THE APPLICATION OF STATISTICS TO THE RESOURCE MANAGEMENT PROGRAM

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ABSTRACT

Resource Management implies appropriate action to promote the availability of resources for all important requirements. Prerequisites of resource management include estimates and comparisons of resource availabilities and requirements under conditions of interest. This paper examines briefly some of the analytical models developed to support resource management in a post-nuclear attack emergency. These models include one which focuses attention on questions of adequacy of certain types of consumption goods for survival of the population and another which focuses attention on the longer-term problems of economic and industrial recovery. Also noted are some of the important statistical elements of both models and the sources from which they are derived.

Introduction

Before discussing the application of statistics to resource management, let me first explain what we mean by "resource management." This term implies appropriate action by government to promote the availability of resources under all contingencies to meet all important requirements for resources.

Before any action may be determined to be appropriate for such a purpose certain types of estimates must be available. These include estimates of resource requirements and estimates of resource availabilities. Resource requirements in a national emergency depend on policy determinations at the highest levels of government.

From such levels, however, it is not reasonable to expect explicit statements of detailed requirements. Such detailed statements must be deduced from generalized high policy determinations of national objectives and priorities. For translation of such policy determinations into explicit requirement schedules, detailed statistical data and computing procedures and equipment are necessary. For determination of the extent to which such requirements can be satisfied, additional detailed statistics and procedures are needed in order to estimate resource availabilities and to compare these with the stated requirements.

The assembly of the necessary statistical data and the development and application of the necessary analytical models constitute the principal mission of the National Resource Evaluation Center, usually called NREC. Located in the Executive Office of the President, NREC is an interagency activity staffed and otherwise supported by upwards of 25 federal departments and agencies. Operating as a part of the Office of Emergency Planning, its prime objective is to meet as many as is feasible of the analytical requirements of that Office and the civil agencies of the federal government in connection with emergency planning and preparedness in the general areas of continuity of government and resource management.

Analytical Models

These analytical requirements are met, for the most part, by operation of several types of analytical models which apply advanced data processing techniques to large arrays of statistics. NREC has developed and used models for hazard analysis, situation analysis, damage assessment and other resource evaluation purposes. The damage assessment models make use of more than 750,000 detailed resource records. NREC's most important supplier of basic information is the Bureau of the Census, which provides detailed statistical data on population, housing, business, and manufacturing; but most of the other statistical collection programs of the federal government funnel information into the NREC system.

In order to provide support for broad resource program determinations we need analytical models for providing detailed estimates of resource requirements and for comparing resource supplies and requirements. No single model appears to be sufficient for all such resource evaluation purposes. Let me suggest two quite different types of resource supply-requirement analyses for which different models appear to be required.

On the one hand, we need comparatively short-term analyses of supplies of, and requirements for, survival items on a fairly detailed product and geographic basis, to support the immediate responses to nuclear attack on the United States. During the initial post-attack period, each area may be dependent upon locally available supplies, either because transportation may not be available from areas in which surpluses exist or because planned mechanisms for transferring surpluses in certain areas to cover deficits in others have not yet become effective. As time passes and as regional and national control systems become more effective, supply-requirement analyses for increasingly larger areas become appropriate and meaningful.

For long-term resource management problems, and especially for problems which involve the economic recovery of the entire country, the supply-requirements analysis is not so much concerned with local balances as with national balances. Moreover, it is concerned, not simply with production of survival items, but with all goods required for operation of the economy. It must take into account the interdependencies among industries and total supply-requirement balances.

Survival Items Analysis

To meet the first of these two types of requirements for supply-requirements analyses, NREC developed an analytical model called SURVIVAL.* A schematic representation of this model is presented in the first of the two charts. There are many parts to the analytical process and the way in which they fit together is moderately complex. But if we follow through the analytical process step-by-step the whole system turns out to be fairly simple.

But, first, a few words about the symbology of the diagrams. The analytical processes are identified in rectangular boxes. The inputs are on magnetic tape, as their circular labels suggest. Some of the outputs which become inputs for succeeding processes also are on magnetic tape. The final output is printed on paper which is suggested by rectangles with a ragged lower edge.

In the first analytical step in the operation of the NREC SURVIVAL model, estimates are computed for various classes of casualties, by cause and severity of injury (as calculated in the NREC casualty model)** and also health experience factors (that is, dying rates for fatal casualties and recovery rates for the various classes of non-fatal casualties) are applied in the casualty time-phasing computation. Thus, the surviving population is distributed among eight health categories, during each of five post-attack time periods in each state and region and in the nation as a whole. To the resulting time-phased distribution of survivors are applied per capita requirements of persons in each health category for each type of survival item. In this computation, the computer builds up a statement of total requirements. The requirements side of the picture is completed when these item requirements are summarized by area and time period.

The survival analysis now moves into the evaluation of the supply side of the problem. First, the analysis considers inventories. The NREC damage assessment model** has provided an evaluation on a plant-by-plant basis of the post-attack status of inventories in each class of survival items. These estimates, together with resource availability assumptions -- that is, assumptions as to how soon inventories which have been subjected to various ranges of blast and radioactive contamination will be available for use -- are used in making a time-phased estimate of available inventories.

Next, the SURVIVAL model considers the question of what quantities of each type of survival item can be expected from production during each time period in each area. Here, the problem is quite a bit more complicated. The SURVIVAL model does not consider all the complexities involved. It does, however, make a simple check to determine whether production will be limited by the availability of plant capacity or by the availability of manpower.

The controlling limitation is used in estimating time-phased supplies available from production. These are added to supplies freed from blast and radiation "frozen" inventories, in the development of total time-phased supply estimates.

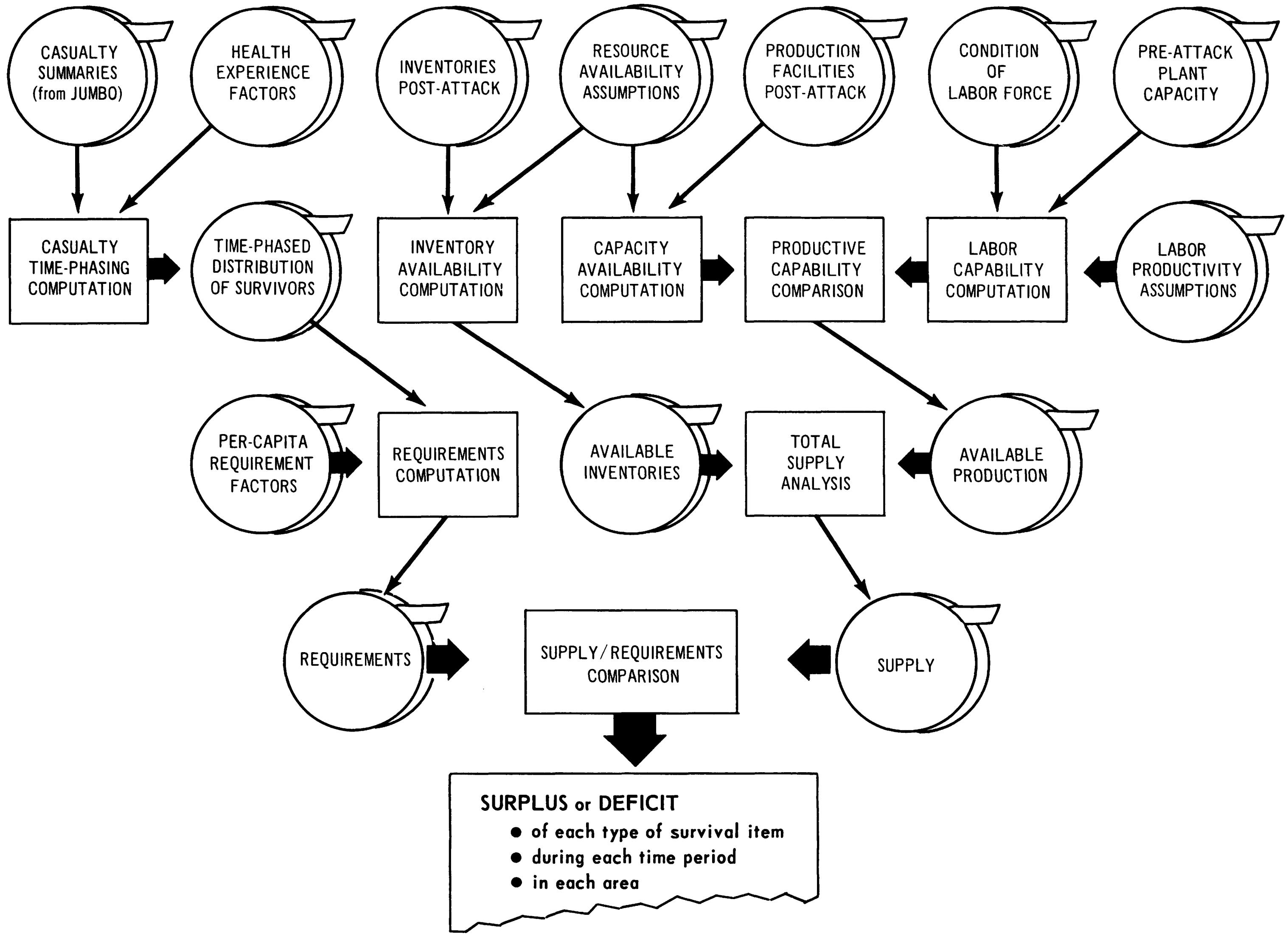
Now the SURVIVAL model is ready for its final operation -- the comparison of requirements and supplies and the printing, for use by analysts and decision makers, of estimates of surpluses or deficits, item by item, period by period, and area by area. In this fashion, it would provide -- very early in a post-attack situation -- the first rough basis for coordinating and guiding national and regional responses to survival resource imbalances. But this type of survival item analysis during pre-attack periods can also provide a rational basis for decisions on stockpiling survival items, and for pre-attack preparations for controlling, conserving, producing, allocating, transporting, and distributing critical survival items under various emergency contingencies.

What can be said in the way of summary appraisal of the SURVIVAL model? It is fairly versatile and sophisticated in some respects but it affords only superficial consideration of vertical supply problems. By vertical supply

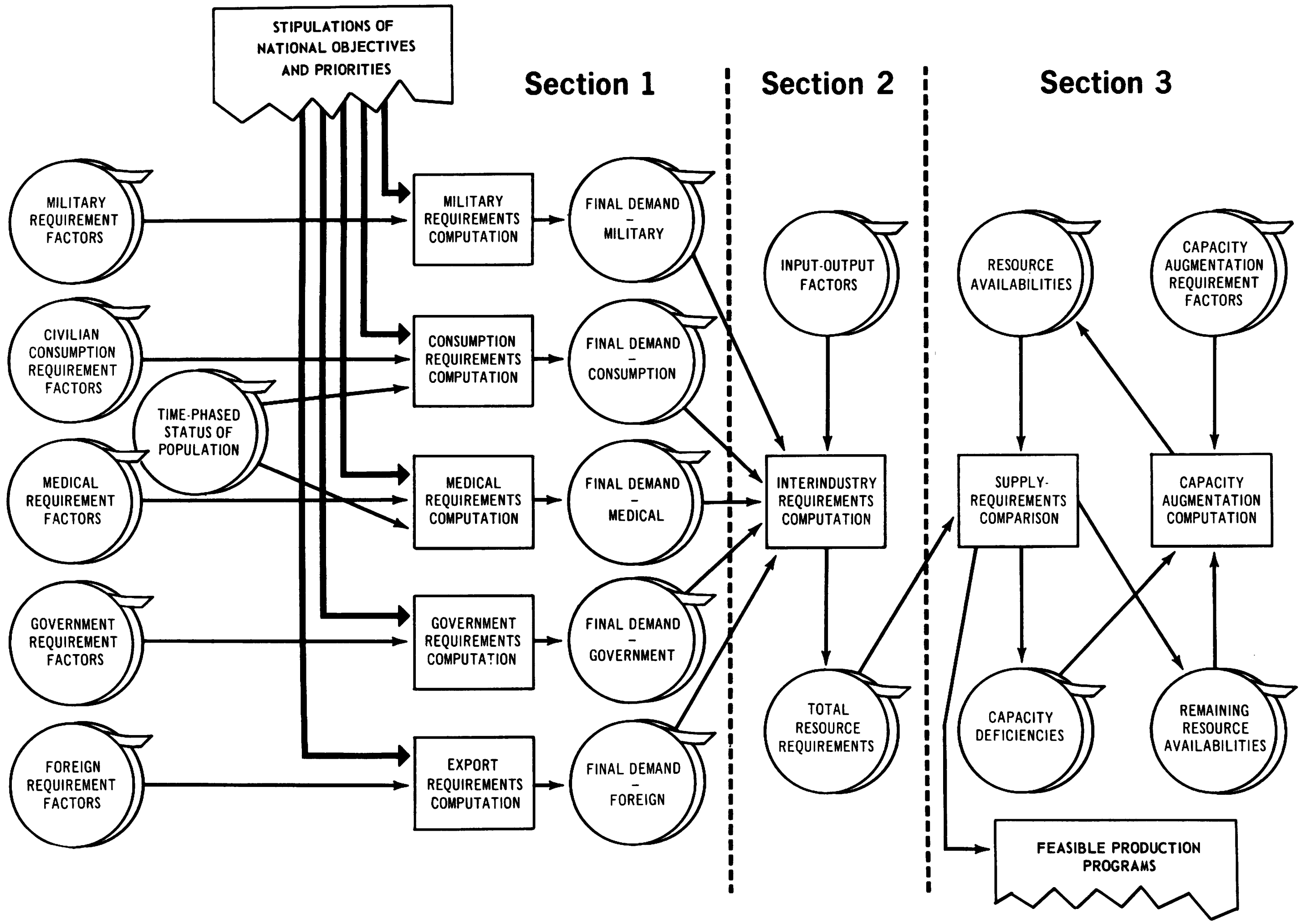
* Survival Item Analysis Program, NREC Technical Report No. 4 (Rev.), Nov. 1960

** Ready I (Third Draft), NREC Technical Report No. 24, July 1963

THE SURVIVAL MODEL



The PARM Model



problems, we mean difficulties which may arise in securing the various inputs required in production of survival items.

The superficial consideration afforded by the SURVIVAL model to these problems is simply that the model offers a choice of estimating production on the basis of either the assumption that there will be a continuing supply of all necessary inputs or the assumption that total post-attack production will be limited by the recorded pre-attack inventory of inputs. The SURVIVAL model makes no analysis of the availability of necessary inputs.

The principal strength of the SURVIVAL model is its power to examine product detail and geographic detail. Its principal weakness is the superficiality of its vertical analysis, that is, its lack of depth in the analysis of the availability of inputs required for production.

It is obvious from even this cursory description of the model that its operation depends upon a very extensive program of data development and derivation. Roughly 100,000 resource records are used in the SURVIVAL model. These include data on inventories, capacity, production and production "runout" (which means production achievable without replenishing plant supplies of input materials). Data for these survival item records were collected by the Census Bureau in consultation with the Business and Defense Services Administration of the Commerce Department, and the Departments of Interior and Health, Education and Welfare. The survival requirement factors were deduced by specialists in those departments from pertinent statistical records developed in their own statistical programs. The important manpower productivity factors used in SURVIVAL were developed by the Bureau of Labor Statistics.

Long-Range Problems of Recovery

Now we shall turn abruptly from survival resource problems to the consideration of recovery management tasks, which demand a very different time dimension and perspective in supporting analyses. In the short-term and primarily local analysis of supply-requirement balances for individual survival items, it is not necessary to give extensive consideration to the vertical and time-phased constraints that may be imposed upon resources used in production. But for long-range problems of recovery management program feasibility must be tested on a total, integrated economy basis, with full consideration of vertical interindustry relationships.

Realistic analysis of these long-term recovery problems calls for a dynamic economic model which will simulate the operation of an entire national economy -- with primary attention focused on the interdependencies and associated lead times between each industrial and service component of the economy and all others at each stage of production. Such a model must consider not only all the direct requirements for finished products; it must be able to compute the indirect requirements for all the resources required for production of such finished products; and it must determine when each increment of all these resources are needed in the production process. Finally, it must compare these total, time-phased resource requirements with time-phased resource availabilities.

The formulation of such an analytical requirement by NREC led to the development (under a research contract with the National Planning Association) of an economic model called PARM. The letters PARM stand for Program Analysis for Resource Management. PARM may be described as a dynamic analytical model, or system of analytical models capable of tracing the time-phased effects on the economy of various emergency situations over a two-year period. PARM can be used to simulate the effects on the economy of either real or hypothetical courses of action by changing data inputs and various conditions of the model. A highly simplified schematic representation of the model is presented in the second chart. PARM projects the impact of proposed programs, endeavors to "break" bottlenecks which would occur if preventive action is not taken, identifies those requiring intervention of program managers, and then spells out the impacts of alternative courses which they choose.

From the analyst's standpoint, there are three major sections of the PARM system. These three sections develop explicitly the economic programs to be tested, generate detailed requirements, and then compare requirements with availabilities under a variety of postattack conditions and adjustments.

The first section of PARM is concerned with developing detailed statements of final demand which are consistent with national objectives and priorities. It also converts them into the form necessary for evaluation by the model. These programs are developed separately for civilian consumers, military requirements, other governmental operations, and foreign trade on a month-by-month basis for a two-year period. A military requirements submodel generates detailed statement of requirements for military materiel on the basis of generalized statements of requirements.* A civilian consumption submodel automatically generates detailed and internally consistent estimates of requirements for surviving consumers based upon numbers of survivors and general stipulations. A medical submodel generates estimates of demand for emergency hospital and medical care by comparing time-phased casualties with surviving doctors and hospital beds and general stipulations. A government submodel estimates the detailed requirements of government operations based upon general decisions as to which agencies and functions would be emphasized. Routines also exist for introducing stipulated foreign trade programs and for estimating their resource requirements.

The second section of the model is an interindustry model -- that is, a model that examines simultaneously the input relationships or requirements among all industries and related services. These requirements are expressed as simple equations. Each industry is represented by an equation which defines the quantities of inputs required from other industries to produce one unit of its output. Through simultaneous solution of these equations an interindustry model determines the production necessary in all the supporting industries to achieve the finished products called for by the programs being tested. Throughout this process and in the section to follow, PARM takes account of all lead-time considerations.

The third, and most important, section of PARM automatically compares the specific program requirements with resource availabilities. This section of the PARM system also includes a variety of submodels and routines designed to simulate postattack conditions and decisions. The initial requirements are balanced against available stocks and are reduced to the extent that these can be met by stocks. Labor force casualties and constraints are computed for each plant or resource point. If available capacity exceeds the extent to which it can be operated by available labor, it is reduced to an effective capacity level. If capacity rather than labor is a bottleneck, then the model will automatically specify the additional capacity required. Also, the model will compute the requirements on other industries for this capacity augmentation and, if the necessary resources are available, the model will proceed under the assumption that the augmentation will be made. In computing the resource requirements of capacity augmentation the model will consider, in order, requirements for conversion of similar plants, decontamination of plants that are unavailable because of fallout, repair of damaged facilities, and finally through construction of new plant. The model keeps a running account of requirements and supplies by source. Finally, it compares these totals to determine the ultimate feasibility of achieving -- time-period by time-period -- production sufficient to meet stipulated requirements.

Against this very general account of the PARM structure, let me say a few words about the data now at hand for operating the system.

The PARM model in its prototype form makes use of approximately 100,000 resource records. Individually, these are less detailed than those developed for survival item analysis. But as a group they are much more comprehensive. The PARM simulation of our economy requires representation of all its significant components. The PARM resource file is therefore drawn from the basic NREC Resource Library, which is an integration of data carefully siphoned from numerous statistical collection streams. These resource data are reasonably current and are subject to ambitious improvement programs in which many governmental and private institutions are participating.

In addition to resource records the PARM system needs a very extensive collection of input-output coefficients and a large series of requirement factors. The PARM interindustry factor file is composed of some 94,000 input-output factors which describe requirements in both production and capital-formation processes. These coefficients have been deduced from many collections of data. These include industrial and capital coefficients derived from the Census of Manufactures and the Census of Business; manpower relationships developed from records of the Bureau of Labor Statistics; construction inputs from the Corps of Engineers and data from the Defense Department, AEC and NASA concerning military end-items, nuclear and space age activities. In far too many cases these input-output factors as now constituted are outdated. These will soon be replaced, however, by factors deduced through multiple regression analyses of data collected in recent economic census operations. PARM requirement factors representing the various elements of final demand also have been drawn and deduced from numerous source materials. These factors have been the subject of extensive cooperative research but are still subject to much further refinement. Elaborate documentation is now available on the data development aspects of the PARM system. Work continues in these areas with the active cooperation of several Federal agencies.

* This submodel is incomplete. It lacks military requirement factor details.

Let me conclude these remarks on the data problems and prospects associated with our PARM project by reference to the use of such resource management models in a real emergency. In a post-attack situation, we would face a massive task of data acquisition and reduction as soon as field survey activities commence. This information flow problem would continue throughout the recovery period. In order to minimize communication loads as well as data processing tasks, it would be necessary to use new and improved statistical procedures of many kinds. For example, various sampling techniques may provide feasible means for rapid updating of resource inventory records and for monitoring program performance. These statistical aspects of readiness for such a contingency pose many challenges and opportunities for the inquiring and innovating statistician.

Summary and Conclusion

We have reviewed briefly some of the analytical processes that are prerequisite to national resource management in an emergency. We have reviewed still more superficially some of the voluminous arrays of statistical data upon which these analytical processes depend. The job of selecting, adapting, and organizing the necessary statistics is often tedious. The realistic clarification of concepts and logical relationships which must be achieved in model formulation is often a painful process. But once the rigorous demands of mathematical model-building have been met and a complete system of computer instructions and input data are ready, the analyst and the decision-maker have at their service truly unprecedented capabilities for the orderly anticipation of experience and the testing of plans and programs. Through the sophisticated and discriminating application of statistics, these analytical systems can provide powerful tools for the management of resources in any emergency.