	55	3548	6	3	13	30	8	2	1	3	1	6				25	11	62	26	13			125	7			102	4045
35 Foreign Capital		261	3	0	14	5	8					4	3	4	5	3	[illegible]	14	9			11			16			362
36 Totals	168	4019	69	43	209	132	113	13	32	65	9	165	88	133	171	165	67	317	90	169	93	34	163	55	208	4045	362	
37 Employment	827	1333	655	1399	2872	2867	1781	247	1151	1624	429	4396								33[illegible]7	1190							24128

Note Imports reallocated to households

Arubian economy. For example, Migrant-Arubians earn about 5 percent of the total wage income from the commerce sector but 16 percent the total wage income from services. Traditional-Arubians earn 24 percent of the wage income from commerce and 22 percent from services.

The composition of the labor force at the refinery is also distinctive with the result that the skilled workers made redundant when the refinery closed would be drawn differentially from each population group. Of the approximately 1,300 jobs lost from the refinery (from 1979 onwards), 427 are estimated to have been occupied by Traditional-Arubians, 210 by Migrant-Arubians and so on. Of the Traditional-Arubian jobs, 34 were professional and administrative workers, and 314 were production workers.

The overall loss of employment by each of the population groups depends in turn on their positions in other sectors of the economy. The extent of this unemployment by sector, occupation and population sub-group is summarized in the Table 11-II. This shows an estimated economy-wide job loss of about 8,200. Of these, 2,855 jobs were lost to Traditional-Arubians, 1,533 lost to Migrant-Arubians, and so on. Of the Traditional-Arubian jobs, 215 are calculated to have been administrative and professional, 1,610 were production workers, and so on. Across the economy as a whole, the results show that a total of 1,182 professional and administration jobs are lost, and a total of 3,686 production jobs, and so on.

The effectiveness of the recovery program in off-setting these job losses can be explored by assuming an increase in tourism just sufficient to bring total employment back to its original level. Because of differences in the cultural and educational composition of the labor force across sectors, the net effects are bound to be rather unevenly felt by the various populations and activities. For some sectors, groups and occupations there will be an excess of jobs, and for others a remaining net job loss. If the prevailing occupational and cultural division of labor is reproduced, the net impact can be calculated straightforwardly by subtracting the jobs lost through the closing of the refinery from the jobs gained from the expansion of tourism as shown in Tables 11-III and 11-IV. The calculation shows a net loss of jobs in all sectors except those directly related to tourism. This kind of calculation provides a "first cut" estimate of the extent

TABLE 11-II Predicted Job Loss by Sector and Occupation

Predicted Job Loss by Sector and Occupation at Registration

	Prof	Admin	Cleric	Sales	Serv	Agric	Prod
Ag/Industry	33	9	32	11	9	5	169
Oil	168	34	159	59	49	1	828
Utilities	33	3	48	0	5	1	173
Construction	31	29	78	10	16	8	901
Trade	23	54	160	216	284	7	154
HORECA	4	8	25	34	44	1	141
Services	159	25	210	22	225	10	271
Government	192	30	253	26	272	12	327
Total	643	192	964	378	905	45	2848
Private	451	162	711	352	633	33	2521

TABLE 11-III Employment Lost by Demographic Groups

Employment lost through Refinery Closing

Occupations	Trad-	Mig-	Mod-	Expat	Total
Professional	215	161	347	187	910
Administrative	47	40	102	83	272
Clerical	467	181	687	61	1396
Sales	185	46	269	41	541
Service	331	422	546	93	1392
Production	1610	683	1210	183	3686
Total	2855	1533	3161	648	8197

TABLE 11-IV Net Employment Impacts by Demographic Groups

Net Employment Gain with Refinery Closing and Tourism Expanding

Occupations	Trad-	Mig-	Mod-	Expat	Total
Professional	-73	-47	-113	-64	-297
Administrative	7	27	52	29	115
Clerical	-19	39	120	4	144
Sales	168	129	387	48	732
Service	98	297	364	37	796
Production	-715	-252	-442	-72	-1480
Total	-534	191	366	-18	-0

Note: Figures are approximated to job/years of this dislocation in the labor force. For example, a predicted net loss of jobs for any occupation or group suggests that there is likely to be unemployment, and a net gain of jobs suggests that there may be constraints on the expansion of the economy because of a shortage of particular skills.

11.2 Unemployment by Skills and Occupations

These results given above may be broken down further into occupation by cultural group and sector - for example, the number of clerical positions lost to Traditional-Arubians in the construction sector. Potentially, this leads to a considerable amount of information, even from the small CAM for a relatively small economy such as Aruba. Although there are no data available to test the predictions of model with respect to the cultural-economic divisions, it is possible to compare some of the predictions of job loss by different segments of the labor force. In particular, the distribution of unemployed by level of education as forecast by the model has been compared with that reported by the Unemployment Registration of May 1986. Because of changes in the designation of qualifications and the way data are reported, this comparison can be made only in terms of the "low," "medium" and "high" skills categories used in the 1979 Aruba SAM.

i) "low" category includes the LO and AVO school leaving standards
ii) "medium" is the LBO qualification and,
iii) "high" includes MBO, HBO and University graduates.

The results shown in Figure 11-1 suggest that the overall predictions of job displacement are reasonable for the low and medium categories. The predicted displacement of high skilled workers is considerably above the number of registrations. The reason for this may be that most of the higher skilled workers (about 20-30 percent of employees) at the oil refinery would have benefitted from the oil refinery job-finding program, while others would have greater opportunities to seek employment overseas.

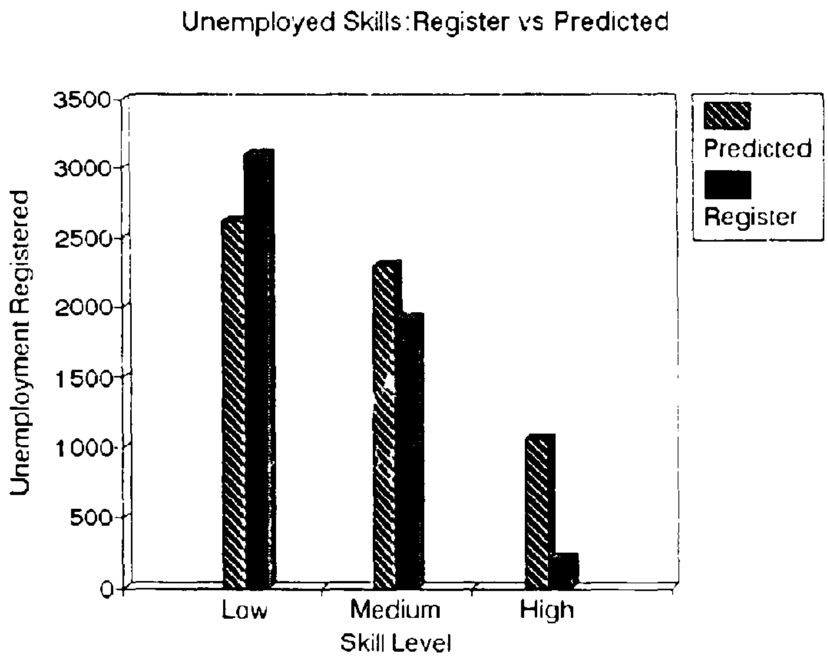


FIGURE 11-1 Unemployed Skills: Prediction versus Register

11.3 Household Income Distribution

Although discussion of economic culture again has focussed on the restructuring of employment and occupations, a great deal more information can be extracted from the calculation in terms of household and business income, public sector revenues, demand for imports, or new investments. For example, an examination of the "trickle-up" and "trickle-down" effects in the Arubian economy suggest that restructuring brought about by the refinery closing and the tourist industry expanding is likely to have complex results on the overall wealth of the Island, and its distribution across the various sub-populations. Here, the main conclusion is that if the goal is to return to full employment (as was the case in the simple exercise above), then most actors in the economy lose income.

Table 11-V shows that there is a net loss in the value of production, in national income (gross island product), wage and household income, and public sector revenues. All sub-populations lose wage and household income, although in different amounts. Traditional-Arubian household income falls by 14 percent, Migrant-Arubian and Modern-Arubian incomes by 10 percent, and expatriate income by 11 percent. Overall, the above results suggest that any industrial restructuring, re-training scheme or regional development policy is likely to advantage or disadvantage particular populations, but that, in general, the trickle-down income from new activities will reflect the biases of the prevailing cultural-economic structur

11.4 The Small Firm Sector Policy

In most societies, the cultural division of labor cuts across technology, sectors and occupations. In Aruba, as elsewhere, sub-groups of the population tend to be associated with particular production techniques and products. The following sections illustrate in a general way some of the possible uses of the CAM for exploring post-disaster social, regional and technology policy.

In Aruba, data are available on ownership and employment in businesses of different size. The 1981 Survey of Business shows that there are considerable differences in standard measures of technology, such as labor and capital-output ratios, across firms of different size. These contrasts are summarized in Table 11-VI. Small sample surveys also indicate that these firms typically also have contrasting purchasing behavior for supplies and serve different customers. Furthermore, Chamber of Commerce and other data shows there to be biases in terms of ownership of small business by the different population sub-groups. For example, in all sectors, the average size of businesses owned by Arubians is considerably smaller than for the sector as a whole.

To indicate the importance of this structure, calculations are presented below which show the contrasts in social impact when economic policy is oriented toward small, rather than large enterprises. The calculations are simplified to show the characteristic implications of such policy which, in practice, would form part of a broader development strategy - such as effort to extend local ownership of the economy.

For this calculation, production activities have been subdivided into "small" and "large" business (below 10 and 10 and above employees respectively). Small businesses in Aruba generate about 28 percent of the total value added, and account for about 40 percent of employment. Categories of employment are again sub-divided into "low," "medium" and "high" skills. The cultural accounts are arranged so that income received by each of the three skill categories is then transferred on a pro-rata basis to the four categories of households. This short-cut procedure is adopted because of lack of data - but again means that predicted shifts in income distribution between the population sub-groups resulting from a "small firms policy" are likely to be under-estimated. Again, it is not necessary to present full details here, and the example will consider only the manufacturing sectors.

One way to compare the potential implications of a successful small firm policy is simply to ask what would be the result of directing a given amount of new business to a particular class of firms. Table 11-VI contrasts the income and employment generated in the economy as a whole when a AFl 1,000 order is given to large and small manufacturing enterprises (using average data for this sector). It is apparent that the overall impact (direct plus indirect) is much greater if the initial increase in demand is directed to small firms. When the order is given to large firms, the

TABLE 11-V Net Income Lost to Sub-Populations

Net Income Loss from Economic Restructuring

Impact (AFl)	Refinery	Tourism	Net
Arubian Economy:			
Output (excl. refinery)	-331	398	67
Wage Income	-169	108	-62
Value Added	-397	265	-132
Government Revenue	-23	9	-14
Household Income:			
Traditional-	-60	37	-23
Migrant-	-25	18	-7
Modern-	-113	81	-33
Expatriate-	-30	22	-8
Total	-228	157	-71

Note: Impacts are AFl million.

TABLE 11-VI Contributions of Large versus Small Businesses

Comparison of Large versus Small Manufacturing Enterprises

Impact	Large	Small
Arubian Economy:		
Local Output	2451	2840
Wage Income	496	849
Value Added	1352	2088
Government Revenue	53	67
Household Income:		
Traditional-	254	267
Migrant-	95	107
Modern-	519	503
Expatriate-	133	122
Total	862	1239

Note: Impacts for AFl 1000 of new demand for manufactures total value added and wage income are Afl 860 and Afl 500 respectively. When the order is given to small firms, the total value added and wage income are Afl 1,239 and Afl 849. These are very substantial differences, and although there may be other reasons to question the viability of a small firm policy, there are clearly potential advantages to the economy as a whole. The implications for educational policy and skills, in particular, may not be straightforward. For example, the calculation here shows that the total demand for labor in all three skill categories is higher with the small firm alternative - which could imply bottlenecks for particular skills in a situation of low unemployment. On the other hand because small firms often employ more "traditional" skills (in the sense implied by the term "economic culture" used in this paper) the small firm alternative may provide more appropriate jobs (as well as more jobs), in a time of unemployment.

In practice, the possibilities for a small firm policy are often limited by production possibilities, for example, small chicken farms in Aruba do not supply the quality or quantity of product required by international hotel chains; small contractors cannot build high rise hotels, and so on. Nevertheless, there are products for which small firms are competitive, or other policies which can help them to become so. Co-operative arrangements to pool and grade output from farms, or to share equipment, or the promotion of a different style of tourism, using low-rise or more traditional building methods, for example, can help to overcome some of the economic constraints on the expansion of the small firm sector.

Given the horizontal division of labor associated with firm size, it is evident that expansion of the small firm sector as a whole will tend to favor particular households. The results in Table 11-VI show that expansion of the small firm manufacturing sector has relative income advantages for Traditional and Migrant Arubians households who receive 27 percent and 11 percent of the total (i.e. direct and indirect) income generated respectively. In contrast, a large firm strategy favors Modern Arubians and Expatriates, who receive 52 percent and 13 percent of income.

11.5 Socially Targeted Technology Policy

To simplify the last results somewhat - the favorable outcome for Traditional-Arubians arises because many small businesses are owned by Arubians, and employ Arubians. Thus, Arubian households are likely to benefit relative to non-Arubians, simply because of the direct income effects. But, in addition, because of the tendency for Arubian owned firms to employ Arubians, and for Arubians to purchase goods from Arubian firms, there are likely to be stronger internal multiplier effects than for other businesses. Clearly, these mechanisms may be used to take economic policy one stage further, so that development is targeted towards particular traditional or minority populations. The applications in this section illustrate the results of policies targeted at the Traditional and Migrant Arubian populations.

i) Traditional Construction Skills: The construction industry offers one illustration of a targeted policy. For the Traditional Arubians, it is clear that construction of dwellings represents a deeply embodied component of their economic culture. A social process and an industrial organization have evolved which involve extended families working together to build homes. Often several generations share the parental home and new parents do not consider themselves truly "married" until they have moved in to their own home. Construction of dwellings takes many years, and the reciprocal obligations incurred among families may be re-paid over many years.

The underlying process of production and construction of dwellings is a "core" reinforcing mechanism of the Traditional Arubian economy. By circulating income within the Traditional community, an important multiplier process is set up which may be reinforced as a matter of policy to strengthen their economic base. The potential importance of this process to the income of Traditional households may be illustrated through the classic example of an economic initiative which is devoted to the construction of dwellings for and by Traditional Arubians. It is assumed here that the construction enterprises involved are owned and operated by them. All direct wage and profit income goes to Traditional households, and the output is consumed primarily by these households. The technology used is taken to be the same as that currently employed in small construction enterprises, except that all raw materials and services are assumed to be purchased from small firms - many of which are also owned by Traditional Arubians. For the calculation, the activity is treated as if it is part of the formal (monetary) economy. In practice, much of this building activity is carried out in the informal sector on the basis of reciprocal obligations.

The impact of this reinforcing set of assumptions is seen from Table 11-VII which compares the impact of AFl 1,000 of this type construction activity with the impact of the same value of large and small firm construction. With the prevailing cultural division of labor the total (direct and indirect) income generated for Traditional Arubian households by this amount of new activity in large construction firms would be AFl 308, compared to AFl 395 for small firms. With the targeted initiative a total of AFl 814 is generated, of which AFl 530 is direct income and AFl 284 is indirect income. Of this, AFl 61 is at the expense of other households. While the illustration may be extreme, and the practical problems of financing and promoting the initiative are assumed away, it is evident that the potential for a very substantial increase in income lies in any economic policy which builds upon an existing set of skills and cultural institutions, and establishes strong economic feedbacks within the Traditional community.

ii) Community Development and Minority Businesses: The same possibilities for generating reinforcing economic processes exist with the Migrant Arubian community. The course of historical events in Aruba has meant that many members of this population group share superior production skills which arose out of the selective recruitment process adopted by the oil refinery and the high value typically placed on education by this population. Political-cultural pressures tended to push this group out of the well-paid positions in the refinery, and even though some of this sub-group are born in Aruba, many still feel themselves to be "treated as outsiders in their own land." Today, these second generation immigrants often occupy key skilled and shop-floor management positions (such as foreman) in manufacturing and other businesses, but less often in senior management and government or entrepreneurial positions. Nevertheless, the potential for entrepreneurship is evident - for example, a number of Migrant Arubians used lay-off payments from the oil refinery to set up small repair shops and service activities.

Included in this group also are the newer immigrants from the Caribbean Basin, including Aruba's former partners in the Netherlands Antilles. Others have arrived from the much poorer islands and countries (especially Dominica, Haiti and Colombia) and these make up the lowest paid groups in the labor force. They make up a good proportion of the illegal work force employed by the formal sector (as opposed to the "self-employed" informal sector which includes a high proportion of native Arubians).

For this group too, the impact of a new policy initiative designed to raise income is considered - in this case, a small scale service and repair activities targets the Migrant Arubian community. These results are given in Table 11-VIII. Using similar assumptions to those for the construction sector example, the new initiative generates a total of AFl 552 income for Migrant Arubian households, of which AFl 440 is direct income and AFl 112 is indirect income. With the prevailing cultural division of labor, the total (direct and indirect) income generated for Migrant Arubian households by this new activity in large and small service firms would be AFl 127 and AFl 131 respectively. The relatively small indirect effect with this example, compared to the construction sector initiative, reflects the low level of Migrant Arubian entrepreneurship in the rest of the economy. In practice, such a "service sector" initiative could target a full range of activities within a regional community, (the township of San Nicolas in the case of Aruba), or be used to provide a basis for increasing minority participation throughout an economy.

TABLE 11-VII The Impact of a Targeted Construction Initiative

Comparison of Targeted Construction Initiative

Impact (AFl)	Targeted	Large	Small
Arubian Economy:			
Local Output	3205	2577	2951
Household Income	1593	1148	1404
Government Revenue	75	67	73
Indo-Households	814	308	395

Note: Impacts for AFl 1000 of new demand for manufactures

TABLE 11-VIII The Impact of a Service Sector Initiative

Comparison of Targeted Service Sector Initiative

Impact (AFl)	Targeted	Large	Small
Arubian Economy:			
Local Output	3429	2314	3116
Households Income	1581	1154	1279
Government Revenue	76	67	68
Migrant Households	552	127	131

Note: Impacts for AFl 1000 of new demand for services

SECTION 12
DESIGN CONSIDERATIONS FOR A DISASTER PLANNING SYSTEM

The conclusions of the model testing fall into two broad areas, the predictive performance of the model and the insights gained for model construction and its use as the basis for an expert system for disaster recovery planning.

12.1 Predictive Performance

The empirical tests with the 1979 Aruba SAM have demonstrated that the model can "track" the historic employment and GDP data for the Island over the decade from 1979 to 1990 with reasonable proficiency. The tests carried out are relatively challenging for an input-output type model (or for any practical planning model in the empirical difficulties encountered). They suggest that the SAM may be used to evaluate the impacts of major natural disasters and the performance of recovery strategies for medium term recovery strategies.

i) Aggregate employment. These tests showed that the model could reproduce the timing and levels of the economic crisis and recovery to the limits of the available data. The lagged model appears to be superior to the conventional un-lagged approach. This is likely to be an unwelcome (and possibly suspect) conclusion to adherents of non-lagged methods but deserves further consideration and research, especially since the empirical data are weak.

ii) Employment by Sector and Region. These tests were limited by the quality of data. The model appears to provide a reasonable performance for the indirect impact on the economy (i.e. the effects arising from the aggregate structure of the economy). However, to obtain a useful forecast, the direct effects must be specified using project specific information about expenditures, sources of materials, and labor requirements, rather than assuming that these projects will adopt current technology.

iii) Gross Island Product. Although the model is capable, in principle, of predicting income changes to households, businesses, and government in a rather detailed fashion, the required income statistics to test these predictions are not available. Moreover, since there are no recent national accounts for Aruba, the GDP estimates by the Central Bank are based on a variety of sources, including the employment statistics. Given this, the model also provides a reasonable prediction of GDP trends.

iv) External Accounts. Preliminary forecasts of import and export requirements, and the balance of payments for the Island are satisfactory, and current forecasts will be monitored against future economic developments in Aruba. Further testing would require that the external sectors of the model be revised to match the current and capital accounts categories adopted by the Central Bank of Aruba.

12.2 Model Construction and Use

The principal conclusion from the study with respect to construction and use is the need to retain considerable flexibility. This represents a considerable challenge for the design of any expert system.

i) Model Updating. In constructing a model in a practical situation there are likely to be contradictions and omissions in the data which must be by-passed if the model is to be developed on a useful time scale. It is necessary to be able to update the model as new data emerges.

ii) Model Configuration. The construction procedures showed that it is possible to develop models with a wide range of applications. Since the model may be called upon to evaluate a variety of problems and strategies, several configurations of the basic model may be needed, for example, using regional, social or sectoral categories. In many cases it may be possible to automate this process, for example, from the available Census of Households and Business.

iii) Details of Projects and Policy. The testing of the model showed that the results are sensitive to the timing of events and the details of projects undertaken. It follows that the design of a reliable planning model should make it possible to incorporate these features.

iv) Strategy Revision. Again, since the aftermath of any natural disaster is likely to be chaotic and unclear, and the practical opportunities for recovery will only be revealed after some time has passed, strategies and detailed plans will change constantly. Any useful model must be able to adapt to changes readily and provide a reliable comparison of policy alternatives.

12.3 The Horizon Model

In order to illustrate future possibilities for applying the impact model, some results from a parallel modelling exercise are now discussed. This "Horizon" model embodies much of the theory and practice which have underpinned the NCEER study. The approach has evolved from more than twenty years experience of building and using economic models for international, national, regional and local development. This includes projects for several national and international agencies (of the United Nations, the European Commission, the United Kingdom Department of Environment), as well as regional agencies such as the New York State Department of Economic Development, the Scottish Development Agency and the Dutch Department for the Netherlands Antilles), and private corporations and consultants.

The Horizon model is distinctive in several important respects:

i) The model is designed to provide local development agencies with an in-house ability to calculate the economic impact of events and policies which may affect their region. Because the model is programmed as a spreadsheet, it can be more readily understood, customized and updated by local development officers.

ii) The model can be used at several levels of sophistication from single events, such as the opening or closing of a business, to complex scenarios which combine a variety of local events or policy responses with external events such as sectoral growth trends in the national economy.

iii) Unlike most input-output models, the Horizon approach allows the impacts up to any specified time horizon to be calculated. This is important because it takes some time for the effect of any event to work its way through the economy and, consequently, the full impact is not felt for several years. For many purposes, it is important to be able to distinguish the size and composition of the near-term, mid-term and long-run impacts. Moreover, with a sequence of events taking place over several years, such as the shut down of the British Steel (Ravenscraig) steel plants in Motherwell, Scotland, the delayed year-by-year effects often combine to produce a complex adjustment to the economy.

iv) The model implementation is designed to make such calculations as straightforward as possible. The approach recognizes that the impact of any given event depends more or less equally on the details of the original event (the wages paid, amount and source of raw materials of the firm in question) and the structure of the local economy (the transactions between local businesses, households and government, and their relationships with the outside world). The model attempts to balance the importance of these two contributions by using a compact input-output model of the area economy with the best possible information on the forthcoming change.

v) The approach also recognizes that information on events such as an economic disaster, such as a plant shut down, or a natural disaster such as an earthquake, is never clear-cut. In some situations, it may be most appropriate to provide a range of possible impacts. Thus, the model is designed to enable a variety of scenarios to be explored (for example, when several alternative proposals for a new enterprise are being compared), or to be updated quickly (for example, when the final schedule for events is not known, or new information becomes available). The underlying belief here is that it is desirable for planners to be able to make these calculations for themselves using the data available to them, and to have the facility to test policy options on an habitual basis.

vi) Finally, the model is probably unique among input-output type models in that its ability to track regional trends over a ten-year time span has been demonstrated in a practical planning situation. In this demonstration - the application to Aruba detailed above - the model predictions were found to match well the employment trends resulting from the dramatic decline and recovery of the Island economy.

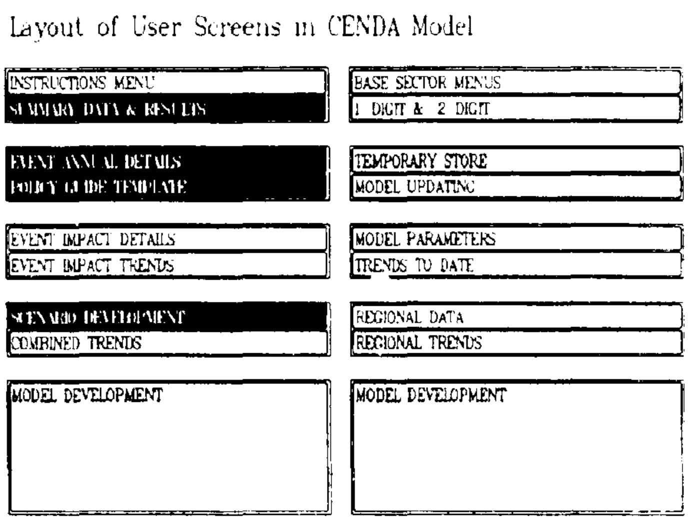
The Horizon model is designed to strike a compromise between providing a sophisticated planning model and a tool which can be understood and adapted by the user. It is programmed as a spreadsheet because this allows users to customize the model to their own needs. Data input and results appear as a series of "screens" laid out as shown in Table 12-I. Table 12-II indicates the level of detail which may be entered into the model.

The model can be applied in an extremely flexible way with only a modest knowledge of spreadsheet programming. For example, first-time users of the model may carry out single event impact studies and customize the pre-programmed tables and graphs in the model by using spreadsheet commands. A little familiarity with the model will allow users to determine the impact of rather detailed events and carry out multiple event calculations. Experienced users may program more sophisticated responses.

The data base and results of the model also may be interfaced directly with a geographic information systems (GIS) data, such as the UDMS (Urban Data Base Management System) developed by the United Nations Habitat Program, or the United Nations Population Division POPMAP System, or even mapped directly by using the graphing facilities within the spreadsheet. This provides an inexpensive and integrated GIS. Two examples of this last use, linked directly to the regional model of Aruba described earlier, are shown in Figure 12-1.

To apply the model, the user provides information about specific events which are expected to disturb the regional economy. An "event" is defined as the change in the level of activity in a specified sector. The event begins in a specified year and continues at a steady annual rate until a specified time horizon. Depending on the level of information available, an event may be

TABLE 12-1 Screen Layout of the Horizon Model



Black entries for User Data. Grey entries for User Storage
Home for Instructions Menu and Summary Screen
For other Screens use Page Up and Down and Tabs.

TABLE 12-II Details of Input and Output Screens

QUICKSTART MENU

LANARKSHIRE ECONOMIC IMPACT MODEL		CENDA © 1992 NY14226	

These macros move cursor to menus and data inputs tables, results tables and graphs

To use a macro press the Alt and Letter Key together

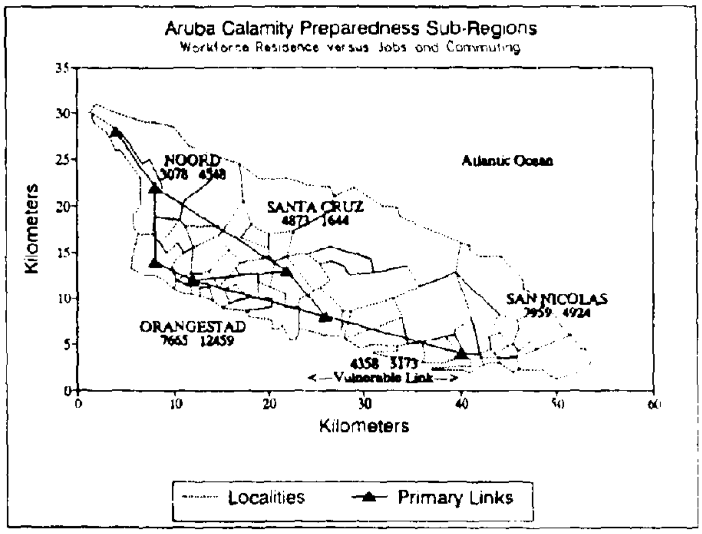
DATA & RESULTS MENU		SAVE & RESET MENU	
Return to MENU	alt m	CLEAR data	alt c
List BASE sectors	alt b	STORE event	alt o
Print EVENT summary	alt e	RECALL event	alt a
Enter event DETAILS	alt d	Event STACK	alt k
Print IMPACT details	alt i	SAVE datafile	alt s
Calculate event TREND	alt t	LOAD datafile	alt l
GRAPH event trend	alt g		
PRINT event totals	alt p		
VIEW scenario details	alt v	UPDATE	alt u
Graph FINAL scenario	alt f		

These macros allow data and results to be stored and recalled within the spreadsheet or to and from the CENDA directory

Description	IMPACT SUMMARY	HORIZON YEAR		
Time elapsed to Horizon in months	EVENT 1 Steel	114	MONTHS	
Brief description of Event	Note: Plant Shutdown			
		£ million		Job
	ITEM	Output	Income	Years
Direct impacts to end of Horizon year	DIRECT	442	127	3070
Tota impacts to end of Horizon year	TOTAL	745	388	10512
Multipliers in Horizon year	MULTIPLIERS	1.7	3.1	3.4
Average multipliers over whole period	AVERAGE	1.6	2.5	3.0
Annual rate of employment and output	ANNUAL DIRECT	442	127	3070
Comparable rate for average of sector	METAL AND OTHER MA	332	95	3070
Year and month of Event and Horizon	START 6/1991	HORIZON		12/200

EVENT SUMMAR	ANNUAL		Description
Ite	Data	Status	
File	LANARK	WQ0	The DOS File name used to store
No	1	Store	The current data and results
Title	Steel		The name of the current Event
Eve	1991.5	OK	The date when the Event begins
Hon	2001.0	OK	The date to calculate Impacts
Jobs	3070	OK	The annual direct FTE jobs
Out	442		The annual output, sales or turnover
Men	2	Digit	The digits (1 or 2) of the reference data
Sect	32	Max 40	The SIC code for the reference sector
Valu	1991	£m	The index year for output and income measure

Advice to users: STATUS PROCEED TO DETAILS TO REFINE DATA BALANCED



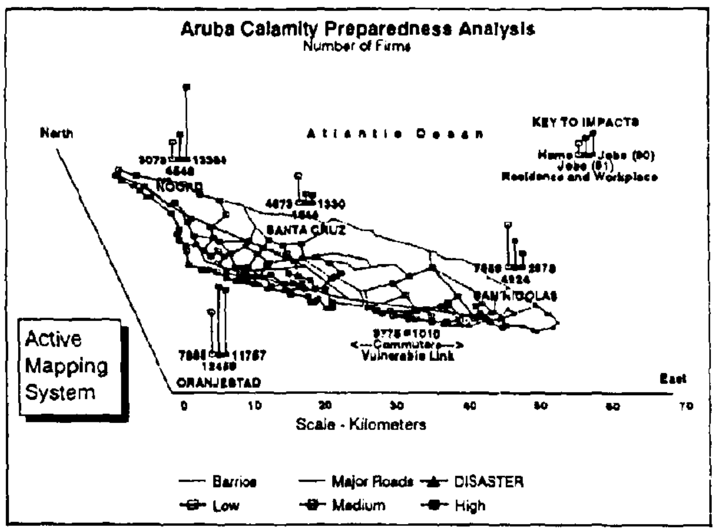


FIGURE 12-1 Regional Geographic Information System

described in summary or in detail. Missing information is substituted by reference to a selected "base sector." Events may be linked to selected policy responses.

Any set of changes affecting an economy, however complicated, may be broken down into a series of single or multiple events beginning in specified years. These are detailed and calculated separately. The model estimates the impact of these events on sectoral employment, household and other income and business activity in the region for a particular time horizon. The model also calculates a trend by repeating the calculation for year-end horizons up to the year 2000. Events and results may be stored in the model, or filed and recalled for later revision or reference, or consolidated into scenarios. The results may be graphed, tabulated or geographically mapped, and printed using in-built spreadsheet macros and commands.

An overview of the model operation is shown in Figure 12-2.

12.4 An Application of the Horizon Approach

The Horizon approach is currently being used for a "real time" application in an on-going economic disaster in Lanarkshire, an industrial region of Scotland. Like many other mature industrial regions, the economy of Lanarkshire has undergone a dramatic transformation over the last decade, losing many of its traditional industries. Coal, steel and heavy engineering, especially, suffered a severe decline during the late 1970's and early 1980's. Even with a modest recovery during the 1980's, unemployment remains at about 13 percent of the labor force, in a total population of about 500 thousand. The area is now confronted with the shutdown of the major British Steel Ravenscraig complex in several stages over the next several years. The total employment loss is expected to be of the order of 20,000 jobs. Although there has been about two years warning (and even longer speculation) that the steel works would close, the major shut down of a plant with over 3000 jobs took place with almost no notice in mid-1991.

The local development agencies (in particular, the Lanarkshire Development Agency) are exploring new opportunities to recover employment through economic development and training

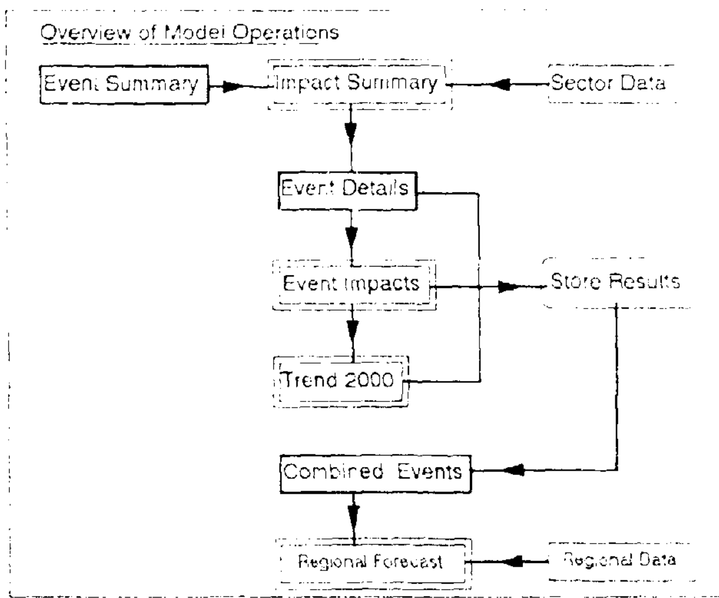
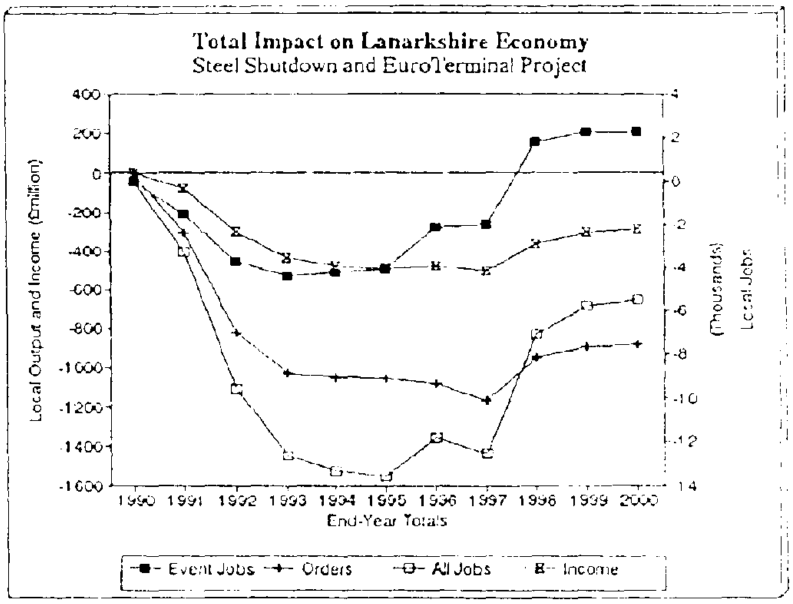


FIGURE 12-2 Operation of the Horizon Model

policies, including the proposal that Lanarkshire should become the site of the northern terminus of the EuroRail freight system. To help address the policy issues which arise from restructuring, a Horizon model has been constructed and is being used by the staff of the LDA to make in-house calculations of events such as the Ravenscraig closing or the construction and operation of the EuroRail Terminal. An illustration of the results is given in Figure 12-3. As the precise timing of the shut down of the steel plant is finalized and the possibilities and costing of the EuroRail Terminal becomes clear, the model will be used to plan the level and timing of the project, the training requirements of the local labor force and so on.



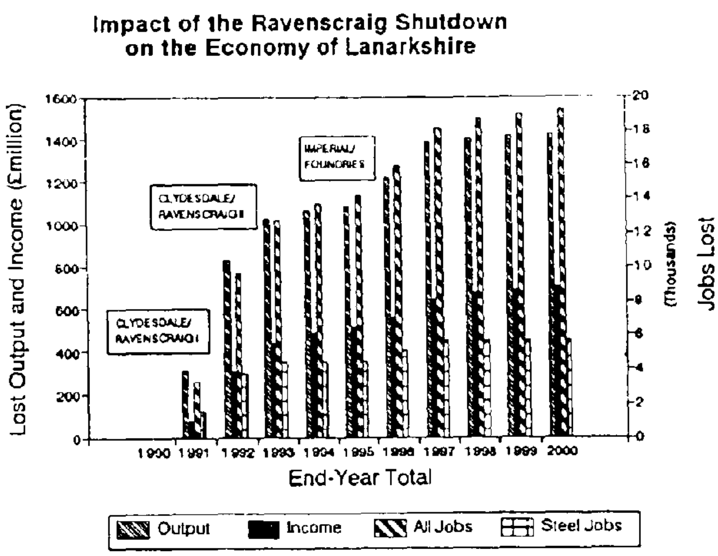


FIGURE 12-3 Scheduling Facilities in the Horizon Model

SECTION 13

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APPENDIX A
MATRIX SCALING FOR MODEL CONSTRUCTION

A.1 Introduction

This appendix presents a scaling algorithm for the construction and updating of Social Accounting Matrix (SAM) type input-output tables. A Lagrangian derivation of the algorithm is presented, and the conditions for the existence, uniqueness and convergence of the iterative solutions are explained. 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 groups 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 social accounting matrices in an inexpensive and rapid fashion.

The most common method for constructing input output tables for a specific locality (such as that which might be impacted by a natural disaster), is to transform a previously constructed table for the encompassing region or for a similar region, using whatever data are available from the locality. Typically this includes employment and household and government expenditures. These data are adjusted, and if possible reconciled (ie. made consistent) using a variety of techniques. Although suitable input-output tables sometimes will be available for some earthquake-prone areas (such as city regions in industrial countries), in general this will not be the case, and a table will be based on a regional table, or a table for a similar economy.

Most tables contain little information about many of the activities which are considered above to be relevant to the disaster and recovery, despite the fact that useable information is often available. For example, there are often partial data or estimates for particular items, such as the total household expenditures and distribution, value added of all manufacturing, or some export and import items for the region. In other cases, there may be no local data, but information from other localities is considered to be a suitable guide, for example, to the difference in production costs between formal and informal sector enterprises or expenditure behavior by different minority populations. All of this may be important to an understanding of the likely impacts of a recovery program. It therefore should be incorporated into the social accounts. Unfortunately, this complicates further the challenge faced when building any input-output table - the bringing together of disparate and often incomplete and inconsistent data into a consistent set of accounts.

Present extended RAS scaling techniques (see section A.2) do not deal well with this kind of partial and usually inconsistent information, especially when it is represented by entries in the interior of the input-output table. Most methods demand that information on individual items is taken to be perfectly accurate, 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. For the exercise here, it is argued that the ability to construct the local area social accounts rapidly, and in a form relevant to the local situation (in terms of economic categories) and the particular impacts of the disaster (in terms of the systems affected), is far more important than a high (and unrealistic) level of precision. Some form of expert system based on a more powerful, yet simple, scaling algorithm appears especially useful here.

In a recent review, Han and Kim (1988) 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. The overall aim is to provide a simple, robust tool.

A.2 The Algorithm used to Scale the SAM

The remainder of the appendix explains the algorithm to be used in building of SAM type input-output tables. The method proposed here 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 an attractive explanation. Of course, if the original data are too inconsistent, or too partial, there may be no solution possible. Moreover, even if a solution is obtained, it may not be credible to the planners who are expected to use it. The need for some expert system is to guide the process of seeking and massaging the data to provide an acceptable result!

Since its introduction, the theoretical basis for the RAS method has been strengthened, in particular, by Bacharach (1965, 1970) who 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, notably 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, provided these do not result in excessive over-determination of entries. Furthermore, the matrix may contain an arbitrary number of dimensions, and so may be applied to, for example, the consistent scaling of multi-regional rectangular input-output tables (see eg. Oosterhaven et al, 1986).

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 information measure of distance across 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 i and j label the rows and columns of the accounts represented in the table (production sectors, households and so on). A base matrix, $A_{ij}(0)$, a national or regional table, is used as the starting point for the new table. If there are Z constraints, defined by the sub-totals B_z, then, after n adjustments, the Z constraints applied are given by:

$$\sum_{ij \in z} A_{ij}(n) = B_z \qquad (A.1)$$

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

$$D[A(Z):A(0)] = \sum_{ij} A_{ij}(Z)\log[A_{ij}(Z)/A_{ij}(0)] \qquad (A.2)$$

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,

$$D[A(n):A(n-Z)] = \sum_{ij} A_{ij}(n)\log[A_{ij}(n)/A_{ij}(n-Z)] \qquad (A.3)$$

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

The Lagrangian for the problem is given by:

$$L = D + \sum_{z} l_z(B_z - \sum_{ij \in z} A_{ij}(n))$$

where l_z are the Z Lagrangian parameters.

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

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

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 (A.4) gives:

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

Substitution of (A.5) into (A.1) gives:

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

This expression may be rewritten, by separating the term in l_z, after setting $r_z = \exp(l_z)$, giving:

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

Using (A.5) and (A.6), 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.

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 (A.1) are all linear, the objective function (A.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.

$$\text{i.e.} \quad \sum_i X_i = \sum_j Y_j \qquad \text{(A.7)}$$

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 (A.7) would be that the sum of the row and column totals must be equal.

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

The primed B'_t 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:

$$X_{i'} \leq \sum_{j \neq j'} Y_j \quad \text{and} \quad Y_{j'} \leq \sum_{i \neq i'} X_i \qquad \text{(A.8)}$$

These only-just-sufficient conditions lead to boundary solutions which 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 (A.7) and (A.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.

$$\text{i.e.} \qquad \sum_{\substack{\text{inner}\\ \text{blocks}}} B_j \leq \sum_{\substack{\text{encompassing}\\ \text{blocks}}} B_j \qquad \text{(A.9)}$$

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 (A.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. Generally, satisfactory convergence (to within one percent of the given B_z) is obtained within twenty iterations, ie. $A_{ij}(\infty)= A_{ij}(20)$. This test is directly comparable to those applied by both Harrigan and McNicholl (1986) and Morrison and Thumann (1980) to their non-RAS methods.

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. It thus appears to provide a means of constructing social accounting matrices for natural disaster event accounting, and also a potentially useful core algorithm for the proposed hybrid expert system.

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APPENDIX B

THE SOLUTION OF THE "EVENT ACCOUNTING MATRIX"

Introduction

This Appendix describes input-output theory used to calculate the economic impacts of the economic events investigated in this report. It is based on a modification of a generalized Leontief inverse method (Cole, 1987). In the last years several theoretical advances which incorporate distributed activities and production delays into regional analysis have appeared. These include, for example, the distributed production method of ten Raa (1986) the sequential industry model of Romanoff and Levine (1986) and the econometric regional model of Charney and Taylor (1985). The last authors especially emphasize how, in considering multiplier effects, one must recognize the way in which these build up over time. The method presented here incorporates expenditure lags into the standard impact model. Because the technique is especially designed for calculating the distributed impact over time on household income, local taxes, employment and other businesses, it may be readily extended to account for the changes in the levels of activities and delays in restoring them to their former (or new) level, thereby simulating the recovery program from a natural disaster.

The report has differentiated between the direct and the indirect effects of a natural disaster on an economy. The majority of the direct effects may be felt immediately - for example the collapse of a building or bridge effectively terminates or cuts back production and distribution. Others, may be delayed as stocks of raw materials are depleted. However, most indirect effects depend on causal links in the economy and so, even though the disaster may itself occur over a very short time period, its full effects are not felt immediately. Indeed, the economic impact is likely to build up over time. All activities in the economy will take some time to adjust to the new circumstances. With some activities this adjustment is rather rapid, with others it is much slower. Even with a small event there is temporary departure from the normal pattern of growth is experienced as the ripple effects work their way through the economy.

The problem with conventional input-output analysis for present purposes is that it tends to avoid the analytic problem posed by expenditure and recovery. In the standard model it is assumed (for reasons of computational and empirical simplicity) that some responses are more or less instantaneous (at most a few months), while all others take an infinite time (or at least many years). Thus, inter-firm transactions and household expenditures respond to changes in income relatively rapidly, while other expenditures such as investment or government have a relatively long response time (at least compared to the time-scale of interest). This may be argued to be a poor approximation even for typical input-output calculations (such as the opening and closing of individual plants or businesses) since, although the precise timing may vary, after several years even these slower accounts are likely to make a significant contribution. Moreover, within the first year, it is unlikely that even production and household expenditures will have reached equilibrium, or that some downstream response by investors or government agencies will not already have begun. The standard solution is even less satisfactory for evaluating "disastrous" events, since here there are several time varying shifts to consider, both in the transmission of the original disaster through the economy, and in the time-phasing of the recovery process.

Since the method proposed here is an extension of the earlier work, it will be briefly summarized here, as a starting point for explaining the application to the "event accounting" procedures. The method described in Cole (1987) for introducing expenditure lags and other delays (such as transportation lags) has the merit of retaining the full simplicity of the standard (generalized Leontief inverse) calculation while enabling "gestation" phenomena in all economic activities in the region to be accounted for. While external links (outside trade and investment) requires some additional considerations, their treatment is similar to the corresponding local activity.

An Extension of the Standard Model

In the standard model (see e.g. Miller and Blair, 1985) the impact on the total production of sectors described by the vector X arising from the forecast vector of new final demands Y is given by the familiar series

$$X = (I + A + A^2 + A^3 + .. A^n + .. \text{ etc. }) Y \quad (B.1)$$
$$= (I - A)^{-1} Y$$

A is the matrix of direct input coefficients with elements a_{ij} where subscripts i,k ...z take values 1 to N. Successive terms in the infinite series in (1) contain products of pairs, triples etc. of aij's and the typical nth order term contains all possible combinations of products of n coefficients such as

$$a_{ik} a_{kl} a_{lm} a_{mn} \ldots\ldots a_{yz}.$$

When lags are introduced, the form of expression (1) is retained involving the same products of pairs, triples etc. of a_{ij}'s but now each term is associated with a nested integral. This may be demonstrated using the example of a general two sector economy. This shows the relationship to the standard approach. For this purpose, the round by round calculation follows that given in Miller and Blair (1985, pp. 31-33) for the case when no lags are included. There are two differences from the standard model, the first concerns the accounts which are to be included in the A matrix, the second concerns the expenditure distributions themselves.

In the revised approach, a new matrix A' is defined. This now includes all accounts, including activities with fast responses such as production and households, activities with slow responses such as government and investment, and external sectors such as intra-regional trade and finance. For an N x N accounts matrix, these accounts are partitioned initially so that for the domestic accounts (i.e. production, factors, households, firms, government, investment, say **k** accounts in all), the new matrix is simply

$$a'_{ij} = a_{ij} \text{ for } i = 1 \text{ to } N \text{ and } j = 1 \text{ to } k$$

and for all external accounts (i.e. inter-regional finance and trade) the aij coefficients are now

$$a'_{ij} = d_j a_{ij} \text{ for } i = 1 \text{ to } n \text{ and } j = k+1 \text{ to } N$$

where d_j measure any feedback into the local economy from extra-regional income circuits (eg expanded imports into the local economy in turn resulting in expanded exports from the economy). The fact that the $0<d_j<1$ means that there will always be leakages from the economy and this prevents solutions to the model diverging. Beyond this, the d_j will not be of further interest until the fourth section of the paper and so, to simplify notation, the matrix elements of the N x N matrix of Figure 1-2 will simply be written as aij in the following calculations.

In the extended method, two sets of expenditure lag are now introduced. The first set of lags $p_i(t)$ describe to the manner and timing of the exogenous demand Y. As a first approximation (to be modified later) the vector Y, and the associated lags p, represent the intensity and time-phasing of the direct effects of the natural disaster. The lags depend on, for example, whether the impact is more of less instantaneous or itself delayed in some way. The cumulative impact is defined in the same way such that the marginal effect (i.e. the fraction of the total event felt up to the time horizon is given by $P_i(t\text{-}t')$.

i.e. $$Q_i(t'\text{-}t'') = \int_{t'}^{t''} q_i(t)dt \qquad \text{(B.2)}$$

These exogenous impacts and lags, in general, will be assumed to be independent of the manner in which the endogenous transactions - the normal day-to-day operation of the local economy - are conducted.

The second set of lags describes the delays in completing the endogenous transactions in the regional economy. This affects all transactions within the a matrix as just defined. These lags are given by $q_i(t)$ and again determine the cumulative transaction in any given time interval. This depends directly on the fraction of income $Q_i(t'\text{-}t'')$ spent in the interval from t' to t".

In Cole (1987), it was assumed that transaction responses are a function only of the actor making the expenditures since this ensures that activities have stable expenditure (i.e. input) patterns. (Without this assumption it would be necessary to introduce a variable stocks account in order to ensure that the material balance was maintained). This assumption is maintained for the moment here, but will be foregone later in considering the incorporation of the "event matrix" into the model. Since expenditures depend directly on the Q_i, the marginal coefficient representing payments to account i from account j up to a time horizon T becomes $Q_i(T)a_{ij}$.

With the lags included the two sector round by round calculation then is repeated. Defining $X_i(n,T)$ as the contribution to the output of sector i coming from round n, the successive terms must be modified to ensure the proper sequencing of transactions. In particular, it is clear that income must not spent until it is received, and the only after a delay. Thus, in any sequence of transactions taking place up to some arbitrary time horizon T, income which is delayed by t' in the first transaction may be spent only at some time in the remaining time T-t'. Given this, the first round contribution to sectoral expenditure of sector 1 now is given by

$$X_1(1,T) = Q_1P_1a_{11}Y_1 + Q_2P_2a_{12}Y_2 \tag{B.3}$$

where Q_iP_j are cumulative joint transaction distributions such that

$$Q_iP_j = \int_0^T dt_0 p_j(t_0) \quad \int_0^{T_j} dt_1 q_i(t_1) \text{ where } T_1=T-t_0.$$

The same argument is repeated for the successive rounds. Thus, income can only enter into the second round once it has completed the first round, and once again it will only be spent after a lag. Again, the amount that can be spent in the second round depends on the time left to spend it, which in turn depends on the delays in spending in the first round, and so on. This round by round calculation demonstrates the meaning of successive terms in the lagged model in relation to the standard model, and also the symmetry between the expenditure coefficients and the expenditure lags. This argument generalizes immediately to the N sector economy. Thus, when lags are introduced, the expression involves the same products of pairs, triples etc. of a_{ij}'s as in the standard model, but now each term is associated with an integral, so that the term corresponding to the above is

$$Q_kQ_lQ_mQ_n\cdots\cdots Q_yQ_zP_za_{ik}a_{kl}a_{l}a_{mn}\cdots\cdots a_{yz}$$

Each nth order term in the regular series is therefore multiplied by a corresponding nested integral F(n,T,j..z) of the form:

$$F(n,T) = \int_0^{T_0} dt_0 p_j(t_0) \int_0^{T_1} dt_1 q_j(t_1) \ldots \int_0^{T_{n-2}} dt_{n-2} q_l(t_{n-2}) \int_0^{T_{n-1}} dt_{n-1} q_k(t_{n-1}) \qquad (B.4)$$

where $T_0 = T$, $T_1 = T - t_1$, $T_2 = T - t_1 - t_2$ and so on. The share of the income which will be transferred at each round will depend on the time remaining after previous transactions have taken place. For example, if the delay in making a particular transaction in the first round is t_1, then the maximum remaining time for the second transaction is T_1, and if a further time t_2 elapses before the second transaction is made, then the maximum time remaining for the third will be T_2, and so on. The final transaction must take place with a time T_{n-1} so that the total time taken for all transactions is T.

The above leads to a rather complex series of convoluted integral. Fortunately, it can be shown numerically for a variety of functional distributions (exponential, normal and gamma) and parameters (eg. short versus delayed responses) that there is a practical approximation to the round by round calculation for an arbitrary distribution which dramatically simplifies the calculation of lagged impacts, and is useful for most practical purposes. For this approximation, the Q_i and P_j are taken to be separable.

$$\text{i.e.} \quad Q_i Q_k \ldots Q_l P_j = Q_i Q_k \ldots Q_l Q_j P_j \qquad (B.5)$$

where P_j, Q_i etc are given as in (2). Given this, the expressions for the contribution to the impact X_i from successive income cycles also become separable because the each integral over an endogenous transactions is associated on a one to one basis with the corresponding A matrix coefficient. This applies for an A matrix with any number of accounts and means that the series expansion for X may now be written.

$$X = (I + QA + (QA)^2 + (QA)^3 + ..(QA)^n + .. \text{etc.}) PY \qquad (B.6)$$

or as a summation similar to (B.1)

$$X(T) = \{I - Q(T)*A\}^{-1}P(T)Y \tag{B.7}$$

With this approximation then, the total impact up to time horizon T may be determined by inverting a reduced N x N matrix given by I - QxA. This is the matrix whose coefficients are $Q_i(T)a_{ij}$ for j = 1 to k and $Q_j(T)d_ja_{ij}$ for the external accounts j=k+1 to N. The merit of (11) is that X may be calculated in a like manner to the standard Leontief inverse since the regular coefficients are simply replaced by the marginal coefficients for the full economy.

Extra-regional trade and financial flows are computed in a similar manner to endogenous accounts, although the Q(T) for external accounts must now include all leakages from the local economy. Because of leakages, the feedbacks to the local economy from the induced changes (i.e. spillover effects) in the external economy are much reduced (and so are modified by the parameters d_j). The reformulated input-output approach presented above therefore provides a straightforward modification of the standard approach.

Incorporation of the "Events Matrix"

The above formulation as it stands provides a basis for calculating the combined direct and indirect impact of the natural disaster, if this is conceived of as a decline in economic activity of impacted sectors, with no change in the composition of inputs. This assumption of linearity is made in most input-output calculations which use fixed coefficient production functions and fixed consumption propensities. In this case the "event matrix" is simply a vector of changes which represent a reduction in the exogenous demand Y. This, then allows the impact of the event on all other sectors of the economy, and the various types of household and institution identified in the SAM to be calculated, up to whatever time horizon is required. In practice these assumptions of linearity etc. in the model, and the lack of a formal structure linking domestic investment to production capacity limit the model to short and mid-range applications.

In general "events" are more complicated than this. As considered earlier, the character of a natural disaster is such that this is unlikely to be an adequate approximation. In this case, the intensity of an event E may be represented by changes in the coefficient matrix, say, E * A, and in the exogenous demand Y. This vector is related directly to the "event matrix" (considered elsewhere) and simply measure the extent to which a particular activity has been disrupted. Hence, the total impact now may be written as:

$$X(T) = \{I - E(T)*A\}^{-1}P(T)Y \qquad (B.8)$$

This formulation allows a number of situations to be accounted for. For example, in the context of a disaster, the composition of inputs will be typically be changed because of diverse impacts on the various parts of the economy, in particular, distribution and other lifeline systems. If the power networks (generating or refining capacity) are destroyed, but water and transportation relatively unaffected by the disaster, then it may be possible for the necessary fuel to be shipped into the region. In this case, the "technology" represented in the input-output table should change to show that consumption of domestic fuel has changed. Moreover, since this may be a temporary event with the expectation that domestic power systems will be restored to full capacity after a specified period, this too should be included in the longer run calculation. Beyond this, it may be that the recovery strategy involves an expansion and an upgrading of the power production system. In this case, both the level of production, and the technology used are to be adjusted. In general then, the "events matrix" is $E(w_{ij}, c_{ij}, t_{ij}, r_{ij})$. The parameter w_{ij} is the characteristic lag associated with the transaction (as prescribed by the formulation of Cole, 1989). The remaining parameters define the impact of the disaster and recovery - c, t and r respectively represent the initial impact, the time-scale for recovery, and the expected impact of reconstruction.

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