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ANALYSIS OF THE U. S. AND USSR POTENTIAL FOR ECONOMIC RECOVERY FOLLOWING A NUCLEAR ATTACK

F. W. Dresch, et al

Stanford Research Institute

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By: F. W. DRESCH
S. BAUM

Prepared for:

OFFICE, CHIEF OF RESEARCH AND DEVELOPMENT
UNITED STATES ARMY
WASHINGTON, D.C. 20310

Under direction of:

OFFICE, DEPUTY CHIEF OF STAFF FOR MILITARY OPERATIONS
UNITED STATES ARMY
WASHINGTON, D.C. 20310

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The results show consistent paths for economic recovery and provide plausible schedules for allocation of postattack investment among sectors. Variations in the size of the attack and postattack austerity (imposed by policy stipulated constraints on personal consumption and government expenditures) displace recovery schedules up or down without significant distortion. Recovery to preattack levels of GNP requires up to a decade after heavy attacks, but such preliminary results should be taken with caution until verified by more refined, less aggregated analyses.

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R. B. FOSTER, *Director*
Strategic Studies Center

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DISCLAIMER

CONTRACTUAL TASK

This technical note is in partial fulfillment of Task Order 72-4 under Contract DAHC19-71-C-0001. The report presents final research findings relating to a specific research object of Task Order 72-4.

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FOREWORD

A central issue in the comparative analysis of the ability of the U.S. and USSR to survive and recover from nuclear attack is the recovery potential inherent in the geographical distribution of their economic resources. Estimates of damage levels to population and industry provide inputs to strategic analysis but the long run economic consequences of direct effects of an attack are poorly understood. This Technical Note describes an approach developed to assess the possibilities for economic recovery under alternative circumstances and policies.

The existence of a U.S. resource location data base developed in connection with earlier National Entity Survival Studies has made it possible to apply the methodology to an analysis of U.S. recovery potential. Although limitations in available unclassified resource location data has precluded an analysis of the USSR economic recovery potential comparable to the U.S. analysis, methodology has been applied to estimate Soviet growth following assumed levels of damage to the major sectors of the Soviet economy.

This study is built on earlier work of the Strategic Studies Center, some by the present authors, relating to problems of postattack recovery including research performed for the Office of Emergency Preparedness, the Office of Civil Defense and the Arms Control and Disarmament Agency. This analysis has been conducted as part of the Strategic Studies Center's Economics and Program Analysis/Costing Program headed by M. Mark Earle, Jr. General concepts for the recovery models were developed by Francis Dresch. Adaptation of the concepts was made in collaboration with Sanford Baum who also carried the computer implementation of the model and designed the attacks. Ben Suta and John Ryan contributed to both attack design and the formulation of economic inputs.

Richard B. Foster
Director
Strategic Studies Center

I INTRODUCTION

A. Background

Analysis of deterrence, damage limiting options and other strategic alternatives have stimulated efforts to give quantitative meanings to such qualitative terms as assured destruction, mutually assured survival and acceptable or unacceptable damage. The measurement criteria usually employed have been based on the percentage of military force strength, population or economic capacity that could be expected to survive any specified nuclear exchange. Criteria of this sort essentially describe situations at some particular point after the attack without providing any information about the longer run consequences of the damage levels sustained. The purpose of this study is to advance the rationale underlying the static criteria by relating them to more dynamic measures of recovery potential.

It is tempting to try to relate such extreme terms as assured destruction or unacceptable damage to the loss of economic viability, that is, to equate such terms with levels of damage sufficient to preclude entirely any hope for postattack economic recovery. Studies of vulnerability to nuclear attack have frequently been directed towards establishing such limits on societal viability but none of these attempts have been successful.

Because recovery would involve a complex process, it has been difficult to quantify such viability limits in any meaningful way. In fact, it is difficult even to conceive of an economic situation that could be termed nonviable in the sense that continued deterioration would be inexorable and irreversible. Severe damage, or severe imbalance between surviving population and industrial capacity or among industry sectors and geographical subdivisions of the economy, could each result in situations which would fail to support adequately all of the surviving population. Even in such extreme cases, however, a point would almost certainly be reached at which industrial potential did suffice to support the then surviving population with at least some slight capacity for investment in regeneration. It is thus more relevant to raise questions about possible recovery rates than about viability.

Two superficially different but inextricably related concepts suggest themselves for relating the nature and severity of attack damage to recovery potential. On the one hand, one could attempt to estimate, for a variety or range of conceivable damage situations, the time that might be required to meet specific recovery objectives. On the other hand, one could attempt to estimate, again as a function of damage parameters, the progress that could be achieved in a specified time toward various specified recovery goals. In practice, however, the same type of estimating problem is involved under either concept. What is required is a method of estimating the general characteristics, and some details, of postattack economic growth under environmental and other socially imposed constraints and toward normal economic objectives. What is required is simply a theory or model of economic growth capable of accommodating unusual constraints and conditions of extreme economic imbalance. A fully persuasive model would be applicable to any study of economic growth, but the gross imbalances created by nuclear attack present extra difficulties.

B. Objective

The objective of this study has been to develop a model of recovery that would permit repeated application to a wide variety of postattack situations to yield plausible projections of the path of recovery under alternative stipulations of investment policy. A primary consideration has been to keep the model as simple as possible without sacrificing its ability to accommodate and reflect differences between recovery from postattack situations and more balanced economic growth under normal economic conditions.

C. The Attack Model

The attack model uses a simple relation between the number of weapons delivered to a SMSA (Standard Metropolitan Statistical Area in the sense used in Census publications for the U.S. and a similar urban complex for the Soviet Union) and the resulting damage to entities at risk within that target. The entities at risk include population, and the productive capacity for the various economic sectors involved.

The weapon assignments considered are all directed against SMSA targets. No counterforce options are considered and the damage model does not readily provide estimates of collateral damage to urban targets from counterforce attacks. Fallout effects are not incorporated in the damage model. It is further assumed that all targets are undefended.

Different attacks vary in total level (i.e., the number of weapons assigned to all targets) and in the allocation of these weapons to different targets. Actually attack levels have been varied in increments of 250 weapons from 250 to 1250 and total damage cumulated over all targets for each entity (or economic sector) attacked with the targets ranked according to the value of some particular entity (the attack objective) present in each target.

Damage levels attributed to the various sector capacities are shown in Appendix C for all attack levels. The damage model has been used only to provide estimates of surviving capacity as inputs to the economic recovery model and has been run independently of the latter. Any other source of inputs to the economic model, that is, of estimates of surviving capacity could be used for the economic recovery runs.

D. A One Variable Economic Recovery Model

As any student of economic development in underdeveloped countries will attest, the problem of developing an adequate model can be extremely complex even if one abandons hope of getting optimal growth and settles for a very broad picture of the growth or recovery process. To illustrate some of the difficulties as well as some of the general characteristics of economic growth it is convenient to consider first some greatly oversimplified models.

In the simplest conceivable description, growth may be described entirely in terms of GNP, distinguishing only two types of end use, namely, gross investment and all other uses which can be referred to as consumption. The investment will be assumed to buy increased capacity (capacity measured by the increase in GNP it can be used to produce). An important parameter is simply the amount that must be invested to produce a billion dollar increase in GNP <u>per annum</u>. Of course, the required investment per billion in increased output varies greatly with industry, but for the simplest model a grand average value is needed. Empirically, it happens that reliable estimates for such an average are difficult to obtain, but suppose that $1.5 billion (a plausible value) in investment is required to increase GNP by $1.0 billion. The increase in GNP would thus be about two-thirds of the amount invested a year or so in the past, say two years ago, if allowance is made for the time lag required before current investment can be carried to completion and new plants and equipment put into operation. This could constitute a growth model with GNP as the only endogenous variable (that is, the only variable determined within the model) but with investment exogenous (that is, to be specified outside the model subject only to the constraint that it be less than GNP). In this simple model, the growth in GNP would be entirely determined by the stipulated path (time series) followed by investment.

If the investment schedule were made endogenous, for example, by merely assuming that a fixed percentage of GNP is set aside for investment each year, the model would become entirely deterministic, dependent only on starting values for GNP and on the values assumed for three parameters:

1) k, the $1.50 investment cost per dollar of GNP;
2) f, the fraction of GNP invested, historically between a sixth and a seventh except during wartime and the Great Depression; and
3) the lag assumed for plant construction times.

If the lag assumed for 3) were one year, only one initial value for GNP would be needed. If a more realistic two year lag were assumed, two initial (that is, two consecutive) values for GNP would be required to fully determine growth.

Among the very many economic details ignored thus far in this model, an important omission relates to the fact that plants and equipment must be repaired and eventually replaced. If we assume that equipment has an average life of five to ten years and facilities have an average life of forty years, depreciation and obsolescence effects could be approximated by assuming an average life of twenty years or an annual depreciation rate of 5%. Incorporating this into the simple deterministic model provides a plausible model of economic growth that is roughly correct historically and might equally apply to postattack conditions. To sum it up, it assumes that the increase in GNP for any year is equal to one-ninth of GNP two years prior (corresponding to the increment purchased by investing one-sixth of the GNP two years prior) less 5% of last year's GNP (correponding to a loss of capacity due to capital depreciation and obsolescence). This model is fully deterministic and, given two initial values, traces out the predicted course of GNP thereafter. The parameter values cited above suffice to impose a constant growth rate of about 3% per year on the economy. Actually, only two parameters need be specified since the model uses only the ratio of 2) divided by 1) or the one-ninth mentioned above.

This model could thus be fitted to historical data to possibly improve on the assigned parameter values: 5% depreciation and the best fitting value of the parameter ratio $\frac{f}{k}$ assumed to be one-ninth. In practice, a wide range of combinations of values fit about equally well, all lying along a curve relating the depreciation rate to the parameter ratio $\frac{f}{k}$. The best combination turns out to be economically meaningless (giving a negative depreciation rate) but the fits to the data over the last 40 years are all relatively poor because of the effect of three military conflicts, a major depression and other cyclical phenomena. The values cited are in the plausible range and give a reasonable fit to the historical growth. Underutilization of capacity, changes in the size of the labor force and in unemployment introduce effects neglected in this simple growth model.

The difference between GNP and investment is regarded as consumption in the very broad sense. It includes personal consumption expenditures, government expenditures including defense, net exports and inventory change--that is, all final demand not included in gross private domestic investment. Except for defense it tends to increase with population and with the standard of living. Historically, it has risen steadily since 1940 on a per capita basis except for a slight decrease during the period 1946-1950. Since 1952 it has been rising steadily.

The fraction of U.S. GNP invested results from:

1) the actions of business leaders in using internal funds (the undistributed surplus, from profits withheld from dividend distributions, or from depreciation reserves) for investment;
2) their ability to increase bonded indebtedness and to borrow in other capital markets, and
3) the consumption and savings behavior of the general public.

In this the U.S. economy differs from planned economies such as the USSR for which investment levels (and their allocations) are centrally decided. In a postattack economy, some degree of central control over investment will undoubtedly occur as it has in the U.S. during World War II and the Korean conflict. Although the methods of control (e.g., rapid amortization allowances with certificates of necessity) were different from the direct controls in the Soviet Union, the U.S. Government has influenced the levels and allocation of investment in the U.S. The more elaborate postattack model described below thus assumes that the level of investment (and hence the per capita consumption) will be stipulated exogenously with no simple relation to the level of GNP, at least for an initial emergency recovery period usually taken to be five years.

E. The Economic Recovery Model Used

In the model used, the economy has been described as composed of from 7 to 16 sectors corresponding to major aggregates of the Standard Industrial Classification codes (SIC codes), or alternatively of the sectors identified in U.S. Department of Commerce/Bureau of Economic Analysis (BEA) input-output (I-O) tables or in BEA's National Income and Product Accounts (NIA). Although differences exist among the various schemes of industry classification, these have no significant effect on the sectors because of the gross aggregation involved in all cases.

Final demand for the model is divided into consumption requirements computed on a per capita basis and investment (defined to correspond to gross domestic private capital formation as used in the NIA and I-O tables). The model attempts to use surviving capacity (limited by interindustry requirements for and availability of intermediate products) as much as possible to meet stipulated consumption levels and to allocate investment in the respective sectors in such a way that the stream of GNP into the indefinite future is as great as possible. Many parameters are involved in this model but only a few require variation from experiment to experiment, since a number of these are derived from official sources (e.g., the I-O tables used) or historical series. Variable parameters are the levels of consumption permitted (and required of the economy) in each of the first five to nine postattack years, and a single growth rate applicable thereafter. Capacity purchased during any year is assumed to be available for production two years later. The objective function to be maximized is generally the present value of the future stream of GNP, i.e., for year D+1, D+2, --D+5, D+H where H is the length of the planning period, and a stream growing at a fixed percentage rate of increase from D+H on into the future. Capacity available in any year for each sector is that available the preceding year less 5% covering a depreciation or replacement loss plus any purchased two years prior. The model starts with the capacity for each sector that has survived attack and proceeds to invest as much as possible each year, allocating this total to the various sectors in an optimal fashion.

The recovery rates obtained depend very significantly on the value of k (investment cost per dollar of incremental GNP) assumed to be appropriate and the consumption levels stipulated. Chapter II summarizes the results obtained from a wide variety of attacks and attack objectives under a variety of stipulated consumption schedules. The detailed sector-by-sector and year-by-year allocations of investment are shown in the more extensive tables in Appendix D.

Initial experiments with this model were carried out in 1971 as discussed in informal note SSC-IN-71-79[1/], September 1971, covering methodology and data used as an input to STRATOP-83. These experiments used a 7 sector model and concerned only the U.S. In the experiments conducted during 1972 both the U.S. and the Soviet economies have been treated with a 15 sector model used for the U.S. and a 16 sector model used for the USSR. A five-year planning period has been used for most of the runs, but a few representative runs have been repeated for periods of seven and nine years. In the new set of runs, an additional constraint has been introduced to consider labor force availability.

Because of limited distribution of the informal note, the present report is designed to be self-contained. It thus repeats and updates the discussion of the models and also includes the results from the 7 sector model reported previously.

F. Assumptions Underlying the Model

The economic model assumes that the percentage loss of output (measured by value added contributed by each sector) due to the attack is a weighted geometric mean of the percentage loss of facilities and that of labor force (taken as proportional to population loss). This assumption is the so-called Cobb-Douglas production function hypothesis applied separately to each of the aggregated sectors considered.

1/ S. Baum, F. W. Dresch, "Analysis of Damage Level Measurement Criteria in Terms of Potential for Economic Recovery," SSC-IN-71-79, Stanford Research Institute, Menlo Park, California (September 1971).

Implicit in these classifications is the assumption that output from each sector is homogeneous and that one subordinate industry has capacity that can be substituted for that of any other subordinate industry in the same aggregated sector. This assumption exaggerates the possibilities for substitution within the economy and leads to overly optimistic recovery rates. A less aggregated model, say one of 400 sectors, in addition to being impractical for machine computation would probably underestimate opportunities for substitution and capacity conversion and would lead to overly pessimistic rates of recovery.

The recovery model assumes that the detailed bill of goods required for capacity augmentation is the same per dollar of investment for all alternatives regardless of the type of capacity required. It also assumes that the investment required per dollar of increased output is the same for all sectors. Either assumption could be relaxed if adequate data could be found permitting sector distinctions. The program has been designed to accommodate such inputs if they could be made available.

Finally, the recovery model treats the general level of investment as a policy variable, primarily by requiring a stipulation of the minimum amounts reserved for personal and governmental consumption, that is a stipulation of the complement of the maximum investment funding. For specific runs of the model, these stipulations of consumption levels have been made in such a way that minimum requirements are allowed to increase at a fixed rate of growth from the second year on through the five-year (seven or nine years for some runs) planning period. Requirements for the first and second year have been varied in different runs and set slightly below the highest level which permits a feasible solution. Slightly higher levels would greatly reduce possible investments in the first and second year (the second year is most critical) postattack, and still higher levels of consumption would eliminate investment possibilities and thus recovery (in the sense described above) altogether. The sensitivity of recovery rates to investment levels has been well illustrated in the runs reported.

G. Applicability to Strategic Planning

The models developed provide tools for studying time phased economic effects of alternative selections of attack options and attack size as well as alternative recovery policies. Among the attack options are imbalancing attacks against one or more economic sectors and counter-population and countervalue attacks of broader scope. Counterforce attacks have not been considered and no fallout has been included. If a counterforce mission were involved, the attack model would require superposition of the separate effects of collateral damage to a few SMSA's from the counterforce mission and a reassignment of countervalue weapons to SMSA targets to maximize effects against SMSA's in the conditions in which they would survive the counterforce action. Moreover, the counterforce option is more likely to involve ground bursts with attendant fallout problems.

Effects of fallout have not been considered in this study. Fallout would affect the results obtained in at least five ways, by

1. Increasing the number of casualties and fatalities
2. Restricting the availability of labor force because of hazards and cumulated radiation doses of surviving workers
3. Delaying access to and utilization of facilities pending decontamination
4. Diverting some labor force and equipment to debris clearance and decontamination
5. Delaying or impeding intersectoral flows of materials and intermediates because of increased impediments to freight movement.

Studies of fallout[1/] indicate that most of the denial of facilities would persist only for three to six months in the absence of decontamination efforts and for lesser periods otherwise. In general, such effects

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1/ For example, see "Denial of Industrial Production Due to Fallout Following Nuclear Attack," by H. Lee, W. L. Owen, and O. Yu, Stanford Research Institute, TN-RMR-41, May 1968.

could substantially depress the level of output and force lower allowances for noninvestment demand during the first year and defer most investment to the second year. The increased number of casualties would put special pressures on limited medical facilities but these are not explicitly considered in the aggregated versions of the models used.

Denial of facilities during the first postattack year could drastically curtail investment and, with the two year lag built into the recovery model, would lower output during the third year. The second year, however, should be almost unaffected. The effects of fallout could possibly extend to later years because of secondary effects on investment but because the direct fallout effects are transitory, the initial displacement of the recovery schedule by fallout should dampen out rapidly.

The degree of initial displacement is difficult to estimate because of possible mismatches between skills and radiation doses. Previous studies[1/] indicate that achieving maximum potential postattack output during the first year could require considerable movement of labor force from areas where plant facilities are denied by fallout to areas where facilities are accessible.

The structure of the models is such that the attack model and the recovery model can be decoupled; each can be run without the other. The economic model requires as inputs information on surviving population and plant capacity. These inputs are usually derived from the results of the attack model but acceptable from any other source. The recovery model could thus be used to analyze the economic consequences of any stipulated pattern of population and capacity loss. The recovery model ignores geographical detail, however, and is not capable of treating effects of transportation bottlenecks, isolation of particular regions or mismatches in the distribution of surviving population and plant capacity.

1/ *Ibid*.

The basic interaction of the models can perhaps be better visualized from the block diagrams of Figures I-1 and I-2. Figure I-1 shows the inputs to and outputs from the attack model. The computer program is shown merely as a black box which assigns incremental weapons to SMSA's to maximize the damage achieved as measured by the specified attack objective. Figure I-2 shows the inputs to and outputs from the receovery model. The main computer program is again shown merely as a black box. This program uses linear programming to allocate investment among economic sectors to maximize a specified objective function. The objective function has usually been taken to be the present value of the future stream of GNP. This means that GNP in future years is given lesser weight than GNP in the present with the weight assigned each year decreasing by a fixed percentage. In the runs carried out, the weight assigned each successive year is 90 percent of that for the preceding year. Although the model thus looks ahead to the distant future, with this high rate of discount (rapid decrease in weights) appropriate for emergency conditions, future GNP's have diminishing effect. The GNP for the tenth postattack year is given only about one third of the weight of that for the first postattack year; the GNP for the twentieth year is given only about one ninth the weight of the first year. This discounting combines some allowance for increasing uncertainty about future conditions with an allowance for the natural rate of interest traditional in analysis of deferred income, for example as in insurance or annuity contracts or in calculations of anticipated rate of return on long lived capital investments.

Three objective function options have been used (1) the present value of all future GNP, (2) a hybrid function which counts investment during all but the last year of the planning period and ignores investment thereafter and (3) the present value of all future noninvestment demand satisfied.

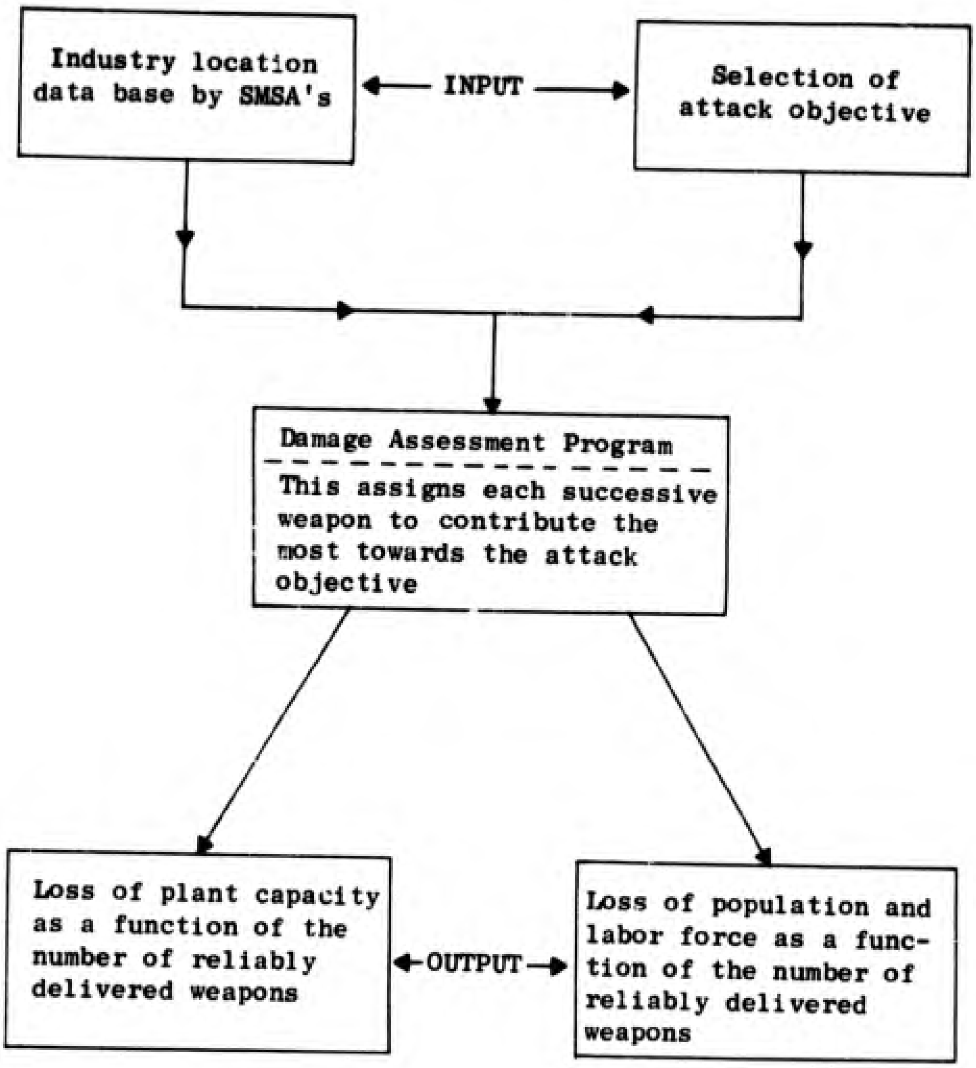

Figure I-2 Block Diagram for the Recovery Model

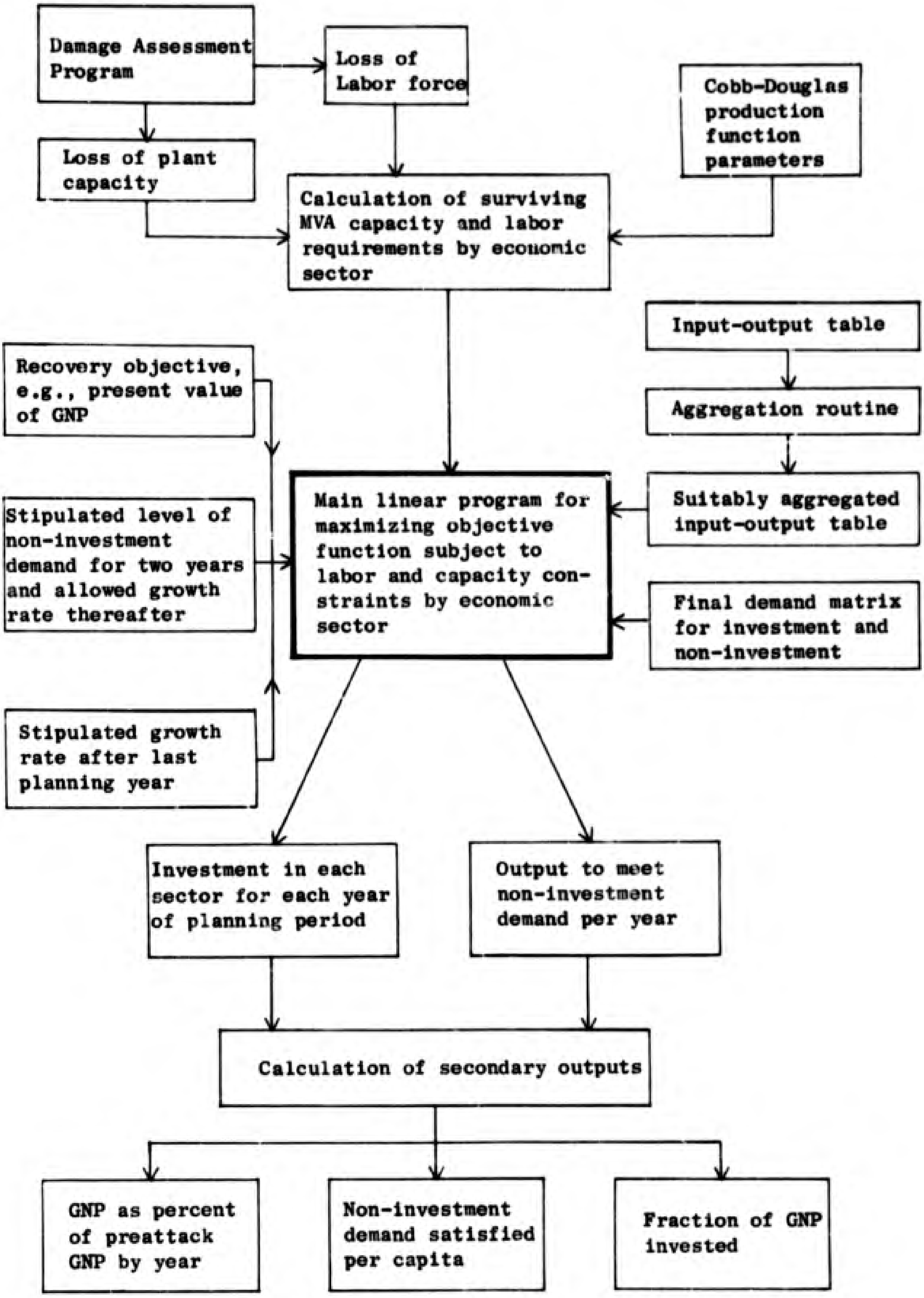

Figure I-1 Block Diagram for the Attack Model

Because the third objective function considers only the present value of noninvestment demand satisfied, it treats investment merely as a long lived intermediate product rather than an end-product in its own right. It thus avoids a tendency of the first objective function to generate investment during the last year of the planning period in excess of long run requirements. The second or hybrid function also ignores investment in the long run but counts it into the objective function during a short run consisting of each year of the planning period except for the final year. The first function is that traditionally discussed in growth theory and paradoxically is perhaps the best reflection of Soviet policy with its emphasis on building up means of production. The third function is controversial but is a logical measure of long term economic growth and may best reflect Western growth policy with its emphasis on satisfaction of consumer needs. The hybrid function is merely a compromise between the other functions but it may best reflect the policy objectives of postattack recovery planning agencies. All objectives give rather similar results except for cases of imbalancing attacks and for the short five-year planning periods for which the first function led to excessive investment in the fifth year. An alternative technical device for avoiding the over-investment problem peculiar to the recovery model is to require investment to be barely adequate to sustain the growth rate stipulated for the postplanning period.

Although the present versions of the models are capable of giving recovery schedules for periods up to ten years and would give a strategic planner time-phased projections of comparative recoveries, refinements of the models are required before these schedules could be used with any degree of confidence. Feasible refinements are discussed in section F of Chapter II. The present results indicate, however, that time-phased schedules are really required only for the first three years postattack, a period adequate to correct major attack induced imbalances and set the stage for balanced growth. On the other hand, a finer time interval, say one at half-year intervals is desirable along with an increase in the number of economic sectors. The recovery models could, however, be used over six half years and from twenty to thirty sectors to provide the planner with a tool for previewing the economic consequences of alternative attack and defense strategies and alternative austerity measures. Outputs would include detailed schedules for the critical early postattack period and a basis for estimating the potential rate of growth following that period.

As discussed in the preceding section and later in Chapters II and IV, the present versions of the recovery models ignore many institutional factors that could make it impossible to achieve the recovery rates projected. The simulations should therefore, be regarded as providing upper limits on potential recovery. Projected recovery rates should thus prove over optimistic when compared with rates actually realized in a real case.

II SUMMARY AND CONCLUSIONS

A. Objective and Approach

The objective of this study has been to develop and exhibit preliminary but plausible postattack recovery schedules for various levels of attack objectives. Such schedules and the recovery rates implied by them provide insight into the full significance of various levels of damage and a basis for criteria quantifying such terms as "unacceptable damage" or "assured destruction".

The approach followed in the preliminary study considers highly aggregated input-output models of the economy and a sequence of attacks of varying severity directed against certain aggregated sectors and other sequences directed against population or against total value added. One sector is composed of widely distributed activities for which location data are not available in the data bases and includes agriculture, forestry, fishing, mining, construction and utilities. The facilities supporting this diffuse sector have been treated as not at risk. One of the sectors is services, which has been treated as collocated with population.

The recovery model used allocates a stipulated portion of postattack GNP to sustaining essential government services, the defense effort and the surviving population. Final demands on the respective sectors for this purpose are taken to be proportional to peacetime usage or in some cases to an alternative vector presumed to be more representative of postattack demand. Final demand so generated is distinguished from final demand implied by investment decisions which are made endogenously within the model. The final demand derived from investment is proportional to the peacetime vector for gross fixed capital investment or in some cases to an alternative vector presumed to be more representative of postattack conditions. These vectors are used to convert total dollar investment into a final demand vector for investment. Finally, the various final demand vectors are multiplied by a matrix (aggregated from the latest available input-output tables) to convert final demand into value added, with allowance made for inter-industry requirements for materials and intermediates.

The recovery model makes the total investment level as large as possible within the constraints imposed by available capacity. Capacity available in any year is that available from the preceding year less an attrition of 4, 5 or 6 percent (for obsolescence or breakdown) plus any new capacity purchased by investments made two years prior. Two different values have been used for the expenditure required to increase capacity by one dollar's worth of value added. These values of $1.50 or $2.00 per dollar of incremental output are believed to bracket the correct average values, both for the U.S. and the USSR. The appropriate value is not well determined from historical peacetime data and moreover the higher value may prove more plausible for postattack conditions. The model allocates investment among the sectors for each of five years in such a way that a selected objective function is maximized, usually the discounted present value of the future stream of GNP, as described in section G, Chapter I.

A discount rate of 10% has been used throughout, reflecting a presumed high rate of time preference, that is a higher than normal preference for current output as compared to future output. This higher rate is more realistic for emergency conditions than the rates prevailing in the peace-time economy.

One flexible policy has been employed to determine the split of GNP between investment and noninvestment uses. It allows total noninvestment uses of GNP to rise at a stipulated rate of growth from the second year to the end of the planning period. Values of this growth rate between 4 and 10 percent have been used.

B. Results of the 1971 Runs

The recovery schedules obtained from the 1971 (7 sector) runs are summarized below and reported in further detail in Appendix D. For these the U.S. economy has been forced to stabilize at a constant rate of growth (usually 4% per year) by the end of the planning period. This growth rate applies to GNP, investment and noninvestment alike.

The attack on energy (actually petroleum refining) eliminated inputs for other sectors preventing them from fully utilizing their surviving capacity. Restoring capacity in energy by relatively modest investments during the first and second years relieved this shortage for D+3 and permitted a remarkable recovery. To a lesser extent, a similar situation arose in the case of the attack on basic metals (primary ferrous and non-ferrous metals). The latter effect is more readily seen in the heavy attack cases, for 500 or 1,000 weapons. In general, the aggregated nature of the other sectors tends to diminish the differences among the results of different attack objectives. The best illustration of the possible consequences of imbalancing attacks on early recovery are the energy and basic metals cases because these are the most specialized sectors among those recognized in the seven sector model.

The primary metals are less critical, but an attack of 1,250 weapons could constitute an imbalancing attack with rather unpredictable short term results. In both cases, the total amount of new investment needed to restore capacity proves to be a small fraction of the total postattack GNP, but even that would be hard to manage without drastic curtailment of personal consumption, military activity and other essential services. Again the uncertainties in all the models make the specifics of these extreme cases very unreliable but do serve to illustrate the gravity of the immediate postattack situation.

Most of the other sectors considered were very broad aggregates and did not exhibit such great differences between the average level of damage and that in the sector attacked.

For any given depreciation rate, the rate of recovery is more favorable for the $1.50 value for k than for the $2.00 value because new capacity is easier to buy at the lower price. In general, rate of recovery depends primarily on the difference between the fraction of GNP invested divided by k and the depreciation rate.

An alternative objective function based on optimizing the flow of consumable output yields only slightly less GNP than that maximizing GNP. The proportion between investment and consumables is drastically altered, however. A hybrid objective function which maximizes GNP reduced by subtracting investment during and after the final year of the planning period gives more realistic allocations among sectors. This is a technical result of the limitation to a fixed planning horizon. With longer base periods, this difference is greatly reduced and all the objective functions used give about the same result. The hybrid objective is useful for short runs in that it avoids stockpiling capacity in excess of that required for future consumption and allocates investment dollars more in proporation to long run requirements. These effects are partially in evidence in the detailed investment schedules presented in Appendix D.

Data from many other runs not exhibited in Appendix D further demonstrate the minor differences obtained from the use of alternative objective functions and the sensitivity of the models to assigned values of critical parameters.

Table II-1 summarizes the postattack GNP obtained from nine of the recovery runs for the U.S. using the seven sector model. These are described in further detail in Appendix D. Figure II-1 shows the data from three representative runs, 7-6, 7-7 and 7-8 in graphical form.

C. Results of 1972 Runs

Table II-2 shows the results from five different levels of attack using the 15 sector U.S. model and a nine-year planning period. Figure II-2 shows the data from the five runs in graphical form.

For the Soviet case, the lack of adequate location data dictated the use of an assumption of uniform damage across all 16 sectors. Table II-3 presents the results from two attack situations. Figure II-3 shows the data from these two runs in graphical form. For the heavy attack it

Table II-1

ILLUSTRATIVE RESULTS: ANALYSIS OF THE RELATIONSHIP OF SURVIVING CAPACITY VS RECOVERY RATE

(1971 Runs - Seven Sector Model)

Run and Attack Number[1/]	Major Parameters: Attack Level (No. of Weapons)[2/]	Major Parameters: Attack Objective	Major Parameters: Capital Cost per Dollar of Output	(Percent of Preattack GNP) Initial Noninvestment Demand	(Percent of Preattack GNP) Surviving Capacity GNP at D+0	Postattack GNP as a Percent of Preattack GNP (Year): One	Two	Three	Four	Five	Average Annual Growth for GNP - Year One to Year Five
7-1	250	energy	$1.50	20 %	85%	23.7%	21.6%	61.4%	70.6%	93.7%	41%[3/]
7-2	250	weighted composite	1.50	45	75	66.2	64.5	82.4	91.3	108.8	13
7-6	250	weighted composite	2.00	45	75	66.2	64.5	78.9	84.7	95.2	10
7-3	500	weighted composite	1.50	37.5	65	54.6	53.0	70.5	77.4	89.8	13
7-7	500	weighted composite	2.00	37.5	65	54.6	53.1	67.7	72.1	81.6	11
7-4	1000	weighted composite	1.50	30	55	43.0	40.7	58.0	62.2	75.9	15
7-5[4/]	1000	weighted composite	1.50	25	55	43.0	40.7	58.0	62.2	75.5	15
7-8	1000	weighted composite	2.00	30	55	43.0	40.7	55.8	58.4	66.7	12
7-9[4/]	1000	weighted composite	2.00	25	55	39.7	38.6	56.6	60.7	71.1	16

1/ Run number designation as indicated in Appendix D.
2/ Number of 1 MT weapons.
3/ The recovery rate is much higher for attack number 7-1 than any of the others, because once the petroleum refineries are rebuilt recovery to preattack GNP levels is very rapid.
4/ Lower initial consumption allocation than attack 7-8. The initial consumption program is assumed to be 1/6th less than in attack 7-8.

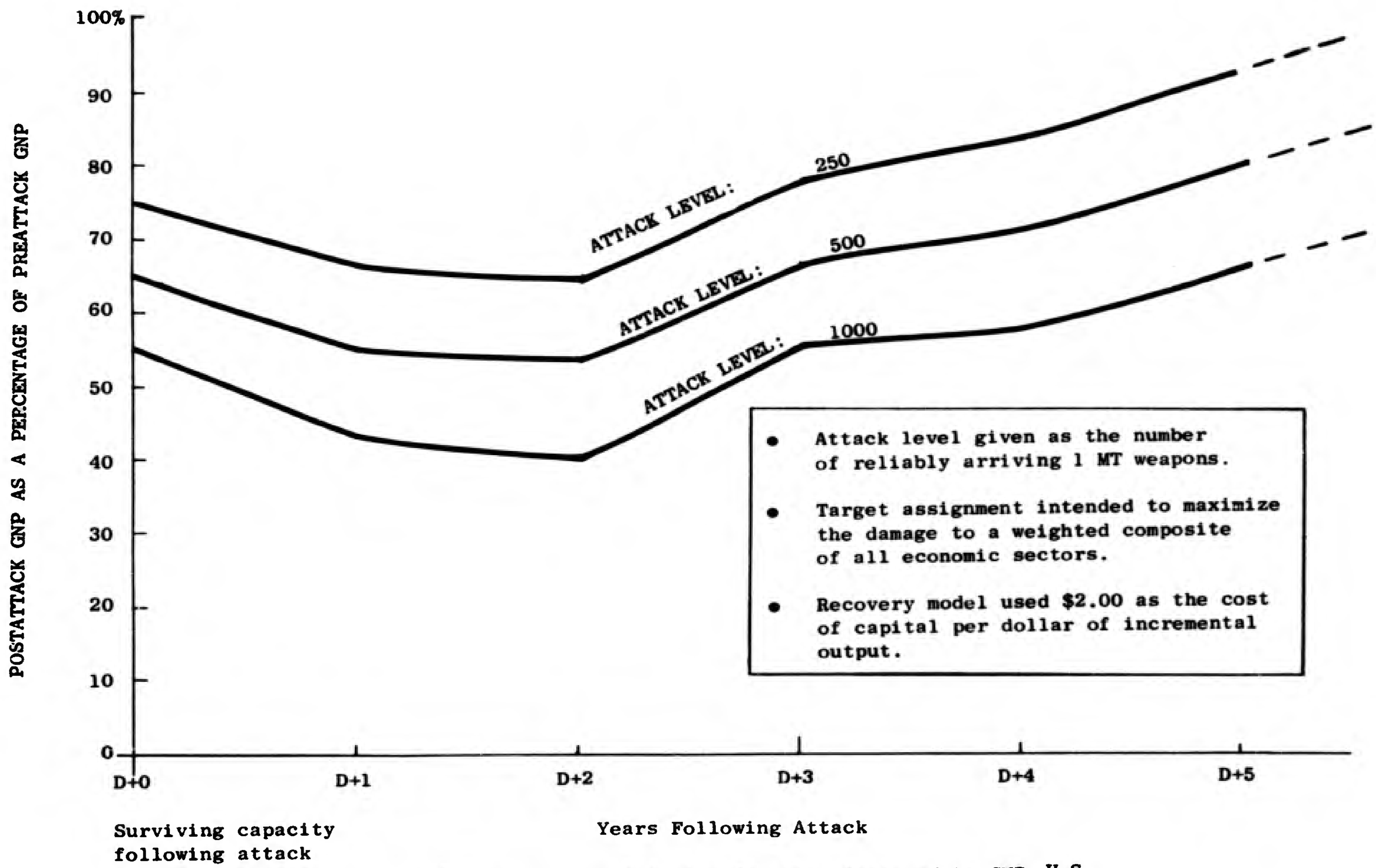

Figure II-1 Postattack Recovery Measured by GNP -U.S. (Seven Sector Model)

Table II-2

ILLUSTRATIVE RESULTS: ANALYSIS OF THE RELATIONSHIP OF SURVIVING CAPACITY VS RECOVERY RATE

(U.S. 1972 Runs with 15 Sector Model)

Run Number	Attack Level (No. of Weapons)	Surviving Capacity GNP at D+O (As a Percentage of Preattack GNP)	Initial Noninvestment Demand	Postattack GNP for Year: One	Two	Three	Four	Five	Six	Seven	Eight	Nine	Average Annual Growth of GNP: Years 1 - 5	Years 5 - 9
29-E	250	80.4%	54%	63.1%	60.8%	75.1%	74.4%	79.4%	82.7%	87.0%	91.6%	96.7%	5.9%	5.1%
29-D	500	72.1	47	53.1	51.3	65.0	64.8	69.0	71.9	75.6	79.5	84.0	6.8	5.0
29-C	750	67.0	43	47.8	46.1	58.2	58.3	62.6	64.7	67.9	71.0	74.6	7.0	4.5
29-B	1000	63.8	40	44.3	42.8	54.6	55.1	59.6	61.9	65.5	69.1	73.4	7.7	5.3
29-A	1250	61.6	39	42.8	41.3	52.2	52.0	56.7	58.2	61.2	63.8	66.8	7.3	4.2

Notes: Investment cost per dollar of incremental GNP was 2.0 for all runs.
The objective function used for optimization was the present value of the future stream of GNP.
The stipulated lower level for noninvestment was increased at the rate of four percent per year from year two to year nine.
The uniform growth rate from the ninth year on was set at four percent.
The depreciation rate was set at six percent.

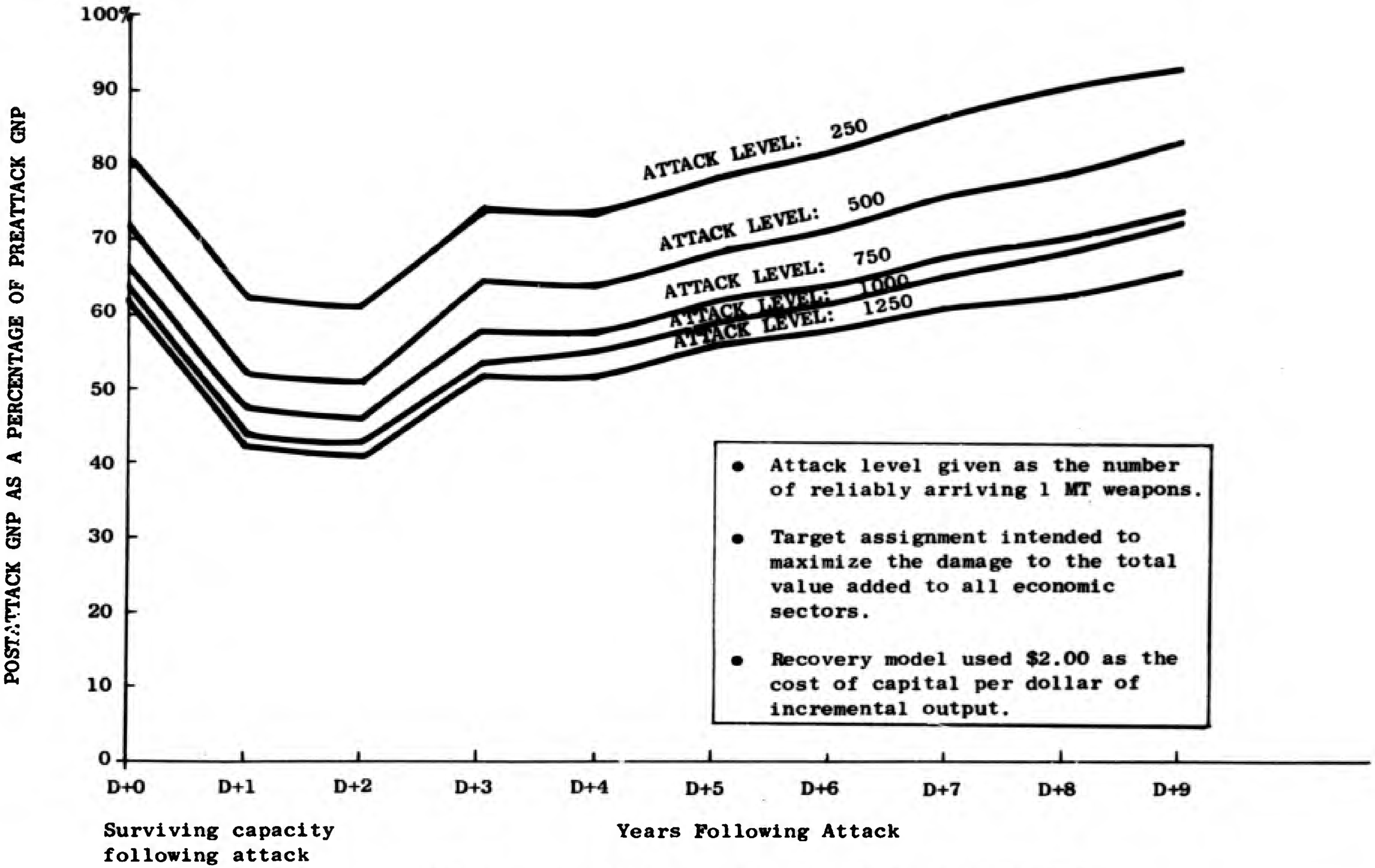

Figure II-2 Postattack Recovery Measured by GNP-U.S.
(Fifteen Sector Model)

Table II-3

ILLUSTRATIVE RESULTS: ANALYSIS OF THE RELATIONSHIP OF SURVIVING CAPACITY VS RECOVERY RATE
(USSR 1972 Runs with 16 Sector Model)

Run	Attack Level	Surviving Capacity GNP at D+O	Initial Noninvestment Demand	Postattack NMP-Year					Average Annual Growth
				One	Two	Three	Four	Five	
32-B	Medium	75%	38%	41.9%	39.2%	56.7%	58.9%	72.2%	14.6%
37-C	Heavy	71	30	32.7	30.6	44.8	46.1	62.4	17.5

Notes: Investment cost per ruble of incremental NMP was 2.0 for both runs.
The objective function used for optimization was the present value of the future stream of NMP. For definition of NMP see page II-11.
The stipulated lower level for noninvestment demand was increased at the rate of four percent per year from year two to year five.
The uniform growth rate from the fifth year on was set at four percent.
The depreciation rate was setat five percent.
For the heavy attack it was assumed that 29 percent of the population (65 percent of the urban population) and 70 percent of plant capacity in each sector was lost.
For the medium attack it was assumed that 25 percent of the population (55 percent of the urban population) and 60 percent of plant capacity in each sector was lost.

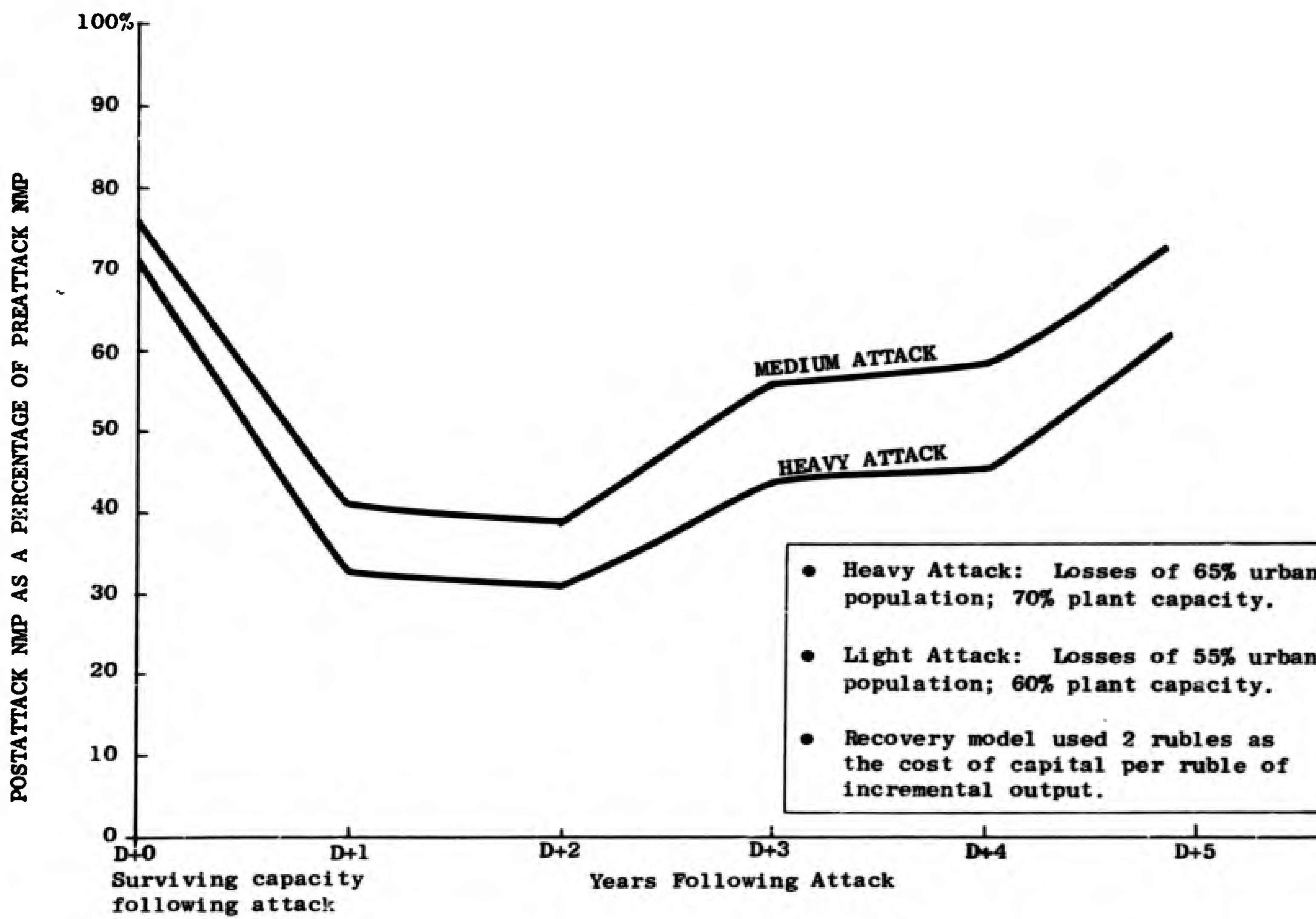

Figure II-3 Postattack Recovery Measured by NMP-USSR was assumed that only 29% of the population, (65% of the urban population) and 70% of the plant capacity was lost. For the lighter attack, it was assumed that 25% of the total population or 55% of the urban population and 60% of plant capacity was lost. These cases show a more rapid rate of recovery than for the U.S., but such results are affected by the assumption of uniform damage which leaves the economy more balanced than would an actual attack and are also very sensitive to the basic parameters; the depreciation rate, the factor k, and the Cobb-Douglas coefficients. None of these parameters are determined with sufficient reliability as yet to provide a suitable level of confidence for using results obtained in comparative analysis of USSR/U.S. recovery potentials. The preliminary results do point out where empirical analysis of the two economies could be most profitable for improving the present data base.

Soviet input-output tables are based on intersector material flows and ignore services contributing directly to personal consumption and government functions. This is consistent with the national income concept used in the national accounts of the USSR. To distinguish the Soviet concept of national income from that of the United States and the West, the Soviet final demand total (following A. Becker) is commonly referred to as net material product or NMP. It is approximately equal to the value of goods and structures going to final demand and differs from GNP only by excluding nonproductive services (services not contributing to the production of tangible product) which are, however, included in GNP. The recovery data shown in Table II-3 and the curves shown in Figure II-3 are thus based on NMP but are expressed as percentages of its preattack level. Because all services are assumed to be colocated with and to have vulnerabilities equal to population, percentage losses for GNP from the attack model would tend to be less than those for NMP. Because services tend to require minimal investment, recovery rates for GNP should tend to be more rapid than those for NMP.

D. General Observations on the Simulations

The limitations of the approach followed in this report and in the data on which the computer runs were based, have been indicated. In spite of the caveats necessitated by these limitations, some general observations on the results of the simulations are in order.

1. The steady recovery after the first two years shown on all schedules is built into the models but is considered to be realistic in view of firm government controls suppressing the political or economic perturbations which normally occur in peacetime.

This is largely the result of the structure of the simple growth models employed and the objective of the computer algorithm which attempts to minimize imbalances and to optimize recovery rates. In the normal peacetime economy, such uniform growth is not maintained because of perturbations introduced by recessions and unemployment; rigidities imposed by corporate or labor union practices or by other institutional constraints; military and other governmental activity; international conditions; and similar exogenous factors. In the postattack emergency period characterized by general shortages, the political and economic environment would presumably not be allowed to constrain recovery unduly, and the emphasis which the models place on production would be rather realistic.

2. The results all show a down-turn in the second year and many cases exhibit a two-year cycle.

The two year cycle is largely a consequence of the two-year lag assumed to be required for capital replacement, and the fact that capital construction in process from preattack years is assumed to have been lost. Whether or not the two-year lag is generally applicable, some initial down-turn is to be expected. The models may exaggerate this effect or err in its predicted duration, but some such effect seems very likely.

3. The curves for the USSR start lower, corresponding to a greater degree of initial damage than even the case of 1,250 reliably delivered weapons on the U.S.

This difference is suspect because it may result from inadequacies in the population data used for the USSR, and the fact that damage to industry was taken to be proportional to loss of urban population. The Soviet damage levels are at best hypothetical and were intended only as basis for alternative tests of the recovery model.

4. The curves for the USSR show a faster recovery than those for the U.S.

This results in part from the arbitrary assumption of uniform industrial damage across all sectors which precludes postattack imbalances. It may also result in part from the lower starting base assumed and discussed under (3) above.

5. The values assumed for the key parameters such as the capital cost coefficient, k, the depreciation rate and the peacetime growth rates from which these were inferred are very similar for the USSR.

It is generally felt among students of the Soviet economy that the USSR does not retire capital as rapidly as would appear optimal or as is the practice in the West. Moreover, it is often asserted that the marginal output to capital ratios (related to the factor k) for the USSR is low and has been declining. The limited sectoral data available failed to indicate any great differences between the two economies or any clear trends of the character mentioned.

E. Tentative Conclusions from the Simulations

1. The general characteristics of the U.S. and Soviet economies may not be as different as often asserted, and may lead to similar recovery capabilities.

2. Comparative analysis of recovery potential in the two countries must develop better data on sectoral relationships between output and inputs of capital and labor and the current allocation of capital stock between structures and equipment within individual sectors.

3. Estimates of industrial damage for the USSR require data on location of industrial capacity about as complete as the unclassified SRI data base for the U.S.

4. Imbalancing attacks can present particularly severe problems for the initial postattack period, but if full resources are devoted to relieving the most critical imbalances, their influence can be restricted to the first five to ten quarters postattack.

5. Analysis of the dynamic aspects of the recovery process can thus be concentrated on detailed examination of the first two or three years postattack.

6. Estimates of postattack recovery rates over longer periods can best be inferred from analysis of possible attack induced changes in capital costs and in the productivity of capital and labor. These involve the most critical parameters in peacetime growth. Attack induced changes in them will largely determine recovery rates.

F. Possible Extensions of the System of Models

The weakest parts of the system of models as actually used for the trials reported at this time are those relating to capital structure, depreciation rates and the costs of capital replacement and capacity expansion. The use of a single average depreciation rate and a single value for k, the cost to purchase a given increase in capacity, can be tolerated only in a preliminary trial of the models with very aggregated data. On the other hand, information on facilities and capital equipment and on the service lives relating thereto is available only in rather aggregated forms by general categories of facilities and equipment. Estimates of the distribution of structures and equipment by economic sectors involve some variant of a perpetual inventory approach using data on plant and equipment expenditures, capital consumption charges and estimates of net and gross stocks of producers durables and structures for major (highly aggregated) parts of the economy as check totals.

With wage and employment data available by sectors and capital estimates generated as above, Cobb-Douglas or more general production functions (e.g., the constant elasticity of substitution, CES functions)[1/] could be fitted to the inputs of capital and labor services for individual sectors. The effects of vintage (average age) of capital and estimates of age of capital by sector may be required, but could probably be averaged out for each sector. Capital construction times and input requirements by type of capital could be inferred from BLS capital flow data[2/] and data on capital expansion parameters from the National Planning Association.[3/]

These data sources and methods could thus be applied to generate the full matrix $G = (g_{ij})$ of requirements on sector i to sustain a balanced investment of one dollar in plant and equipment for sector j, and also for (1/kj) the change in capacity (value added) per dollar of investment.

Ideally, detail approximately equivalent to that for the 1958 and 1963 input-output tables as published in the Survey of Current Business[4/][5/] would be desirable. Problems in generating capital data would probably force some compromise with this and would force some aggregation of sectors.

The rather sketchy treatment of labor supply in the initial model was improved by the introduction of an economy-wide labor constraint into the 1972 model. This did not involve the special complications of the capital allocations but increased by one the number of constraints and (by 5 or 9) the number of decision variables in the linear program.

The extension of the planning horizon to 9 years facilitated examination of recovery from heavy and imbalancing attacks. The computer program currently used is not capable of handling more than 9 years with 16 sectors.

1/ Grimm, Bruce T., Estimation of CES Production Functions for U.S. Manufacturing by Input-Output Sector. Institute for Defense Analyses Research Paper, p. 525, Washington, D.C., July 1969.

2/ Department of Labor, Bureau of Labor Statistics, Capital Flow Matrix, 1958, Washington, D.C., October 1968.

3/ Waddell, et. al., Capacity Expansion Planning Factors, National Planning Association, Washington, D.C., April 1966.

4/ Survey of Current Business, September 1965, Vol. 45, No. 9, U.S. Dept. of Commerce, Office of Business Economics.

5/ Survey of Current Business, November 1969, Vol. 49, No. 11, U.S. Dept. of Commerce, Office of Business Economics.

The attack model has been used in other connections with allowances for active and passive defense. The latter is treated by variations of the vulnerability factors. The active ABM defense has been simulated by reducing the number of delivered missiles. Both refinements could be introduced to provide other analysis of the attack results. Combined effects of mixed counterforce and countervalue attacks could also be accommodated.

The simplifications employed in the present version of the models resulted in parallel movements of the various recovery curves following alternative attack objectives and thus similar growth rates independent of attack levels and initial postattack conditions. Moreover, all the recovery curves show maximum potential and are thus optimistic, particularly so in the few cases of imbalancing attack. The refinements cited could lead to more realistic simulations of recovery processes.

Soviet data include the input-output tables for 1959[1/] and 1966[2/], and Judith Thornton's fits of Cobb-Douglas functions to Soviet capital and labor input data[3/]. Data on labor requirements are also available from Treml's 1966 I-O tables and may also be used for these. Population location data are available on an unclassified basis, but full application of the attack model would require capacity location data by sector. The recovery model has been applied, however, to arbitrary uniform specifications of surviving capacity and labor force without considering the means or plausibility of inflicting the damage implicitly assumed or the attack levels required to achieve such damage. Thus the recovery rate methodology has been applied to the USSR. Some capital flow data are available by sector, for the USSR for 1959 but not for 1966.

1/ Annual Economic Indicators for the USSR, JEC, Congress of the United States, February 1964.

2/ V. G. Treml, D. M. Gallik, B. L. Kostinsky, K. W. Kruger, The Structure of the Soviet Economy, Analysis and Reconstruction of the 1966 Input-Output Tables, Praeger, New York, N.Y., November 1972.

3/ Thornton, Judith, "Estimation of Value Added and Average Returns to Capital in Soviet Industry from Cross Section Data," Journal of Political Economy, December 1965.

III DESCRIPTION OF THE ATTACK MODEL

This chapter describes the attack model employed and its underlying concepts. It has been applied only to resource location data within the counties comprising each Standard Metropolitan Statistical Area (SMSA) as defined by the Census Bureau and comparable urban complexes in the Soviet Union. Each such area is a possible target for one or more weapons. The percentage of any resource surviving an optimized attack delivering N_i weapons on such a target area has been approximated by a function which depends on the square root of the number of weapons, modified by a factor related to the characteristics of the weapon type, the target and the sector or entity attacked. More specifically, it is assumed that the fraction f_{ij} of entity j in target i destroyed by the attack given by

$$1-f_{ij} = \left(1+k_{ij}\sqrt{N_i}\right)e^{-k_{ij}\sqrt{N_i}}$$

where N_i is the number of weapons reliably delivered on target i, f_{ij} is the fraction of entity j in target i that is destroyed and k_{ij} is a constant appropriate to each i and j. The allocation is assigned in such a way as to maximize the damage nationally to a stipulated target system, i.e., to a particular j or to total value added or some other weighted composite summed over all j.

Assumptions about target and sector hardness are implicit in the values assigned k_{ij}. Assumptions about abort rate, miss distances, etc., are avoided by or subsumed under the assumption that N_i weapons are reliably delivered on target i, with perfect knowledge of aborts, prior damage and other tactical circumstances. Passive defense could be incorporated in variations of the parameter k_{ij}; active defense could be reflected in the difference between N_i weapons penetrating and a larger group M_i assigned. Assumptions relating to the differences between the vulnerability of population and facilities are already incorporated in differences among the k_{ij} but facility vulnerabilities were taken to be the same for all sectors except for the diffuse sector which was treated as not at risk and the services sector which was treated as collocated with and vulnerable like population.

Thus with the exception of population, the services sector and the diffuse sector, all estimates of the fraction of damage to sectors at a given SMSA for a given number of weapons are the same regardless of the economic sector in question. Differences in the absolute amount of damage to the various sectors reflect differences in the sector values associated with each particular SMSA. For the same reasons, the allocation of weapons over the whole target system (i.e., over the full set of SMSAs) varies with the resource used as the objective for the design of an optimal attack.

The formula used can be obtained empirically as an approximation to the results of direct effects damage assessment simulations. It can also be derived from the assumptions that population density declines exponentially with the distance from the center of the city and that a standard weapon has a fixed lethal radius. This is discussed in Appendix A. The same function (with different k values) has been found to hold for other target value systems, such as the value added by manufacturing for some particular sector of the economy. Given the distribution of a particular resource among the SMSAs, the vulnerability of the resource to direct effects, and its dispersion or concentration in each SMSA, the model assigns weapons to different SMSAs to maximize the total amount of the resource destroyed.

The value systems considered have been population, the capacities certain selected aggregated industrial sectors with known distributions, and a weighted composite of all sectors, roughly equivalent to gross national product, i.e., total value added from all sectors. The diffuse sector, including dispersed industry largely outside the SMSAs, has been treated as not at risk in the attacks. No denial of access to facilities or casualties from fallout have been considered.

The model is applicable to any resource for which geographical distribution by SMSA is known. The model algorithm essentially depends on a single parameter which is varied continuously from large to small values to yield attack levels of increasing size. This parameter, λ , can be thought of as a limiting or marginal amount of damage per incremental weapon. If the damage to any SMSA from a single weapon is less than λ , that SMSA is not attacked. If it is greater than λ , as many weapons are assigned as necessary to bring the damage that could be obtained from one more weapon below λ . The total number of weapons assigned thus depends on λ . As λ is decreased, more weapons are assigned; as λ is increased, fewer weapons are assigned. Thus one way to arrive at an optimal allocation of N weapons is to manipulate the value of λ until the given number of weapons is used in the attack. This can be done with a computer program that cumulates the total value of the resource λ destroyed in the cities attacked for specified levels of N. Such a computer program was used to allocate weapons to targets in the 1971 analyses.

The damage estimating procedure assumes that the damage produced by an optimally targeted weapon is independent of any subsequent weapon allocations to the same SMSA. Under this assumption, the model algorithm described above is equivalent to allocating N weapons to the N aimpoints having the largest damage increment. For reasons to be discussed below, the latter formulation was incorporated into the computer program that was used for designing the 1972 U.S. attacks.

Although the attack is always optimized against a particular resource, collateral damage to other resources can be calculated in the same run from the weapon assignments made. The collateral damage is always less than or at most equal to the damage that would be sustained had that resource been the explicit objective of an imbalancing attack.

In the 1971 studies, the fraction of collateral damage to any economic resource was assumed to be the same as the fraction of damage for the resource used as a primary objective, i.e., for the resource used to allocate weapons to aimpoints in the design of an optimal attack. With this assumption, computation of the collateral damage was most easily carried out with the algorithm based on λ .

In the 1972 studies of U.S. recovery, the only primary resource objective used was urban plant capacity measured by manufacturing value added. The procedure used to prepare empirical estimates of individual weapon damage (i.e., damage increments) was also used to prepare collateral damage from individual weapons for five other selected value systems. These primary and collateral damage estimates were obtained with the aid of a target representation that gave the geographic distribution of each value system in terms of a five km grid. The five collateral value systems were population, chemicals, petroleum, primary metals, and machinery. Each of these five value systems was taken as a surrogate for one or more of the 78 economic sectors that comprise our basic description of the U.S. economy. With this input, computation of the overall collateral damage from an optimized attack was most easily carried out with the algorithm that assigns weapons to the aimpoints having the largest damage increments.

Some of the sectors considered are rather specialized. One was petroleum refining, the other primary metals. A small number of weapons directed against petroleum refining would eliminate most of the productive capacity located in the SMSAs. The capacity in the SMSAs account for about 85% of total output. For petroleum refining, therefore, the concept of reliably delivered weapons was relaxed somewhat and it was assumed that 225 weapons (of a total of 250) with a reliability factor of 0.8 were directed against 71 targets in the SMSAs and 25 weapons were directed against the largest of the targets outside the SMSAs. Rough calculations based on an assumed form for the cumulative distributions of targets ranked in order of decreasing value indicated that perhaps 10% of preattack capacity might survive. For the 500 weapon attack, 425 weapons were allocated against SMSA targets and 75 weapons were directed against the largest of the remaining refinery targets. From such an attack only 1% of preattack capacity would survive. With such over-saturation of the target system, the estimate of the surviving percentage is subject to a large percentage error. In these attacks, collateral damage to other resources was calculated considering only weapons on SMSAs, thus ignoring collateral damage to resources outside the SMSAs. Even in the case of the 10% survival rate for petroleum, sectors using petroleum products would be drastically affected and the survival of inventories, expedient production of diesel fuel, imports or other sources of gasoline would greatly affect the first year postattack economy. The results obtained cannot be regarded as precise, but merely as illustrating the gravity of such a situation and its temporary character.

Strictly speaking, the damage percentages obtained relate to population loss or to physical capital associated with the industries in question. Surviving capacity measured in terms of potential contribution of each sector to GNP depends on the capital destroyed and the surviving labor supply. It has been treated as a composite of these losses. Value added produced in a sector may fall very short of this potential depending on bottlenecks in other sectors as disclosed in the recovery model.

IV DESCRIPTION OF THE ECONOMIC RECOVERY MODEL

The economic recovery model is basically an input-output model supplemented by production-function relations between value added from each sector and inputs of the services of capital and labor to the sector. This model is based on an aggregation of U.S. and Soviet input-output tables which show interindustry requirements. For the U.S. these are based on the input-output tables for 1963 first published in the Survey of Current Business for November 1969. For the Soviet Union, Treml's reconstruction of the 1966 tables have been used. A major assumption is that the technology implicit in these tables still applies to a postattack situation. The errors introduced by this assumption could be considerable and could be greater for less aggregated models but may nevertheless be less than the changes between 1963 or 1966 and some future date, say 1984.

Only two sources of demand are distinguished. One relates to investment in capital plant and equipment and is equivalent to the gross private domestic capital formation category of the national income accounts and the official input-output tables. The other comprises all other final demand including personal consumption expenditures, government purchases of goods and services (for defense and all other functions), inventory change and net exports. For some comparisons of recovery times under alternative policy decisions, the total demand of the second or catch-all type is assumed to be proportional to population and the sector distribution of such demand is estimated from per capita requirements. The peacetime distribution of such per capita requirements was not used in the initial 7 sector runs and a so-called recovery vector prepared by the Office of Emergency Preparedness (OEP) was used as more representative of the mix of products required in a postattack situation. Similarly the peacetime mix of sector requirements per dollar of investment (in gross private domestic capital formation) was replaced by an OEP vector presumed to be more representative of postattack conditions. The peacetime distribution of final demand, however, was used for the 15 sector runs and the 16 sector Soviet runs.

The input-output coefficients used relate final demand to required capacity by means of a matrix equation

$$V = E^{-1} F$$

where V is a vector showing the value added required to meet F, a specified vector of final demand, and E^{-1} is the inverse of a constant input-output matrix E.

The vector V has one component for each sector, each of these components represents the value added required from the corresponding sector. The vector F also has one component for each sector, each of these components represent the total final demand for end-products from that sector. The input-output matrix E (or more precisely its inverse E^{-1}) translates final demand into required value added after allowing for interindustry demand for materials and other intermediate products.

The vector F for the recovery model is separated into two parts:

1) one part is proportional to total investment and has components proportional to the expected allocation of each investment dollar among the supplying sectors, and

2) a second part is proportional to surviving population and has components proportional to per capita requirements for consumables including military and other government uses.

The proportions in these vectors for the 7 sector experiments were derived from OEP data on anticipated requirements for gross private investment in fixed capital in a recovery situation and similar recovery requirements for personal and governmental consumption. These two vectors have been derived from a more detailed listing of anticipated per capita requirements shown in Appendix C.

Input-output coefficients normally relate intermediate requirements to total sector activity levels, i.e., total sector sales. For convenience the input-output coefficients have been modified by dividing each column by the ratios of value added to sector sales. Intermediate requirements can thus be related directly to value added rather than to sector sales. In effect, it is assumed that the purchase by any sector of intermediates from each sector is proportional to the value added in the purchasing sector and that the coefficients of proportionality (the modified input-output coefficients) are constant and are unchanged by the attack.

On the other hand, changes in capital stock or labor supply induced by attack losses or by investment are assumed to affect value added from each sector in accordance with production function relations of Cobb-Douglas type. Specifically, it is assumed that a given percentage change in capital services combined with another given percentage change in labor used results in a percentage change in value added that can be calculated by taking a weighted average of the given percentage changes in capital and labor inputs, respectively. Stated differently, it is assumed that the logarithm of value added is a linear function of the logarithms of the inputs of labor and capital. Available capital and labor thus determine potential sector capacity measured in terms of potential value added. The value added actually achievable, however, may fall below this potential because of shortages of required intermediates resulting from capacity constraints on other sectors.

In many of the postattack cases considered, surviving capacity proved inadequate to meet the specified per capita requirements and this component of final demand had to be scaled down to some fraction of the stated requirements. This does not necessarily imply that the survival of the postattack population would be in jeopardy, since the minimum per capita requirements were only about half the peacetime levels and gains in real GNP (in dollars of 1963 purchasing power) since 1963 would raise total capacity above these levels. The U.S. has gradually grown to the current standard of living over many decades and has survived periods of greater relative austerity (the Great Depression and World War II) without major problems.

In any case, the two final demand vectors (investment and other final demand) have been used merely to indicate the allocation of final demand among sectors rather than the total level. The recovery model, as explained elsewhere, assumes that the noninvestment demand is kept low enough to permit at least minimal investment even during the first two postattack years.

The economic recovery model allocates the total investment allowed among sectors in such a way as to provide the best rate of recovery. Different recovery objectives are possible, but the one that has seemed most defensible and has been used for most trials is to maximize the present value (at a high rate of discount) of the future flow of GNP.

One weakness of the economic model in its present form is the reliance on a single final demand vector for investment, regardless of the sector in which the investment is to be made. Lack of adequate data rather than any theoretical or computational constraint has forced this over-simplification of economic reality. Consideration is being given to possible analysis of available investment data to ameliorate the difficulty. At least a split between requirements for producers durable equipment and plant facilities or other structures appears to be a future possibility.

The attack model provides estimates of surviving population (and labor force) for the country as a whole and of plant capacity by economic sector. The economic model translates these results into estimates of potential value added. The attack model has no further role, but the attack results are used to transform the economic model into a recovery model. The input-output coefficients from the peacetime data are applied to the normalized final demand vectors (i.e., normalized by expressing each vector component as a percentage of the column total for each of the two types of final demand) to estimate the total direct and indirect requirements on each sector to meet one dollar of investment or one dollar of noninvestment demand. These requirements are in units of value added and for convenience have been converted to percentages of preattack GNP. Exogenous to the model, a policy decision is made to set the initial level of noninvestment final demand. The model gives some guidance for this policy decision by rejecting settings which are too high as measured by potential value added capacity surviving. In particular, the level of noninvestment final demand must be less than the sum of the total potential value added surviving in the various sectors. Once the noninvestment demand has been set within feasible capacity limits, the model invests as much as possible in capacity generation. In fact, it also allocates this investment among sectors and by years in such a way that a specified objective function is maximized subject to a large number of constraints. These constraints enforce the following conditions:

1. Final demand in any year must not require capacity in any sector in excess of that available.

2. Capacity in each sector during any year is equal to that available the preceding year less a fixed fraction corresponding to physical depreciation (capital retirement or necessary repairs) plus any capacity generated by investments two years prior.

3. During the last year of a preassigned planning period, investment in each sector must be great enough to maintain indefinitely a fixed uniform rate of growth in all sectors of the economy.

4. During the planning period, noninvestment demand is allowed to grow in accordance with a stipulated schedule usually taken as a fixed rate of growth from the second year on to the end of the planning period.

5. The capacity purchased by any specified investment is proportional to the investment made.

For the experiments conducted in 1972, the OEP recovery vector for 1958 was abandoned for the U.S. data and new vectors were derived directly from the final demands reported in the 1963 U.S. and the 1966 Soviet I-O tables. The derivations of the vectors used are also given in Appendix C.

For the economic model, the economy is described in terms of seven sectors for the 1971 experiments and in terms of 15 U.S. sectors and 16 Soviet sectors in the 1972 experiments. Data from each sector of the input-output tables and the final demand vectors in the source documents have been reclassified into one of these sectors as shown in Appendix C, where the systems of classification used are also indicated.

The level of aggregation in the models used has been dictated by expediency and a desire to have a model useful for gross sensitivity experiments. Conversion from 7 to 15 or 16 sectors increased computer times by a factor of 4. Conversion to an 80 sector model would require runs longer by a factor of 20 or more and would require more elaborate data collection and investment policy specifications.

The recovery model assumes a fixed two year lag between the year an investment is committed and the availability of output from the increased capacity. It further assumes that the labor force can be shifted among sectors as needed to man the facilities provided. The labor force constraint is thus applied only to the economy as a whole.

Capital flow data exist for the U.S. for 1958[1/] and show minor intersector differences but these proved to be small in comparison to changes in the investment final demand vector between 1958 and 1963. The major differences appear to result from changes in the allocation of investment funds between plant and equipment.

1/ Department of Labor, Bureau of Labor Statistics, Capital Flow Matrix, 1958 Washington, D.C., October 1968.

Appendix A

MATHEMATICAL FORMULATION OF THE ATTACK MODEL

Let population density in area i at a distance r_i from the center of the SMSA be given by

$$\rho_i = a_i e^{-b_i r_i} \qquad (1)$$

Then the population in a circle of radius r_i with center at the center of the target is

$$P(r_i) = 2\pi a_i \int_0^{r_i} e^{-b_i r_i} r_i dr_i$$

$$= \frac{2\pi a_i}{b_i^2} \int_0^{b_i r_i} x e^{-x} dx$$

$$= \frac{2\pi a_i}{b_i^2} \left\{ \left[-xe^{-x} \right]_0^{b_i r_i} + \int_0^{b_i r_i} e^{-x} dx \right\}$$

$$= \frac{2\pi a_i}{b_i^2} \left\{ 0 - b_i r_i e^{-b_i r_i} - \left[e^{-x} \right]_0^{b_i r_i} \right\}$$

$$= \frac{2\pi a_i}{b_i^2} \left\{ - b_i r_i e^{-b_i r_i} + 1 - e^{-b_i r_i} \right\}$$

$$= \frac{2\pi a_i}{b_i^2} \left\{ 1 - \left[1 + b_i r_i \right] e^{-b_i r_i} \right\} \qquad (2)$$

As r_i increases indefinitely $P(r_i)$ approaches the total population $P(\infty) = \frac{2\pi a_i}{b_i^2} = P_i$. The population in a circle of radius r_i concentric with the center of the city is

$$P(r_i) = P_i \left\{ 1 - \left(1 + b_i r_i\right) e^{-b_i r_i} \right\} \tag{3}$$

If d is the radius of lethality of a standard weapon, then the number of weapons required to cover a circle of radius r_i is given by $N_i = \pi r_i^2 / \pi d^2 = (r_i/d)^2$ and $r_i = d\sqrt{N_i}$. The fraction of P_i lost with N_i reliably delivered weapons is thus

$$P(r_i)/P_i = F_i = 1 - \left(1 + b_i d \sqrt{N_i}\right) e^{-b_i d \sqrt{N_i}} \tag{4}$$

The fraction of the population surviving N_i weapons is

$$S_i = 1 - F_i = \left(1 + b_i d\sqrt{N_i}\right) e^{-b_i d\sqrt{N_i}} \tag{5}$$

This is generalized to state that the fraction of any resource j in target i surviving N_i weapons is given by

$$S_{ij} = 1 - F_{ij} = \left(1 + k_{ij}\sqrt{N_i}\right) e^{-k_{ij}\sqrt{N_i}} \tag{6}$$

where k_{ij} depends on the weapon size, the area of the city, and the nature and hardness of the resource j. If V_{ij} is the total value of resources j in target i, the value destroyed by N_i weapons is thus

$$W_{ij} = V_{ij} F_{ij} = V_{ij} \left\{ 1 - \left(1 + k_{ij}\sqrt{N_i}\right) e^{-k_{ij}\sqrt{N_i}} \right\} \tag{7}$$

An alternative way to treat damage estimates against individual targets is to work with damage increments. In terms of the above notation, these can be approximated by

$$\frac{dW_{ij}}{dN} \approx \frac{\Delta W_{ij}}{\Delta N_i} = V_{ij} \left[F_{ij}(N_i) - F_{ij}(N_i - 1)\right] \tag{8}$$

where $\Delta N_i=1$ and the W_{ij} or F_{ij} can either be obtained from (7) or empirically by numerical integration of a damage function over a geographical representative of V_{ij} in the SMSA. Both methods have been used.

The attack strategy given N deliverable weapons is to assign to particular targets to maximize

$$W_j = \sum_i W_{ij} \tag{9}$$

subject to $\Sigma N_i = N$. This may be done by the use of a Lagrangian multiplier λ in a constrained maximum where λ represents a desired level of damage per weapon.

Weapons will be assigned until the incremental damage from the last weapon is equal to the value of λ appropriate for a given N. If damage increments are used, the computational procedure consists of sorting through the set of increments until the N largest increments are found. The overall damage (to the resource used for designing the attack) is obtained by summing these increments.

Corresponding values using the analytical expression (7) are obtained as follows. Let $k_{ij}\sqrt{N_i} = \theta_i$.

We have

$$\frac{dW_{ij}}{dN_i} = V_{ij}\ \frac{dF_{ij}}{d\theta_i}\ \frac{d\theta_i}{dN_i} = \lambda \tag{10}$$

Since $F_{ij} = \quad 1 - (1 + \theta_i)e^{-\theta_i}$ (11)

$$\frac{dF_{ij}}{d\theta_i} = (1 + \theta_i)e^{-\theta_i} - e^{-\theta_i} = \theta_i e^{-\theta_i} \tag{12}$$

and

$$\frac{d\theta_i}{dN_i} = k_{ij} / 2\sqrt{N_i} \ . \tag{13}$$

so that $$V_{ij}\ \theta_i e^{-\theta_i}\ k_{ij} \ / \ (2\theta_i/k_{ij} = \lambda \qquad (14)$$

or $$\frac{1}{2}\ V_{ij}\ k_{ij}^2\ e^{-\theta_i} = \lambda \qquad (15)$$

Hence $$\log \frac{V_{ij}k_{ij}^2}{2} - \theta_i = \log \lambda, \qquad (16)$$

or $$\theta_i = k_{ij}\sqrt{N_i} = \log \frac{V_{ij}k_{ij}^2}{2\lambda} \qquad (17)$$

The parameter λ can be adjusted until

$$\Sigma_i\ N_i = \Sigma_i \frac{1}{k_{ij}^2} \left\{ \log \frac{V_{ij}k_{ij}^2}{2\lambda} \right\}^2 = N \qquad (18)$$

where the summations are understood as including only targets for which $N_i \geq 1$. that is for which

$$k_{ij} \geq \log \frac{V_{ij}k_{ij}^2}{2\lambda} \qquad (19)$$

In practice we may proceed by starting with a very large value of λ obtaining a small or zero N and continue to reduce λ obtaining successively larger values for N. The relation between λ and N is monotone decreasing, if the minor effects of the integer nature of N are ignored. In any case assertions about λ can be translated into assertions about N or vice versa. The parameter λ can be interpreted as a marginal return desired, as measured by damage produced, per incremental weapon in each SMSA attacked.

Substituting any value for λ in (17) yields $\theta_i(\lambda)$ for all i and thus F_{ij} for all i and j after substituting θ_i in (11). Hence the percentage damage to resource j in target i can be directly established as a function of λ for each i and j. By summing the value of j destroyed over the cities attacked we have total value lost

$$W_j = \sum_i V_{ij} F_{ij} (N) = \sum_i V_{ij} F_{ij} (\lambda) \qquad (20)$$

The N_i have been obtained as a function of N or λ with the attack optimized against resource j. Two methods of obtaining the collateral damage to any other resource system, h, were used. In the 1971 studies, the fraction of damage to the resource h was assumed equal to the fraction for the resource selected as primary attack objective, j. The total collateral damage to resource h from an optimal attack on resource j, W(h/j) is given by

$$W(h/j) = \sum_i W(i,h/j) \qquad (21)$$

where

$$W(i,h/j) = V_{ih} F_{ij}(N_i) \qquad (22)$$

In the 1972 studies, the expression for W(h/j) was the same, but the expression for W(i,h/j) is given by

$$W(i,h/j) = V_{ih} F_{is} (N_i) \qquad (23)$$

where F_{is} N_i is the fraction of damage obtained by N_i weapons against one of six surrogate resources selected to represent damage to resource h where the index s refers to the surrogate selected. We can write

$$s = s(h), \; s = 1, \; . \; . \; . 6, \qquad (24)$$

The surrogates used consist of urban plant capacity, population, chemicals, petroleum, primary metals, and machinery. With the exception of population, all surrogates were expressed in terms of large plant value added. Damage to the last five surrogates was computed as collateral damage from an attack optimized against the first. In all six surrogates, the damage increments were obtained empirically by numerical integration.

Strictly speaking, the resources at risk are the population or the physical facilities and equipment associated with each industrial sector. The damage estimates reflect the general level of vulnerability of such resources to weapons of a specific yield within the situation existing in each target city, considering its geographical concentration and other aspects of the local terrain and the intrinsic hardness of the resource in question. If facilities and population were equally vulnerable, the surviving percentages as shown in Table C-3 of Appendix C would represent the percentages of productive capacity surviving for each sector measured either in terms of value added or gross output In practice, physical plant and equipment and population or labor force have different survival expectations, and the plant capacity associated with physical assets may be operated to exceed normal output if labor can be substituted for capital, and below normal output if labor shortages are more serious than loss of capital assets.

As input to the economic model the attack results are translated into expected loss of <u>potential</u> value added by averaging the percentage loss of capital and the percentage loss of labor. The weights used in this average have been derived from the assumption that value added is a function of capital and labor available. The specific function used is that called the Cobb-Douglas function for which the logarithm of value added is a linear function of the logarithms of surviving capital and labor force. For small changes this assumption results in estimating the percentage change in value added to be a weighted arithmetic mean of the percentage changes in labor force and capital, with weights equal to the peacetime fraction of value added represented by compensation of employees or to its complement. This is further discussed in Appendix C.

Appendix B

MATHEMATICAL FORMULATION OF THE ECONOMIC RECOVERY MODEL

The economic model is simply an input-output model adapted for application to an unbalanced economy such as might be expected in a postattack situation.

Let s_j be the total sales from sector j and let z_{ij} be the sales of sector i to sector j. The basic assumption of input-output (IO) analysis is that

$$z_{ij} = a_{ij} s_j \tag{1}$$

where the a_{ij} are constant or at least are slowly changing with changing technology. The portion v_j of s_j that exceeds the total inputs of raw materials or other purchased semifinished intermediates is called value added. We thus have

$$v_j = s_j - \sum_i z_{ij} = s_j - \sum_i a_{ij} s_j = (1 - \sum_i a_{ij}) s_j \tag{2}$$

Value added can also be interpreted as the sum of the cost of the services of labor and other social or intangible cost elements. Specifically it is the sum of compensation of employees including fringe benefits, current capital consumption allowances (current contribution to or charges for depreciation reserves), taxes including property taxes, corporate profits taxes, and indirect business taxes such as sales and excise taxes, and net profits after taxes whether paid out as dividends or proprietor income or retained as undistributed surpluses.

Equation (2) can be rewritten in matrix notation as

$$V = DS \tag{3}$$

where V and S are n-component columnar matrices (vectors) having v_j and s_j as their components and where D is a diagonal matrix having $(1 - \sum_i a_{ij})$ as its jth component down the diagonal with zeros everywhere off the diagonal. D is thus a matrix

$$D = (d_{ij})$$

where

$$d_{ij} = \delta_{ij} (1 - \sum_k a_{kj}) \qquad (4)$$

and δ is the Kronecker δ such that $\delta_{ij} = 1$ if $i = j$ and $\delta_{y} = 0$ if $i \neq j$.

On the other hand the total sales of sector i can be written

$$s_i = \sum_j z_{ij} + f_i = \sum_j a_{ij} s_j + f_i \qquad (5)$$

where f_i is the sales of i to final demand, i.e., to some ultimate consumer. Final demand includes personal consumption expenditures, gross private fixed capital investment, net exports, change in business inventories and government purchases of goods and services.

Equation (5) can also be written in matrix form as

$$S = AS + F \qquad (6)$$

where $A = (a_{ij})$ is an n x n matrix of I-O coefficients and F is a columnar matrix (vector) called the final demand vector.

Equation (6) can also be written as

$$S - AS = (I - A)S = F \qquad (7)$$

where I is the unit matrix consisting of ones down the diagonal and zeros elsewhere. In terms of Kronecker deltas $I = (\delta_{ij})$. As long as value added is positive, equation (7) can be solved for S in terms of F by inverting the matrix (I-A) obtaining

$$S = (I - A)^{-1} F \tag{8}$$

Similarly equation (3) can be solved for S in terms of V writing

$$S = D^{-1} V = (I - A)^{-1} F \tag{9}$$

or

$$V = D (I - A)^{-1} F \tag{10}$$

Also (7) can be written as

$$F = (I - A)S = (I - A)D^{-1} V = EV \tag{11}$$

where $E = (I - A)D^{-1}$. With this definition of E, we also have

$$V = E^{-1} F \tag{12}$$

If $\tilde{V}$ is capacity surviving attack, one is tempted to use (11) to estimate the output available postattack to meet final demand writing

$$\tilde{F} = E\tilde{V} \tag{13}$$

This could give meaningful results if the changes in capacity were very slight corresponding to those likely in the case of a slowly moving economic equilibrium.[1/] In general, however, and most certainly under the drastic changes in capacity that would occur after a massive attack, $E\tilde{V}$ would have some negative components. These would not be economically meaningful, except as indications that surviving capacity could not satisfy some of the implied intermediate (intersectoral) requirements.

1/ Some approximation of an economic equilibrium is tacitly assumed in the usual applications of input-output theory.

Unless these can be met from inventories, the economy must be operated at levels below those that might otherwise be expected from surviving capacity. Equation (13) is thus unacceptable and must be replaced by constraints in the form of inequalities. We thus require that $E^{-1} \tilde{F} \leq \tilde{V}$ (14) where these vector inequalities are understood as applying to each component of V.

The relative distribution of surviving capacity postattack is likely to be very different from that prevailing preattack and from that for a balanced or equilibrium state. Thus, final demand postattack ($\tilde{F}$) must usually be set in such a way that some sectors operate below the levels permitted by their individual surviving capacities. In other words, in the system of n inequalities (14), the inequality sign (and not the equal sign) must apply for some components (i.e., sectors). The wastage implied can be minimized by linear programming techniques in such a way that the rate of recovery is maximized. The program developed, however, accepts a number of alternative optimizing functions corresponding to alternative measures of recovery. It also treats a number of alternative systems of constraints. Selections among all these alternatives correspond to alternative recovery planning policies.

The following discussion develops the constraint equations, and is followed by a description of the admissible objective functions.

Let $v_i(t)$ be the potential value added (capacity) for sector i in postattack year D + t, that is, t periods after the attack. The initial vector $V(1) = \{v_i(1)\}$ is derived from the attack effects and the economic model. For convenience V(1) will be expressed in percentages of preattack GNP. It is thus proportional to (but not equal to) postattack value added in real terms, that is, in dollars of constant purchasing power, with the final preattack year as the base year for the prices. Let $F(t) = \{f_i(t)\}$ be the final demand vector in which $f_i(t)$ is the final demand for output of sector i in year D + t. The model requires first that $v_i(t) \geq f_i(t)$ for every year and for each sector i. Where convenient we will write vector inequalities such as $V(t) \geq F(t)$ to indicate a system of inequalities holding for each component of the sectors involved.

We will separate F(t) and each of its components $f_i(t)$ into two parts to be treated differently. One covers investment and is written:

$$\sum_{j=1}^{n} g_{ij} \, y_j(t) \qquad (15)$$

where $G = (g_{ij})$ is a constant matrix[1/] of order n x n and $y_j(t)$ is the amount of investment in each sector j. The other portion of final demand covers all the rest including personal consumption expenditures, government purchase of goods and services, net exports and inventory change. In particular it includes defense expenditures. We express this non-investment demand as proportional to a requirement vector $H = [h_i]$ normalized so that $\Sigma h_i = 1$. We have therefore

$$f_i(t) = x(t) \, h_i + \sum_{j=1}^{n} g_{ij} \, y_j(t) \qquad (16)$$

where x(t) and $y_j(t)$ are both expressed in terms of percentages of

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1/ Unfortunately only scattered data exist relative to the sector differences in rows of the matrix G and each row must be approximated by an average taken over all kinds of investments. We have thus been forced to assume that

$$g_{ij} = \frac{1}{n} \sum_{j=1}^{j=n} g_{ij} = \bar{g}_i$$

If detailed data were available on individual g_{ij}, the programs developed could accommodate the appropriate G matrix.

preattack GNP where $x(t)$ is required to exceed a value given exogenously, i.e., a value calculated from a stipulated level of austerity c and the number of survivors π, with $x(t) \geq c(t)\,\pi$. The system of equations (2) can be written in matrix form as

$$F(t) = x(t)\,H + G\,Y\,(t) \tag{17}$$

where

$$Y(t) \text{ is the vector } Y(t) = \left[y_i(t)\right]$$

The capacity each year is given by a system of recursion relations as follows:

$$\begin{aligned} V_i(t+1) &= v_i(t) - \delta\, v_i(t) + \frac{1}{k_i}\, y_i\,(t-1) \\ &= (1-\delta)\, v_i(t) + \frac{1}{k_i}\, y_i\,(t-1) \\ &= r\, v_i\,(t) + \frac{1}{k_i}\, y_i\,(t-1) \end{aligned} \tag{18}$$

where δ is the depreciation rate or capital consumption rate and k_i is the number of dollars of investment in i needed to increase potential value added in i by one dollar per year. The capacity discount factor r is merely shorthand for $1 - \delta$. We ignore capacity under construction at time of attack (or assume none survives) and set $y_i(t) = 0$ for $t < 1$. The lagged variables $y_i\,(t-1)$ in equations (18) reflect the assumption that an average two year capital gestation period applies throughout.

The system of equations (18) may be written in matrix form as

$$V(t+1) = r\,V(t) + K\,Y\,(t-1) \tag{19}$$

where K is a diagonal matrix with components or elements $1/k_i$ down the diagonal and zeros elsewhere. The constraint equations are now

$$V(t) \geq x(t)\,H + G\,Y\,(t) \tag{20}$$

where the V(t) vector changes over time in accordance with (19). We have initially

$$
\begin{aligned}
V(2) &= r\,V(1) \\
V(3) &= r\,V(2) + K\,Y(1) = r^2\,V(1) + K\,Y\,(1) \\
V(4) &= r\,V(3) + K\,Y(2) = r^3\,V(1) + K\,[r\,Y(1) + Y(2)] \\
\cdots &\qquad \cdots \qquad \cdots \qquad \cdots \qquad (21) \\
V(t) &= r^{t-1}\,V(1) + K\,[r^{t-3}\,Y(1) + r^{t-4}\,Y(2) + \cdots + Y\,(t-2)] \\
&= r^{t-1}\,V(1) + K\,r^{t-2} \sum_{s=1}^{t-2} r^{-s}\,Y(s) \\
\cdots &\qquad \cdots \qquad \cdots \qquad \cdots
\end{aligned}
$$

In order to avoid infinitely many decision vectors Y(t), it is assumed that for $t > T$, where T will be called the planning horizon or planning period, Y(t) is given by $(1 + \lambda)^{t-T}\,Y(T)$. In other words, it is assumed that Y(t) grows at a rate λ per year from $t = T$ on. In effect, we will assume that x(t) also grows at the same rate λ from $t = T$ on, but it will be useful to distinguish the growth in x from that in Y. We will therefore set $x(t) = (1 + \mu)^{t-T}\,x(T)$ for $t > T$ and will find that we must take $\lambda \geq \mu$. The strong inequality $\lambda > \mu$ makes poor sense economically (although it may characterize growth policy in centrally planned economies) because there is really no economic reason for expanding capital faster than needed to cover anticipated noninvestment demand. The distinction between λ and μ is thus introduced only to clarify the mathematical analysis.

If we replace $Y\,(T + \tau)$ by $(1 + \lambda)^{\tau}\,Y(T)$ for $\tau \geq 0$, equations (7) may be written for $t \geq T$ as follows:

$$V(T) = r^{T-1}\, V(1) + K\, r^{T-2} \sum_{s=1}^{T-2} r^{-s}\, Y(s)$$

$$V(T+1) = r^{T}\, V(1) + K\, r^{T-1} \sum_{s=1}^{T-1} r^{-s}\, Y(s)$$

$$V(T+2) = r^{T+1}\, V(1) + K r^{T} \sum_{s=1}^{T-1} r^{-s}\, Y(s) + K\, Y\,(T) \tag{22}$$

$$V(T+3) = r^{T+2}\, V(1) + K\, r^{T+1} \sum_{s=1}^{T-1} r^{-s}\, Y(s) + K\,[r + (1+\lambda)]\, Y(T)$$

and

$$V(T+\tau) = r^{T+\tau-1}\, V(1) + K r^{T+\tau-2} \sum_{s=1}^{T-1} r^{-s}\, Y(s) + K\,(1+\lambda)^{\tau-2} \sum_{s=0}^{\tau-2} \left(\frac{r}{1+\lambda}\right)^{s} Y(T)$$

$$= r^{T+\tau-2} \left[r\, V(1) + K \sum_{s=1}^{T-1} r^{-s}\, Y(s) \right] + K\,(1+\lambda)^{\tau-2}\, \frac{1-\left(\frac{r}{1+\lambda}\right)^{\tau-1}}{1-\left(\frac{r}{1+\lambda}\right)}\, Y(T) \tag{23}$$

or

$$V(T+\tau) = r^{T+\tau-2} \left[rV(1) + K \sum_{s=1}^{T-1} r^{-s}\, Y(s) \right] + K\, \frac{(1+\lambda)^{\tau-1} - r^{\tau-1}}{\lambda+\delta}\, Y(T) \tag{24}$$

since

$$(1+\lambda) - r = 1 + \lambda - (1-\delta)$$

$$= \lambda + \delta$$

The constraints for $t \geq T$ now become

$$V\,(T+\tau) \geq (1+\mu)^{\tau}\, x\,(T)\, H + (1+\lambda)^{\tau}\, G\, Y\,(T) \tag{25}$$

from (20). Making use of (24) we have

$$r^{T+\tau-2} \left[r\, V(1) + K \sum_{s=1}^{T-1} r^{-s}\, Y(s) \right] + K\, \frac{(1+\lambda)^{\tau-1} - r^{\tau-1}}{\lambda+\delta}\, K\, Y\,(T)$$

$$\geq (1+\mu)^{\tau}\, x\,(T)\, H - (1+\lambda)^{\tau}\, G\, Y\,(T) \tag{26}$$

or

$$r^{T+\tau-2}\left[rV(1) + K\sum_{s=1}^{T-1} r^{-s}\, Y(s)\right] + \frac{(1+\lambda)^{\tau-1} - r^{\tau-1}}{\lambda+\delta}\, K\, Y\,(T)$$

$$- (1 + \mu)^{\tau}\, x\,(T)\, H - (1 + \lambda)^{\tau}\, G\, Y\,(T) \geq 0 \qquad (27)$$

Dividing (27) through by $(1 + \lambda)^{\tau-1}$ gives

$$r^{T-1}\left(\frac{r}{1+\lambda}\right)^{\tau-1}\left[rV(1) + K\sum_{s=1}^{T-1} r^{-s}\, Y(s)\right] + \frac{1-\left(\frac{r}{1+\lambda}\right)^{\tau-1}}{\lambda+\delta}\, K\, Y\,(T) \qquad (28)$$

$$- (1 + \mu)\left(\frac{1+\mu}{1+\lambda}\right)^{\tau-1} x\ (T)\ H\ -\ (1 + \lambda)\, G\, Y\,(T) \geq 0$$

The expression on the left side of inequality (28) can be expressed as a function of τ as follows:

$$M(\tau) = A\left(\frac{r}{1 + \lambda}\right)^{\tau-1} + B - B\left(\frac{r}{1 + \lambda}\right)^{\tau-1} - C\left(\frac{1 + \mu}{1 + \lambda}\right)^{\tau-1} - D \geq 0 \qquad (29)$$

where

$$A = r^{T-1}\left[rV(1) + K\sum_{s=1}^{T-1} r^{-s}\, Y(s)\right] = V\,(T + 1) \qquad (30)$$

$$B = K\, Y\,(T)/(\lambda + \delta) \qquad (31)$$

$$C = (1 + \mu)\, x\,(T)\, H \qquad (32)$$

and

$$D = (1 + \lambda)\, G\, Y\,(T) \qquad (33)$$

Hence $M\,(1) = A + B - B - C - D = A - C - D \geq 0$ from (25) and the second equation of (22) because $A = V\,(T + 1)$ and $C + D$ is the right hand side of (25) with $\tau = 1$.

$$M(\tau + 1) = \left(A - B\right)\left(\frac{r}{1 + \lambda}\right)^{\tau} - C\left(\frac{1 + \mu}{1 + \lambda}\right)^{\tau} + B - D \tag{34}$$

$$M(\tau + 1) - M(\tau) = \left(A - B\right)\left(\frac{r}{1 + \lambda}\right)^{\tau-1}\left(\frac{r}{1 + \lambda} - 1\right) - C\left(\frac{1 + \mu}{1 + \lambda}\right)^{\tau-1}\left(\frac{1 + \mu}{1 + \lambda} - 1\right)$$

$$= \left(A - B\right)\left(\frac{r}{1 + \lambda}\right)^{\tau-1}\frac{1-\delta-1-\lambda}{1 + \lambda} - C\left(\frac{1 + \mu}{1 + \lambda}\right)^{\tau-1}\frac{\mu - \lambda}{1 + \lambda}$$

$$= \left(B - A\right)\frac{\delta + \lambda}{1 + \lambda}\left(\frac{r}{1 + \lambda}\right)^{\tau-1} + C\,\frac{\lambda - \mu}{1 + \lambda}\left(\frac{1 + \mu}{1 + \lambda}\right)^{\tau-1}$$

$$= \frac{r^{\tau-1}}{(1 + \lambda)}\tau\left\{(B - A)(\delta + \lambda) + (\lambda - \mu)\left(\frac{1 + \mu}{r}\right)^{\tau-1} C\right\} \tag{35}$$

$M(\tau + 1) - M(\tau) \geq 0$ if and only if

$$(B - A)\ (\delta + \lambda) \geq (\mu - \lambda)\left(\frac{1 + \mu}{r}\right)^{\tau-1} C \tag{36}$$

Since $(1 + \mu) > 1 > r = 1 - \delta$, the right hand side of (36) increases in absolute value with τ. If $\mu > \lambda$ then the right hand side would eventually exceed the left hand side even if $B - A$ is positive. For $M(\tau + 1)$ to be greater than $M(\tau)$, that is, for $M(\tau)$ to be monotone increasing we must have $\mu \leq \lambda$ and hence $(\mu - \lambda) \leq 0$. If $\mu = \lambda$ (36) merely requires that $B \geq A$ or from (30) and (31) that

$$K\ Y\ (T) \geq (\lambda + \delta)\ r^{T-1}\left[r\ V(1) + K\sum_{s=1}^{T-1} r^{-s}\ Y(s)\right] \tag{38}$$

or from (22) that

$$K\ Y\ (T) \geq (\lambda + \delta)\ V\ (T + 1) \tag{40}$$

which states that Y (T) must be large enough to meet retirement losses and growth requirements. If on the other hand $\mu < \lambda$ so that $\mu - \lambda < 0$ then (36) requires that $C \geq \frac{\delta + \lambda}{\lambda - \mu}\left(A - B\right)\left(\frac{r}{1 + \mu}\right)^{\tau-1}$.

Since $1 - \delta = r < (1 + \mu)$ the final inequality is satisfied for all $\tau > 1$ if it is satisfied for $\tau = 1$, that is if

$$C \geq \frac{\delta + \lambda}{\lambda - \mu} (A - B) \qquad (41)$$

or

$$B - A \geq - \frac{\lambda - \mu}{\delta + \lambda} C \qquad (42)$$

or

$$B \geq A - \frac{\lambda - \mu}{\delta + \lambda} \qquad (43)$$

$$K\, Y(T) \geq (\delta + \lambda)\ V(T + 1) - (\lambda - \mu)(1 + \mu)\, x(T)\, H \qquad (44)$$

If (40) is satisfied, so is (44) and $M(\tau)$ is monotone increasing, but (44) implies (40) only if $\lambda = \mu$. The general case (44), however, applies for all $\lambda \geq \mu$, and insures that the inequalities $M(\tau) > 0$, holds for all T if the inequality (25) holds for $T = 1$. In summary we require

$$V(1) \geq x(1)\, H + G\, Y(1)$$

$$V(2) = r\, V(1) \geq x(2)\, H + G\, Y(2)$$

$$\ldots \qquad \ldots \qquad \ldots \qquad \ldots$$

$$V(t) = r^{t-2} \left[r\, V(1) + K \sum_{s=1}^{t-2} r^{-s}\, Y(s) \right] \geq x(t)\, H + G\, Y(t)$$

$$\ldots \qquad \ldots \qquad \ldots\ldots \qquad \ldots$$

$$V(T) = r^{T-2} \left[r\, V(1) + K \sum_{s=1}^{T-2} r^{-s}\, Y(s) \right] \geq x(T)\, H + G\, Y(T)$$

$$V(T+1) = r^{T-1} \left[r\, V(1) + \sum_{s=1}^{T-1} r^{-s}\, Y(s) \right]$$

$$\geq (1 + \mu)\, x(T)\, H + (1 + \lambda)\, G\, Y(T) \qquad (45)$$

and the monotonicity constraint (44)

$$K\, Y(T) \geq (\delta + \lambda)\ V(T + 1) + (\mu - \lambda)(1 + \mu)\, x(T)\, H$$

or

$$K\,Y\,(T) \geq (\delta + \lambda)\, r^{T-1}\; r\, V(1) +$$

$$K \sum_{s=1}^{T-1} r^{-s}\, Y(s) - (\lambda - \mu)(1 + \mu)\, x\,(T)\, H \tag{46}$$

Note that in case $\lambda = \mu$, the meaningful case, when (46) reduces to (40) we have

$$\begin{aligned} K\,Y\,(T) &\geq (\lambda + \delta)\, V\,(T + 1) \\ &\geq (\lambda + \delta)\,(1 + \lambda)\left[x\,(T)\,H + G\,Y\,(T)\right] \end{aligned} \tag{47}$$

If the matrix K reduces to a single scalar $\frac{1}{k}$ and we sum all components on both sides of (47),

$$(T) \geq k\,(\lambda+\delta)(1+\lambda)\,(GNP)_T \tag{48}$$

where y(T) is total investment. We thus conclude that the fraction of GNP invested in the horizon year must exceed $k\,(\lambda + \delta)\,(1 + \lambda)$.

This completes the discussion of the constraints imposed on the linear programming formulation used. The objective function maximized under these constraints has been taken to be the present value of the future stream of GNP or some variant of this. If ρ is the discount factor, the linear objective function when defined as the present value of future GNP becomes

$$\begin{aligned} S = {} & x(1) + \rho\, x\,(2) + \cdots + \rho^{T-2}\, x\,(T-1) + \rho^{T-1}\, x\,(T) \sum_{s=0}^{\infty} (\rho\mu)^s \\ & + y(1) + \rho y(2) + \cdots + \rho^{T-1}\, y(T) \sum_{s=0}^{\infty} (\rho\lambda)^s \end{aligned} \tag{49}$$

where y(t) is the total investment in year t.

Summing the geometric series in (48) gives

$$S = \sum_{s=1}^{T-1} \rho^{s-1}\left[x(s) + y(s)\right] + \rho^{T-1}\left[\frac{x(T)}{1-\rho\mu} + \frac{y(T)}{1-\rho\lambda}\right] \tag{50}$$

Appendix C

DERIVATION OF DATA USED IN THE MODELS

This appendix presents the data used in the models and computer programs and indicates how these data were derived. The data include the input-output matrices, the final demand vectors and the Cobb-Douglas production function coefficients. Aggregated versions of all the I-O tables were used based on the classifications of industries into major sectors as shown. The data for the 1972 runs were different from those for the seven sector 1971 runs. Those used in the 1971 runs are shown first; those used in the 1972 runs follow. Some data considered for the models but not used are also shown for purpose of comparison or general interest. For reading convenience, all tables have been placed in sequence at the end of this appendix.

Data used for the 1971 runs

Table C-1 shows the composition of the six economic sectors assumed to be at risk as well as that of the diffuse residual treated as not at risk. It indicates the assignment of industries to these sectors for both the U.S. and the USSR. However, none of the runs in 1971 used the Soviet data. U.S. industries are numbered in accordance with the system used for the BEA's I-O tables for 1958 and 1963. Soviet industries are identified by numbers used in Treml's 38 sector I-O table for 1959.

Table C-2 shows the precent damage to the six sectors at risk for attack levels increasing in weight from 225 to 1,000 reliably delivered weapons. The final column of this table shows percent damage to a weighted composite of all sectors. Table C-2 first shows the results obtained when the attack is optimized against finished nonmetals, the first of the sectors at risk. Subsequent groups select other sectors for attack optimization. The final group in Table C-1 is similar to the other groups except that the attack has been optimized against the weighted composite of all sectors.

Table C-3 shows the percentages of capacity surviving attacks for 250, 500 and 1,000 reliably delivered weapons. It has been computed as the complement of the damage level estimates in Table C-2.

Table C-4 shows the value added surviving by sector expressed as a percentage of preattack GNP. This has been obtained from Table C-3 by taking a weighted geometric mean of the percentage of capacity and labor forces surviving. Surviving labor force has been taken to be proportional to surviving population and is also proportional to the capacity surviving in the services sector. The weights used in the geometric average are shown below in Table C-5. More precisely, Table C-5 gives the coefficient, s, in the Cobb-Douglas production function relation for the U.S. The equation used is

$$\log V = \text{constant} + s \log L + (1-s) \log K$$

where V is value added, L is labor input and K is capital input. The percentage changes in V due to loss ΔL and ΔK in inputs L and K are given by

$$\log \left(1-\frac{\Delta V}{V}\right) = s \log \left(1-\frac{\Delta L}{L}\right) + (1-s) \log \left(1- \frac{\Delta K}{K}\right)$$

from which $\frac{\Delta V}{V} \quad s\frac{\Delta L}{L} + (1-s) \frac{\Delta K}{K}$ for small changes. Table C-6 gives the coefficient, s, for the USSR.

Table C-7 shows alternate sources of estimates of s for both the U.S. and the USSR to indicate degree of uncertainty.

Table C-8 shows the aggregated version of the U.S. (BEA) interindustry transaction table for 1963. Table C-9 gives the matrix multiplier that converts value added to final demand, the modified direct requirements coefficient matrix. Table C-10 gives the inverse of the matrix in Table C-9 and represents the total (value added) requirements per dollar of final demand. This is the matrix E^{-1} referred to in Appendix B.

Table C-11 shows the aggregated version of the USSR interindustry transaction table for 1959. Table C-12 converts this to a matrix of direct requirements coefficients referred to as E in Appendix B. Table C-13 is in the inverse of the matrix E.

Table C-14 shows per capita final demand in 1958 dollars for the OEP recovery levels and for 1958 as actually observed. Since the OEP data are not available for 1963, the ratios derived below from Table C-14 are not as recent as might be generated if the OEP study were repeated.

Table C-15 distributes the final demand generated by capital investment among the seven aggregated sectors and sums these demands for each of the seven aggregates.

Table C-16 similarly distributes that part of final demand remaining after excluding investment demand and aggregates the demand for each of the seven major sectors.

Table C-17 summarizes Tables C-14 through C-16 showing for the seven aggregates the final demand for 1958 and for the OEP recovery vector data. These final demands are then expressed as percentages of their respective totals. The percentages thus obtained are used for the vectors H and G of Appendix B, the noninvestment demand representing H and the investment demand representing G. The 1971 run used the recovery vector versions of these percentages but the 1958 actual values are shown for comparison.

The values of δ and k used in the models were intended to bracket plausible values while relating properly to historical growth rates. The simple equation of the one variable model of economic recovery which is also basic to the models used is

$$(GNP)_{t+1} = (1 - \delta)\ (GNP)_t = \frac{f}{k}\ (GNP)_{t-1}$$

where f is the fraction of GNP invested, k is the cost of capital per dollar of incremental GNP and δ is the depreciation rate. This equation is a second order difference equation leading to a constant growth rate. Let $r = (GNP)_{t=1}/(GNP)_t$ so that $r - 1+g$ where g is the growth rate. Then the basic equation above transforms into

$$\left[r^2 - (1 - \delta)r - \frac{f}{k}\right]\ (GNP)_{t-1} = C(GNP)_{t-1} = 0$$

from which $C = r^2 - (1 - \delta)r - \frac{f}{k}$ must vanish. Replacing r by (1+g) gives

$$1+2g+g^2-1-g+\delta + \delta g - \frac{f}{k} = 0 \quad \text{or} \quad (g+\delta)\ (1+g) = \frac{f}{k}$$

This equation* relates k and δ to the more readily established parameters f and g.

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* Note the similarity of this equation to the inequality (48) of Appendix B when $g = \lambda = \mu$ and $f = y(T)/(GNP)_T$.

For the U.S. for the period 1952-1972, investment measured by gross private domestic capital formation has averaged 15.2 percent of GNP and the growth rate g has averaged 3.4 percent. An imprecise estimate of average depreciation can be obtained by dividing capital consumption allowances by gross capital stocks both in constant dollars. This gave a rather high figure of 6.6 percent for δ . Substituting these values for δ , g and f in $k = f/\left[(g+\delta)(1+g)\right]$ gives $k = 1.47$ which is rather low. On the other hand, allowing for possible increases in k for postattack inefficiencies and increases in real (constant dollar) costs suggests using a k of 2. This value could be inserted in the equation $g+\delta = f/\left[k(1+g)\right]$ to obtain $g+\delta = .074$ for a δ of 4 percent.

In general higher k values correspond to lower δ values, but the plausible ranges seem to be $1.5 < k < 2.0$ and $.040 < \delta < .064$.

The input-output tables for the USSR are based on an aggregate called national income in Soviet accounts but referred to by A. Becker as net material product (NMP) to distinguish it from the concept of national income as used in the U.S. As defined by the USSR, NMP differs from GNP by the exclusion of many services classified as non-productive and approximates the net production of material end-products The estimates for δ, k, f and g for the USSR are similar to those for the U.S. except with NMP used instead of GNP. In constant rubles, NMP has grown at an average annual rate of 7.2 percent and the fraction invested has averaged 26.2 percent. Data are given on capital depreciation in the 1966 Soviet input-output tables. With the exception of one sector, sector rates (also available) were either 7.2 percent or 7.6 percent. Using the average value of 7.3 percent gave a k of 1.67. Retaining g = .073 and f = .262, imputed depreciation rates of 9 and 5 percent are obtained corresponding to k values of 1.5 and 2.0 respectively.

Data Used in the 1972 Runs

The 1972 runs increased the number of economic sectors from the seven sectors used in the 1971 runs. These were generated as aggregates of industries in the BEA I-O tables for the U.S. for 1963 and in Treml's 1966 tables for the USSR. The classification of industries into aggregated sectors for the U.S. is shown in Table C-18; that for the USSR is shown in Table C-19. Individual industries are designated by numbers as used in the 1963 U.S. tables and the 1966 Soviet tables. The 15 aggregated sectors used for the U.S. and the 16 used for the USSR are given descriptors intended to indicate their coverage, but do not represent any established nomenclature. Tables C-20 and 21 give the aggregated versions of the U.S. and Soviet transactions tables. Table C-22 shows the matrix multiplier (E) that can be used to convert final demand into value added for the U.S. Table C-23 similarly shows the E matrix for the USSR. Table C-24 shows the inverse E^{-1} of the E matrix of Table C-22. Similarly Table C-25 shows the inverse of the Soviet E matrix given in Table C-23.

Table C-26 shows the vectors H and G used for the U.S. as described in Appendix B. The H vector shows the allocation of one dollars worth on noninvestment final demand among supplying sectors and is derived from Table C-20 by subtracting gross private domestic investment from total final demand and then normalizing so that the components of H add to unity. The G vector is similarly derived from Table C-20 and shows the allocation among supplying sectors of one dollar investment in gross private domestic capital formation. The last two columns of Table C-26 show, for purposes of comparison, rounded versions of G as obtained from the 1958 and 1963 U.S. I-O tables. Aggregated sector number one, the diffuse sector, shows an appreciable increase over the five year span involved, at the expense of most of the other sectors. Table C-27 shows the results of aggregating (to 15 sectors) the 1958 capital flow matrix. Were such data available for 1963 or later years, the equivalent of Table C-27 could be used as a matrix $G = (g_{ij})$. The 1972 runs used instead a matrix with 15 identical columns as given by the G vector of Table C-26. To facilitate comparison, the last column of Table C-27 repeats that column of Table C-26 derived from an aggregation of the 1958 U.S. I-O transactions table. Although the individual columns of Table C-27 differ from the average values shown in the final column, the change in the latter from 1958 to 1963 (as shown in Table C-26) are more significant than the column differences in Table C-27. An adequate G matrix for 1963 or later years could provide a desirable improvement over the vector (i.e. the matrix with 15 identical columns) actually used. No such detailed data have appeared for the USSR.

Table C-28 shows the vectors used for H and G for the USSR. These were derived from the 1966 I-O tables for the USSR, Table C-21, by a somewhat inferential calculation. Although the 1959 I-O tables gave a suitable breakdown of total final demand between investment and other final demand, the 1966 tables showed merely public and private consumption and other final demand. The latter presumably includes net exports and inventory change as well as investment. Some adjustments were therefore made to other final demand based on the 1959 data to better represent investment alone. The G vector was calculated first and the investments so inferred were subtracted from the total final demand before calculating the H (or noninvestment) vector.

Table C-29 indicates the calculations and results of estimating the Cobb-Douglas coefficients for the U.S. for 1963. These were obtained simply by taking the labor coefficient s to be the ratio, by individual sectors, of the compensation of employees to the value added. Table C-29 also shows the labor requirements coefficients used in the labor constraint. These were obtained simply by dividing, for each sector, the number of full time equivalent employees by the value added.

Table C-30 shows the calculation of the Cobb-Douglas coefficient for the USSR obtained by dividing wages by value added for each sector as obtained from the 1966 I-O tables. These tables also showed depreciation charges and total capital. Dividing depreciation by capital gave estimates of the Soviet depreciation rate as developed in the last three columns of Table C-30. The depreciation rates and the capital cost per dollar of increased output (NMP) actually used were treated as variable parameters in both the U.S. and Soviet runs and the values used are indicated separately for each run. In general the larger k value of 2 dollars (rubles) per dollar (ruble) of increased GNP (NMP) was used to reflect postattack inefficiency with lower depreciation rates, δ, of from 4 to 6 percent.

Table C-1

ASSIGNMENT OF INDUSTRIES TO AGGREGATED SECTORS
(The 7 sectors used in the 1971 runs)

Aggregated Sector		U.S. Input-Output Sector		USSR Input-Output Sector	
Description	Symbol	Number 1/	Description	Number 2/	Description
Finished nonmetals	FN	14-15	Food and tobacco	25	Lumber and woodworking
		18-19	Apparel, miscellaneous fabricated textiles	30	Apparel and footwear
		22-23	Furniture	31	Food
Basic nonmetals	BN	16-17	Fabrics and textiles	21	Abrasives
		20-21	Lumber, wood & wooden containers	22	Mineral & basic chemicals
		24-25	Paper & paperboard containers	23	Synthetics, paints
		26	Painting & publishing	24	Rubber
		27-30	Chemicals, plastics, drugs & paints	26	Paper
		32-34	Rubber, leather, & footwear	27	Construction materials
		35-36	Glass, stone, and clay	28	Glass
				29	Textiles
				32	Industries n.e.c.
Services	SV	65	Transportation & machinery		
		66	Communications		
		67	Radio & TV broadcasting		
		69	Trade	20	Repair of machinery
		70-71	Finance, insurance, & real estate	36	Transportation and Communication
		72-77	Other services	37	Trade & distribution
		78-79	Government enterprises	38	Products n.e.c.
		80-87	Miscellaneous including imports, government & dummy industries		

1/ Survey of Current Business, September 1965/Vol. 45, No. 9; November 1969/Vol. 49, No.11; July 1971/ Vol. 51, No. 7, Part I, United States Department of Commerce/Office of Business Economics.
2/ Annual Economic Indicators for the U.S.S.R. JEC, Congress of the United States, February 1964.

Table C-1 (continued)

Aggregated Sector		U.S. Input-Output Sector		USSR Input-Output Sector	
Description	Symbol	Number[1/]	Description	Number[2/]	Description
Finished mentals	FM	13	Ordnance	6	Metal products
				12-19	Machinery, transportation equipment, other equipment and metalworking
		39-64	Durables fabricated from metal including transportation, & industrial equipment, machinery, appliances		
Basic metals	BM	37-38	Primary ferrous and non-ferrous metals	2	Ferrous metals
				4	Nonferrous metals
Energy	EN	31	Petroleum refining & related industries	8	Oil
Diffuse residual	DR	1-3	Agriculture & forestry	1,3	Ferrous & nonferrous ores
		5-10	Mining	5	Coking coal
		11-12	Construction	9,10	Gas, other fuels
		68	Electric, gas, water & sanitary services	11	Electrical power
				33	Construction
				34	Agriculture
				35	Forestry

1/ Ibid.
2/ Ibid.

Table C-2

PERCENT DAMAGE TO ECONOMIC SECTORS WHEN ATTACK IS OPTIMIZED AGAINST SELECTED SECTORS*

Attack Optimized Against	No. of Reliably Delivered Weapons	Percent damage to: FN	BN	SV	FM	BM	EN	Weighted Composite
FN	250	44.146%	33.236%	24.048%	47.182%	32.805%	28.803%	39.770%
	500	55.220	43.453	34.690	62.000	47.634	41.453	52.463
	750	60.660	50.407	41.492	68.995	55.871	49.568	59.193
	1000	63.858	54.151	46.259	73.319	63.149	56.002	63.442
BN	250	38.278	39.044	23.753	46.393	34.541	39.429	40.747
	500	50.234	49.707	34.090	59.443	46.098	53.030	52.506
	750	56.101	55.257	40.668	67.525	57.30[illegible]	60.855	59.695
	1000	60.116	58.607	45.323	71.979	63.9[illegible]0	65.030	63.869
SV	250	39.281	33.079	26.436	49.388	37.506	34.462	40.818
	500	51.522	45.599	37.354	63.872	53.126	46.899	54.152
	750	58.026	51.403	44.258	70.814	62.100	55.317	60.756
	1000	61.647	55.362	48.997	75.012	67.961	60.065	64.871
FM	250	37.190	31.502	22.837	56.906	34.719	30.464	43.326
	500	49.341	42.122	33.828	69.100	50.415	41.199	55.032
	750	55.586	48.058	40.483	74.846	58.526	47.038	60.953
	1000	59.509	51.956	45.220	78.176	65.704	53.820	64.842
BM	250	27.659	24.482	18.809	36.656	57.630	29.140	33.084
	500	37.899	34.193	27.694	50.617	69.533	41.845	44.821
	750	46.063	41.889	34.292	59.707	75.157	52.438	52.831
	1000	50.680	45.810	38.640	64.515	78.361	58.329	57.101
EN	225	23.506	22.643	14.707	30.213	27.948	90.000**	26.842
	425	30.735	29.312	20.689	39.459	38.802	99.000**	34.952
Weighted Composite	250	39.580	35.068	24.290	55.081	44.308	38.846	44.814
	500	51.589	46.812	34.974	67.393	59.218	52.291	56.856
	750	58.008	52.942	41.961	73.440	67.127	60.477	63.007
	1000	61.776	56.723	46.697	77.060	71.715	64.951	66.704

* Industries included in aggregated sectors are shown in Table C-1
FN = Finished nonmetals, BN = Basic nonmetals, SV = Services, FM = Finished metals, BM = Basic metals, EN = Energy = Petroleum refining.

** Based on estimate of percent damage to petroleum refineries from the joint effects of 225 or 425 weapons with reliability factor of 0.8 directed against refineries in SMSA's and 25 or 75 similar weapons directed against largest refineries outside the SMSA's.

Table C-3

PERCENTAGE OF CAPACITY SURVIVING VARIOUS ATTACKS DIRECTED AGAINST ALTERNATIVE TARGET SYSTEMS*

Attack optimized against:

No. of Weapons	Sector	FN	BN	SV	FM	BM	EN	Weighted Composite
250	FN	55.854%	61.722%	60.719%	62.810%	72.341%	76.494%	60.420%
	BN	66.764	60.956	66.921	68.498	75.518	77.357	64.932
	SV	75.952	76.247	73.564	77.163	81.191	85.293	75.710
	FM	52.868	53.607	50.612	43.094	63.344	69.787	44.919
	BM	67.195	65.459	62.494	65.281	42.370	72.052	55.692
	EN	71.197	60.571	65.538	69.536	70.860	10.000	61.154
	DR	100.000	100.000	100.000	100.000	100.000	100.000	100.000
Weighted Composite		60.230	59.253	59.182	56.674	66.916	73.158	55.186
500	FN	44.780	49.766	48.478	50.659	62.101	69.265	48.411
	BN	56.537	50.293	54.401	57.878	65.807	70.688	53.188
	SV	65.310	65.910	62.646	66.172	72.306	79.311	65.026
	FM	38.000	40.557	36.128	30.900	49.383	60.541	32.607
	BM	52.366	53.902	46.874	49.585	30.467	61.853	40.782
	EN	58.547	46.970	53.101	58.801	58.155	1.000	47.709
	DR	100.000	100.000	100.000	100.000	100.000	100.000	100.000
Weighted Composite		47.537	47.494	45.848	44.968	55.179	65.048	43.144
1,000	FN	36.142	39.884	38.353	40.491	49.320	**	38.224
	BN	45.849	41.393	44.638	48.044	54.190	**	43.277
	SV	53.741	54.677	51.003	54.780	61.360	**	53.303
	FM	26.681	28.021	24.988	21.824	35.485	**	22.940
	BM	36.851	36.040	32.039	34.296	21.639	**	28.285
	EN	43.998	34.970	39.935	46.180	41.671	**	35.049
	DR	100.000	100.000	100.000	100.000	100.000	**	100.000
Weighted Composite		36.558	36.131	35.129	35.158	42.899	**	33.296

* Derived from Table 1 using lines for 250, 500 and 1,000 weapons except for attack against EN which uses the line for 225 weapons and an estimate for damage to EN by 250 weapons, and the line for 425 weapons and an estimate for damage to EN by 500 weapons.

** Not applicable because approximately 500 weapons suffice to complete destruction of petroleum refineries, the principal type of facility included in EN.

Table C-4

PERCENTAGES OF VALUE ADDED SURVIVING*

No. of Weapons	Sector	Attack optimized against: FN	BN	SV	FM	BM	EN	Weighted Composite	Preattack value added as a percentage of preattack GNP
250	FN	65.937%	69.187%	67.349%	70.193%	76.945%	81.128%	68.247%	5.67%
	BN	72.600	70.500	71.167	74.015	79.158	82.427	71.748	8.32
	SV	75.952	76.247	73.563	77.167	81.192	85.294	75.710	56.79
	FM	69.124	69.573	66.748	66.321	76.117	80.958	66.100	11.66
	BM	72.855	72.393	69.597	72.900	65.085	80.540	68.205	2.44
	EN	73.110	66.566	68.718	72.568	74.927	24.083	66.748	0.86
	DR	90.076	90.208	88.988	90.620	92.388	94.135	89.966	14.34
500	FN	54.903	57.919	55.676	58.520	67.420	74.522	56.774	5.67
	BN	62.096	59.959	59.627	63.143	69.962	76.180	60.610	8.32
	SV	65.310	65.910	62.646	66.171	72.307	79.312	65.027	56.79
	FM	56.733	58.093	54.293	54.286	65.482	73.933	54.344	11.66
	BM	60.586	61.554	56.764	59.987	53.896	72.882	55.489	2.44
	EN	61.231	53.969	56.816	61.717	63.586	6.008	54.168	0.86
	DR	85.053	85.350	83.718	85.478	88.408	91.570	84.912	14.34
1000	FN	44.777	47.292	44.735	47.669	55.495	**	45.742	5.61
	BN	50.836	49.603	48.682	52.320	58.749	**	49.554	8.32
	SV	53.741	54.678	51.003	54.780	61.360	**	53.304	56.79
	FM	44.796	45.954	42.367	43.122	53.218	**	42.810	11.66
	BM	47.270	47.452	43.546	46.717	43.052	**	42.972	2.44
	EN	47.759	42.003	44.150	49.529	48.834	**	41.623	0.86
	DR	78.980	79.500	77.427	79.558	81.170	**	78.735	14.34

* Calculated by taking weighted geometric average of percentage of surviving labor force and of surviving capacity from Table C-3.

** Not applicable because about 500 weapons suffice.

Table C-5

COBB-DOUGLAS PRODUCTION FUNCTION DATA FOR THE U.S.

Sector	Percentage of Total Value Added*	Substitution Parameters	
		s	1-s
Finished Nonmetal	5.7%	.54	.46
Basic Nonmetal	8.3	.65	.35
Services	56.8	.58	.42
Finished Metal	11.7	.74	.26
Basic Metal	2.4	.66	.34
Energy	0.9	.41	.59
Diffuse Residual	14.3	.38	.62

* Total value added is GNP

Table C-6

COBB-DOUGLAS PRODUCTION FUNCTION DATA FOR THE USSR

Sector	Percentage of Total Value Added*	Substitution Parameters	
		s	1-s
Finished Nonmetal	20.9%	0.46	0.54
Basic Nonmetal	14.7	0.55	0.45
Services	14.4	0.54	0.46
Finished Metal	10.0	0.61	0.39
Basic Metal	2.4	0.53	0.47
Energy	2.2	0.17	0.83
Diffuse Residual	35.3	0.54	0.46

* Total value added is GNP

Table C-7

COMPARISON OF ALTERNATIVE ESTIMATES
OF COBB-DOUGLAS SUBSTITUTION PARAMETERS "s"

U.S. Data	FN	BN	SV	FM	BM	EN	DR
Strell	.79	.59	.71	.79	.81	.52	n.a.
OBE	.539	.653	.584	.744	.658	.406	.380
Used	.54	.65	.58	.74	.66	.41	.38
USSR Data							
Strell	.48	.57	.54	.61	.53	.52	n.a.
Judith Thornton, revised classes	.46	.55	.39	.61	.53	.17	.54
Treml, labor cost data	.22	.22	.52	.41	.51	.09	.66
Used	.46	.55	.54	.61	.53	.17	.54

Table C-8

AGGREGATION OF INTERINDUSTRY TRANSACTIONS FOR THE U.S.
(In millions of 1963 dollars)

Supplying Sector	Purchasing Sector							Total Intermediate Output	Final Demand	Total
	FN	BN	SV	FM	BM	EN	DR			
FN	18822	1583	4208	959	33	28	4320	29953	78928	108881
BN	13541	41199	16452	9265	956	895	16022	98330	25207	123537
SV	14642	19200	92858	17874	6992	3340	35934	190840	292965	483805
FM	3063	2953	8742	53341	1967	23	13611	83700	89570	173270
BM	334	705	658	21136	10447	184	4136	37600	1290	38890
EN	241	1742	4191	493	239	1622	3209	11737	10100	21837
DR	24786	7021	21425	1351	3824	10646	31127	100180	92836	193016
Total Intermediate Inputs	75429	74403	148534	104419	24458	16738	108359	552340		
Value Added	33452	49134	335271	68851	14432	5099	84657		590896*	
Total	108881	123537	483805	173270	38890	21837	193016			1143236
Value added as % GNP	5.6661	8.3223	56.7881	11.6620	2.4445	0.8637	14.3392		100.0859*	
Final demand as % GNP	13.3688	4.2696	49.6224	15.1713	0.2185	1.7107	15.7245		100.0858*	

* Total final demand which equals total value added differs from GNP (of 590389) by -507 millions in transactions not distributed to sectors.

Table C-9

THE INPUT-OUTPUT E MATRIX FOR THE U.S.

Sector	FN	BN	SV	FM	BM	EN	DR
FN	2.69222	-.03221	-.01255	-.01392	-.00229	-.00548	-.05103
BN	-.40481	1.67576	-.04908	-.13456	-.06624	-.17555	-.18926
SV	-.43772	-.39077	1.16606	-.25961	-.48448	-.65503	-.42446
FM	-.09156	-.06009	-.02608	1.74187	-.13630	-.00450	-.16078
BM	-.00999	-.01436	-.00196	-.30698	1.97082	-.03610	-.04886
EN	-.00719	-.03545	-.01250	-.00717	-.01657	3.96454	-.03792
DR	-.74094	-.14289	-.06390	-.01963	-.26497	-2.08788	1.91229

Table C-10

THE INVERSE, E^{-1}, OF THE INPUT-OUTPUT E MATRIX FOR THE U.S.

Sector	FN	BN	SV	FM	BM	EN	DR
FN	.37765	.01006	.00543	.00555	.00432	.00877	.01303
BN	.12298	.61810	.03402	.06295	.04502	.07575	.07995
SV	.26393	.25193	.89368	.20837	.28048	.29940	.26096
FM	.04502	.03286	.01888	.59035	.05507	.03763	.06043
BM	.01442	.01174	.00514	.09360	.51896	.01896	.02419
EN	.00440	.00710	.00356	.00303	.00444	.25691	.00707
DR	.17160	.06823	.03930	.03616	.09173	.30258	.55437

Table C-11

AGGREGATION OF INTERINDUSTRY TRANSACTIONS FOR THE USSR
(In millions of rubles)

Supplying Sector	Purchasing Sector							Total Inter-mediate Output	Final Demand	Total
	FN	BN	SV	FM	BM	EN	DR			
FN	19487.2	2119.2	688.4	501.2	128.5	16.0	6036.0	28976.5	57356.5	86333.0
BN	8010.6	11584.1	1991.4	1650.9	120.0	65.1	6798.1	30220.2	18653.2	48873.4
SV	8248.1	5595.4	368.1	1441.8	1202.8	1897.2	7065.4	25818.8	3551.3	29370.1
FM	578.7	771.8	1575.3	3771.3	217.7	60.6	3714.1	10689.5	16736.7	27426.2
BM	114.0	545.0	624.5	4107.3	1958.4	11.1	1458.8	8819.1	1480.0	10300.0
EN	488.2	381.3	1057.4	176.8	173.3	1066.5	1719.8	5063.3	1639.7	6703.0
DR	17671.3	5594.5	1229.0	618.1	2886.2	182.4	16236.4	44417.9	52104.4	96522.3
Total Intermediate Inputs	54598.1	26591.2	7534.1	12267.4	6686.9	3298.9	43028.6	154005.3		
Value Added	31734.9	22282.2	21836.0	15158.8	3613.1	3404.1	53493.7		151522.7	
Total	86333.0	48873.4	29370.1	27426.2	10300.0	6703.0	96522.3			305528.0
Value added as % GNP	20.9440	14.7055	14.4110	10.0043	2.3845	2.2466	35.3041		100.0000	
Final demand as % GNP	37.8534	12.3105	2.3437	11.0457	0.9773	1.0821	34.3872		99.9999	

Table C-12

THE INPUT-OUTPUT E MATRIX FOR THE USSR

Sector	FN	BN	SV	FM	BM	EN	DR
FN	2.10638	-.09511	-.03153	-.03306	-.03557	-.00470	-.11284
BN	-.25242	1.67350	-.09120	-.10891	-.03321	-.01912	-.12708
SV	-.25991	-.25112	1.32817	-.09511	-.33290	-.55733	-.13208
FM	-.01824	-.03464	-.07214	1.56047	-.06025	-.01780	-.06943
BM	-.00359	-.02446	-.02860	-.27095	2.30871	-.00326	-.02727
EN	-.01538	-.01711	-.04842	-.01166	-.04796	1.65580	-.03215
DR	-.55684	-.25107	-.05628	-.04077	-.79882	-.05358	1.50085

Table C-13

THE INVERSE, E^{-1}, OF THE INPUT-OUTPUT E MATRIX FOR THE USSR

Sector	FN	BN	SV	FM	BM	EN	DR
FN	.49337	.03820	.01819	.02005	.02657	.00964	.04355
BN	.10041	.62379	.05332	.05862	.04427	.02839	.06918
SV	.14665	.14996	.78982	.09488	.16327	.2727[illegible]	.10643
FM	.02469	.02780	.04130	.65358	.03784	.02266	.03925
BM	.00906	.01337	.01592	.07959	.44323	.00775	.01511
EN	.01445	.01434	.02565	.01205	.02365	.61356	.01869
DR	.21136	.13253	.05580	.08131	.26117	.04520	.70779

Table C-14

PER CAPITA FINAL DEMAND IN 1958 DOLLARS--RECOVERY LEVELS AND 1958 ACTUAL

	Sector	Personal Consumption Expenditures		Federal Government Expenditures		State & Local Government Expenditures		Subtotal		Private Fixed Capital Investment		Total Final Demand	
		Recovery	1958	Recovery	1958	Recovery	1958	Recovery	1958	Recovery	1958	Recovery	1958
1.	Livestock & Livestock Products	14.14	12.07	-.01	-.02	.04	.06	14.17	12.11			14.17	12.11
2.	Other Agricultural Products	18.93	13.88	.08	6.14	.10	.15	19.11	20.17			19.11	20.17
3.	Forestry and Fishery Products	1.37	1.61	-.52	-.78			.85	.83			.85	.83
4.	Agricultural, Forestry & Fishery Services				.26	-.32	-.39	-.32	-.13			-.32	-.13
5.	Iron & Ferroalloy Ores Mining												
6.	Nonferrous Metal Ores Mining			.17	1.10			.17	1.10			.17	1.10
7.	Coal Mining	1.41	1.49	.51		.44	.35	2.36	1.84			2.36	1.84
8.	Crude Petroleum & Natural Gas				.01				.01				.01
9.	Stone and Clay Mining and Quarrying	.93	.10	.1[illegible]	.06	.10	-.07	1.18	.09			1.18	.09
10.	Chemical & Fertilizer Mineral Mining		.01	.02	.06	.03	.07	.05	.14			.05	.14
11.	New Construction			27.91	19.37		69.01	27.91	88.38	154.98	211.32	182.99	299.70
12.	Maintenance & Repair Construction			37.95	6.18		19.09	37.95	25.27			37.95	25.27
13.	Ordnance & Accessories	.03	.90	13.78	19.04		.02	13.81	19.96			13.81	19.96
14.	Food & Kindred Products	175.81	259.47	.18	.31	1.50	1.56	177.49	261.34			177.49	261.34
15.	Tobacco Manufactures	12.54	24.30					12.54	24.30			12.54	24.30
16.	Broad & Narrow Fabrics, Yarn & Thread Mills	6.79	3.98	.67	.29	.04	.05	7.50	4.32			7.50	4.32
17.	Miscellaneous Textile Goods & Floor Coverings	2.22	4.25	.02	.03		.01	2.24	4.29	.23	.26	2.47	4.55
18.	Apparel	53.29	63.09	1.97	.23	1.43	.53	56.69	63.85			56.69	63.85
19.	Miscellaneous Fabricated Textile Products		6.30	1.19	.59			1.19	6.89			1.19	6.89
20.	Lumber & Wood Products, Except Containers	.09	.85	.17	-.03		.01	.2[illegible]	.[illegible]3		.03	.26	.86
21.	Wooden Containers			.18	.01			.18	.01			.18	.01
22.	Household Furniture	40.81	13.82	.30	.14	1.38	.33	42.49	14.29	.63	.72	43.12	15.01
23.	Other Furniture & Fixtures	10.62	.74	.40	.15	.85	.72	11.87	1.61	5.04	4.56	16.91	6.17
24.	Papers & Allied Products, Except Containers	3.52	4.85	.60	.41	.0[illegible]	.34	4.15	5.60			4.15	5.60
25.	Paperboard Containers & Boxes	.06	.22	.03	.03			.09	.25			.09	.25
26.	Printing & Publishing	7.04	13.98	.96	.53	1.14	.99	9.14	15.50			9.14	15.50
27.	Chemicals & Selected Chemical Products	1.14	1.22	5.42	4.71	2.55	1.38	9.11	7.31			9.11	7.31
28.	Plastics & Synthetic Materials	.02	.06	.07	.07			.09	.13			.09	.13
29.	Drugs, Cleaning & Toilet Preparations	23.22	21.18	.93	.86	2.58	1.02	26.73	23.06			26.73	23.06
30.	Paints & Allied Products	.03	.10	.11	.02			.14	.12			.14	.12
31.	Petroleum Refining & Related Industries	22.52	41.50	8.13	4.26	5.08	2.18	35.73	47.94			35.73	47.94
32.	Rubber & Miscellaneous Plastic Products	7.44	7.48	.85	.74	.92	.43	9.21	8.65	.08	.30	9.29	8.95
33.	Leather Tanning & Industrial Leather Products												
34.	Footwear & Other Leather Products	8.32	14.83	.78	.13	.03	.01	9.13	14.97		.03	9.13	15.00
35.	Glass & Glass Products	.90	.74	.03	.02			.93	.76			.93	.76

Table C-14 (continued)

PER CAPITA FINAL DEMAND IN 1958 DOLLARS--RECOVERY LEVELS AND 1958 ACTUAL

Sector	Personal Consumption Expenditures		Federal Government Expenditures		State & Local Government Expenditures		Subtotal		Private Fixed Capital Investment		Total Final Demand	
	Recovery	1958	Recovery	1958	Recovery	1958	Recovery	1958	Recovery	1958	Recovery	1958
36. Stone & Clay Products	1.23	1.22	.10	.03	.06	.02	1.39	1.27			1.39	1.27
37. Primary Iron & Steel Manufacturing	.04	.11	.79	.67	.01	.01	.84	.79			.84	.79
38. Primary Nonferrous Metal Manufacturing		.06	2.47	1.96			2.47	2.02			2.47	2.02
39. Metal Containers			.13	.10			.13	.10		.06	.13	.16
40. Heating, Plumbing & Structural Metal Products	.33	.40	.43	.10			.76	.50	.01	4.05	.77	4.55
41. Stamping, Screw Machine Products & Bolts	1.63	1.43	.49	.54	.02	.03	2.14	2.00	4.21		6.35	2.00
42. Other Fabricated Metal Products	1.80	2.13	3.81	.75	.26	.26	5.87	3.14	.70	.95	6.57	4.09
43. Engine & Turbines	.26	.72	1.60	1.65	.02	.02	1.88	2.39	3.37	3.29	5.25	5.68
44. Farm Machinery & Equipment	.01	.05	.03	.10		.10	.04	.25	1.52	9.55	1.56	9.80
45. Construction, Mining & Oil Field Machinery			1.29	.48	.28	.12	1.57	.60	1.46	7.54	3.03	8.14
46. Materials Handling Machinery & Equipment			2.16	.79	.58	.29	2.76	1.08	1.39	2.01	4.15	3.09
47. Metalworking Machinery & Equipment	.02	.18	1.37	1.56	.05	.03	1.44	1.77	8.16	6.59	9.60	8.36
48. Special Industry Machinery & Equipment	.13	.11	.21	.19	.29	.17	.63	.47	4.55	8.39	5.18	8.86
49. General Industrial Machinery & Equipment			1.80	1.16	.03	.03	1.83	1.19	5.63	6.01	7.46	7.20
50. Machine Shop Products			.20	.25	.66	.20	.86	.45			.86	.45
51. Office, Computing & Accounting Machines	.06	.33	4.60	.50	.32	.51	4.98	1.34	5.12	5.81	10.10	7.15
52. Service Industry Machines	.06	1.41	.53	.42	.20	.12	.79	1.95	1.90	5.46	2.69	7.41
53. Electric Industrial Equipment & Apparatus	.05	.09	2.72	2.01	.07	.03	2.84	2.13	9.82	9.25	12.66	11.38
54. Household Appliances	2.66	13.56	.33	.98	.01	.01	3.00	14.55	.39	.53	3.39	15.08
55. Electric Lighting & Wiring Equipment	1.08	1.79	.30	.51	.09	.05	1.47	2.35	.05	.14	1.52	2.49
56. Radio, Television & Communication Equipment	.23	7.74	7.86	10.12	.65	.35	8.74	18.21	20.02	5.77	28.76	23.98
57. Electronic Components & Accessories	.07	.85	1.62	2.14			1.69	2.99	.02	.15	1.71	3.14
58. Misc. Electrical Machinery, Equipment & Supplies	2.26	1.49	1.20	.65	.31	.19	3.77	2.33	1.43	.47	5.20	2.80
59. Motor Vehicles & Equipment	5.80	52.60	2.46	2.80	4.32	2.50	12.58	57.90	7.70	20.44	20.28	78.34
60. Aircraft & Parts		.15	10.91	46.01			10.91	46.16	1.56	2.05	12.47	48.21
61. Other Transportation Equipment	.14	4.15	2.44	3.75	.13	.22	2.71	8.12	2.93	6.74	5.64	14.86
62. Scientific & Controlling Instruments	1.62	2.00	3.80	3.76	1.46	.49	6.88	6.25	10.41	3.04	17.29	9.29
63. Optical, Ophthalmic & Photographic Equipment	1.42	2.58	1.73	.96	.15	.09	3.30	3.63	1.10	.93	4.40	4.56
64. Miscellaneous Manufacturing	3.73	14.44	.31	.23	1.84	1.02	5.88	15.69	.70	1.60	6.58	17.29
65. Transportation & Warehousing	91.26	48.99	18.56	8.23	7.81	2.30	117.63	59.52	2.58	2.90	120.21	62.42
66. Communications; Except Radio & TV Broadcasting	34.19	22.35	2.16	.97	3.30	1.09	39.65	24.41	11.73	2.07	51.38	26.48
67. Radio & TV Broadcasting												
68. Electric, Gas, Water & Sanitary Services	61.77	46.08	1.97	1.99	3.60	2.78	67.34	50.85			67.34	50.85
69. Wholesale & Retail Trade	157.20	351.57	.02	3.69		1.35	157.22	356.31	16.78	21.43	174.00	377.74
70. Finance & Insurance	73.33	67.55	.01	.01	1.03	1.09	74.37	68.65			74.37	68.65

Table C-14 (concluded)

PER CAPITA FINAL DEMAND IN 1958 DOLLARS--RECOVERY LEVELS AND 1958 ACTUAL

Sector	Personal Consumption Expenditures Recovery	Personal Consumption Expenditures 1958	Federal Government Expenditures Recovery	Federal Government Expenditures 1958	State & Local Government Expenditures Recovery	State & Local Government Expenditures 1958	Subtotal Recovery	Subtotal 1958	Private Fixed Capital Investment Recovery	Private Fixed Capital Investment 1958	Total Final Demand Recovery	Total Final Demand 1958
71. Real Estate & Rental	187.90	228.41	.77	.64	1.56	1.33	190.23	230.38	.58	6.91	190.81	237.29
72. Hotels; Personal & Repair Services except Auto	56.48	52.97	1.55	1.41	.60	.50	58.63	54.88			58.63	54.88
73. Business Services	7.25	10.80	1.32	2.81	2.43	3.17	11.00	16.78			11.00	16.78
74. Research and Development	12.20	5.40	5.56	3.52	2.32	1.17	20.08	10.09			20.08	10.09
75. Automobile Repair & Services	29.35	25.08	1.07	.74	2.17	.47	32.59	26.29			32.59	26.29
76. Amusements	6.66	18.22		.10		-.25	6.66	18.07			6.66	18.07
77. Medical, Educational Services & Nonprofit Organizations	304.17	116.91	.66	3.74	4.74	1.78	309.57	122.43			309.57	122.43
78. Federal Government Enterprises		22.04		15.54	.01	.02	.01	37.60		.09	.01	37.69
79. State & Local Government Enterprises												

Table C-15

ALLOCATION OF PRIVATE FIXED CAPITAL INVESTMENT DEMAND BY AGGREGATED SECTORS

	Private Fixed Capital Investment Recovery	Private Fixed Capital Investment 1958	Aggregate Sector Assigned	FN Finished Nonmetals Recovery	FN Finished Nonmetals 1958	BN Basic Nonmetals Recovery	BN Basic Nonmetals 1958	SV Services Recovery	SV Services 1958	FM Finished Metals Recovery	FM Finished Metals 1958	BM Basic Metals Recovery	BM Basic Metals 1958	EN Energy Recovery	EN Energy 1958	DR Diffuse Residual Recovery	DR Diffuse Residual 1958
1. Livestock & Livestock Products																	
2. Other Agricultural Products																	
3. Forestry and Fishery Products																	
4. Agricultural, Forestry & Fishery Services																	
5. Iron & Ferroalloy Ores Mining																	
6. Nonferrous Metal Ores Mining																	
7. Coal Mining																	
8. Crude Petroleum & Natural Gas																	
9. Stone and Clay Mining and Quarrying																	
10. Chemical & Fertilizer Mineral Mining																	
11. New Construction	154.98	211.32	DR													154.98	211.32
12. Maintenance & Repair Construction																	
13. Ordnance & Accessories																	
14. Food & Kindred Products																	
15. Tobacco Manufactures																	
16. Broad & Narrow Fabrics, Yarn & Thread Mills																	
17. Miscellaneous Textile Goods & Floor Coverings	.23	.26	BN			.23	.26										
18. Apparel																	
19. Miscellaneous Fabricated Textile Products																	
20. Lumber & Wood Products, Except Containers		.03	BN				.03										
21. Wooden Containers																	
22. Household Furniture	.63	.72	FN	.63	.72												
23. Other Furniture & Fixtures	5.04	4.56	FN	5.04	4.56												
24. Papers & Allied Products, Except Containers																	
25. Paperboard Containers & Boxes																	
26. Printing & Publishing																	
27. Chemicals & Selected Chemical Products																	
28. Plastics & Synthetic Materials																	
29. Drugs, Cleaning & Toilet Preparations																	
30. Paints & Allied Products																	
31. Petroleum Refining & Related Industries																	
32. Rubber & Miscellaneous Plastic Products	.08	.30	BN			.08	.30										
33. Leather Tanning & Industrial Leather Products																	
34. Footwear & Other Leather Products		.03	BN				.03										
35. Glass & Glass Products																	

Table C-15 (continued)

ALLOCATION OF PRIVATE FIXED CAPITAL INVESTMENT DEMAND BY AGGREGATED SECTORS

	Private Fixed Capital Investment Recovery	Private Fixed Capital Investment 1958	Aggregate Sector Assigned	FN Finished Nonmetals Recovery	FN 1958	BN Basic Nonmetals Recovery	BN 1958	SV Services Recovery	SV 1958	FM Finished Metals Recovery	FM 1958	BM Basic Metals Recovery	BM 1958	EN Energy Recovery	EN 1958	DR Diffuse Residual Recovery	DR 1958
36. Stone & Clay Products																	
37. Primary Iron & Steel Manufacturing																	
38. Primary Nonferrous Metal Manufacturing																	
39. Metal Containers		.06	FM								.06						
40. Heating, Plumbing & Structural Metal Products	.01	4.05	FM							.01	4.05						
41. Stamping, Screw Machine Products & Bolts	4.21		FM							4.21							
42. Other Fabricated Metal Products	.70	.95	FM							.70	.95						
43. Engine & Turbines	3.37	3.29	FM							3.37	3.29						
44. Farm Machinery & Equipment	1.52	9.55	FM							1.52	9.55						
45. Construction, Mining & Oil Field Machinery	1.46	7.54	FM							1.46	7.54						
46. Materials Handling Machinery & Equipment	1.39	2.01	FM							1.39	2.01						
47. Metalworking Machinery & Equipment	8.16	6.59	FM							8.16	6.59						
48. Special Industry Machinery & Equipment	4.55	8.39	FM							4.55	8.39						
49. General Industrial Machinery & Equipment	5.63	6.01	FM							5.63	6.01						
50. Machine Shop Products																	
51. Office, Computing & Accounting Machines	5.12	5.81	FM							5.12	5.81						
52. Service Industry Machines	1.90	5.46	FM							1.90	5.46						
53. Electric Industrial Equipment & Apparatus	9.82	9.25	FM							9.82	9.25						
54. Household Appliances	.39	.53	FM							.39	.53						
55. Electric Lighting & Wiring Equipment	.05	.14	FM							.05	.14						
56. Radio, Television & Communication Equipment	20.02	5.77	FM							20.02	5.77						
57. Electronic Components & Accessories	.02	.15	FM							.02	.15						
58. Misc. Electrical Machinery, Equipment & Supplies	1.43	.47	FM							1.43	.47						
59. Motor Vehicles & Equipment	7.70	20.44	FM							7.70	20.44						
60. Aircraft & Parts	1.56	2.05	FM							1.56	2.05						
61. Other Transportation Equipment	2.93	6.74	FM							2.93	6.74						
62. Scientific & Controlling Instruments	10.41	3.04	FM							10.41	3.04						
63. Optical, Ophthalmic & Photographic Equipment	1.10	.93	FM							1.10	.93						
64. Miscellaneous Manufacturing	.70	1.60	FM							.70	1.60						
65. Transportation & Warehousing	2.58	2.90	SV					2.58	2.90								
66. Communications; Except Radio & TV Broadcasting	11.73	2.07	SV					11.73	2.07								
67. Radio & TV Broadcasting																	
68. Electric, Gas, Water & Sanitary Services																	
69. Wholesale & Retail Trade	16.78	21.43	SV					16.78	21.43								
70. Finance & Insurance																	

Table C-15 (concluded)

ALLOCATION OF PRIVATE FIXED CAPITAL INVESTMENT DEMAND BY AGGREGATED SECTORS

	Private Fixed Capital Investment		Aggregate Sector	FN Finished Nonmetals		BN Basic Nonmetals		SV Services		FM Finished Metals		BM Basic Metals		EN Energy		DR Diffuse Residual	
	Recovery	1958	Assigned	Recovery	1958	Recovery	1958	Recovery	1958	Recovery	1958	Recovery	1958	Recovery	1958	Recovery	1958
71. Real Estate & Rental	.58	6.91	SV					.58	6.91								
72. Hotels: Personal & Repair Services except Auto																	
73. Business Services																	
74. Research and Development																	
75. Automobile Repair & Services																	
76. Amusements																	
77. Medical, Educational Services & Nonprofit Organizations																	
78. Federal Government Enterprises		.09	SV						.09								
79. State & Local Government Enterprises																	
Total for each Aggregated Sector				5.67	5.28	.31	.62	31.67	33.40	94.15	110.82					154.98	211.32

Table C-16

ALLOCATION OF PER CAPITA FINAL DEMAND EXCLUDING PRIVATE FIXED CAPITAL INVESTMENT

	Noninvestment Per Capita Demand Recovery	1958	Aggregate Sector Assigned	Finished Nonmetals Recovery	1958	Basic Nonmetals Recovery	1958	Services Recovery	1958	Finished Metals Recovery	1958	Basic Metals Recovery	1958	Energy Recovery	1958	Diffuse Residual Recovery	1958
1. Livestock & Livestock Products	14.17	12.11	DR													14.17	12.11
2. Other Agricultural Products	19.11	20.17	DR													19.11	20.17
3. Forestry and Fishery Products	.85	.83	DR													.85	.83
4. Agricultural, Forestry & Fishery Services	-.32	-.13	DR													-.32	-.13
5. Iron & Ferroalloy Ores Mining																	
6. Nonferrous Metal Ores Mining	.17	1.10	DR													.17	1.10
7. Coal Mining	2.36	1.84	DR													2.36	1.84
8. Crude Petroleum & Natural Gas		.01	DR														.01
9. Stone and Clay Mining and Quarrying	1.18	.09	DR													1.18	.09
10. Chemical & Fertilizer Mineral Mining	.05	.14	DR													.05	.14
11. New Construction	27.91	88.38	DR													27.91	88.38
12. Maintenance & Repair Construction	37.95	25.27	DR													37.95	25.27
13. Ordnance & Accessories	13.81	19.96	FM							13.81	19.96						
14. Food & Kindred Products	177.49	261.34	FN	177.49	261.34												
15. Tobacco Manufactures	12.54	24.30	FN	12.54	24.30												
16. Broad & Narrow Fabrics, Yarn & Thread Mills	7.50	4.32	BN			7.50	4.32										
17. Miscellaneous Textile Goods & Floor Coverings	2.24	4.29	BN			2.24	4.29										
18. Apparel	56.69	63.85	FN	56.69	63.85												
19. Miscellaneous Fabricated Textile Products	1.19	6.89	FN	1.19	6.89												
20. Lumber & Wood Products, Except Containers	.26	.83	BN			.26	.83										
21. Wooden Containers	.18	.01	BN			.18	.01										
22. Household Furniture	42.49	14.29	FN	42.49	14.29												
23. Other Furniture & Fixtures	11.87	1.61	FN	11.87	1.61												
24. Papers & Allied Products, Except Containers	4.15	5.60	BN			4.15	5.60										
25. Paperboard Containers & Boxes	.09	.25	BN			.09	.25										
26. Printing & Publishing	9.14	15.50	BN			9.14	15.50										
27. Chemicals & Selected Chemical Products	9.11	7.31	BN			9.11	7.31										
28. Plastics & Synthetic Materials	.09	.13	BN			.09	.13										
29. Drugs, Cleaning & Toilet Preparations	26.73	23.06	BN			26.73	23.06										
30. Paints & Allied Products	.14	.12	BN			.14	.12										
31. Petroleum Refining & Related Industries	35.73	47.94	EN											35.73	47.94		
32. Rubber & Miscellaneous Plastic Products	9.21	8.65	BN			9.21	8.65										
33. Leather Tanning & Industrial Leather Products																	
34. Footwear & Other Leather Products	9.13	14.97	BN			9.13	14.97										
35. Glass & Glass Products	.93	.76	BN			.93	.76										

Table C-16 (continued)

ALLOCATION OF PER CAPITA FINAL DEMAND EXCLUDING PRIVATE FIXED CAPITAL INVESTMENT

		Noninvestment Per Capita Demand		Aggregate Sector	Finished Nonmetals		Basic Nonmetals		Services		Finished Metals		Basic Metals		Energy		Diffuse Residual	
		Recovery	1958	Assigned	Recovery	1958	Recovery	1958	Recovery	1958	Recovery	1958	Recovery	1958	Recovery	1958	Recovery	1958
36.	Stone & Clay Products	1.39	1.27	BN			1.39	1.27										
37.	Primary Iron & Steel Manufacturing	.84	.79	BM									.84	.79				
38.	Primary Nonferrous Metal Manufacturing	2.47	2.02	BM									2.47	2.02				
39.	Metal Containers	.13	.10	FM							.13	.10						
40.	Heating, Plumbing & Structural Metal Products	.76	.50	FM							.76	.50						
41.	Stamping, Screw Machine Products & Bolts	2.14	2.00	FM							2.14	2.00						
42.	Other Fabricated Metal Products	5.87	3.14	FM							5.87	3.14						
43.	Engine & Turbines	1.88	2.39	FM							1.88	2.39						
44.	Farm Machinery & Equipment	.04	.25	FM							.04	.25						
45.	Construction, Mining & Oil Field Machinery	1.57	.60	FM							1.57	.60						
46.	Materials Handling Machinery & Equipment	2.76	1.08	FM							2.76	1.08						
47.	Metalworking Machinery & Equipment	1.44	1.77	FM							1.44	1.77						
48.	Special Industry Machinery & Equipment	.63	.47	FM							.63	.47						
49.	General Industrial Machinery & Equipment	1.83	1.19	FM							1.83	1.19						
50.	Machine Shop Products	.86	.45	FM							.86	.45						
51.	Office, Computing & Accounting Machines	4.98	1.34	FM							4.98	1.34						
52.	Service Industry Machines	.79	1.95	FM							.79	1.95						
53.	Electric Industrial Equipment & Apparatus	2.84	2.13	FM							2.84	2.13						
54.	Household Appliances	3.00	14.55	FM							3.00	14.55						
55.	Electric Lighting & Wiring Equipment	1.47	2.35	FM							1.47	2.35						
56.	Radio, Television & Communication Equipment	8.74	18.21	FM							8.74	18.21						
57.	Electronic Components & Accessories	1.69	2.99	FM							1.69	2.99						
58.	Misc. Electrical Machinery, Equipment & Supplies	3.77	2.33	FM							3.77	2.33						
59.	Motor Vehicles & Equipment	12.58	57.90	FM							12.58	57.90						
60.	Aircraft & Parts	10.91	46.16	FM							10.91	46.16						
61.	Other Transportation Equipment	2.71	8.12	FM							2.71	8.12						
62.	Scientific & Controlling Instruments	6.88	6.25	FM							6.88	6.25						
63.	Optical, Ophthalmic & Photographic Equipment	3.30	3.63	FM							3.30	3.63						
64.	Miscellaneous Manufacturing	5.88	15.69	FM							5.88	15.69						
65.	Transportation & Warehousing	117.63	59.52	SV					117.63	59.52								
66.	Communications; Except Radio & TV Broadcasting	39.65	24.41	SV					39.65	24.41								
67.	Radio & TV Broadcasting																	
68.	Electric, Gas, Water & Sanitary Services	67.34	50.85	DR													67.34	50.85
69.	Wholesale & Retail Trade	157.22	356.31	SV					157.22	356.31								
70.	Finance & Insurance	74.37	68.65	SV					74.37	68.65								

Table C-16 (concluded)

ALLOCATION OF PER CAPITA FINAL DEMAND EXCLUDING PRIVATE FIXED CAPITAL INVESTMENT

	Noninvestment Per Capita Demand		Aggregate Sector	Finished Nonmetals		Basic Nonmetals		Services		Finished Metals		Basic Metals		Energy		Diffuse Residual	
	Recovery	1958	Assigned	Recovery	1958	Recovery	1958	Recovery	1958	Recovery	1958	Recovery	1958	Recovery	1958	Recovery	1958
71. Real Estate & Rental	190.23	230.38	SV					190.23	230.38								
72. Hotels; Personal & Repair Services except Auto	58.63	54.88	SV					58.63	54.88								
73. Business Services	11.00	16.78	SV					11.00	16.78								
74. Research and Development	20.08	10.09	SV					20.08	10.09								
75. Automobile Repair & Services	32.59	26.29	SV					32.59	26.29								
76. Amusements	6.66	18.07	SV					6.66	18.07								
77. Medical, Educational Services & Nonprofit Organizations	309.57	122.43	SV					309.57	122.43								
78. Federal Government Enterprises	.01	37.60	SV					.01	37.60								
79. State & Local Government Enterprises			SV														
Total for each Aggregated Sector				302.27	372.28	80.29	87.07	1017.64	1025.41	103.26	217.50	3.31	2.81	35.73	47.94	170.77	200.66

Table C-17

THE RECOVERY VECTORS FOR THE SEVEN SECTOR MODEL COMPARED WITH THE 1958 PEACETIME VALUES

							As Percentage of Totals			
			Private Fixed Capital Investment		Noninvestment Demand		Private Fixed Capital Investment		Noninvestment Demand	
	Sector	Symbol	Recovery	1958	Recovery	1958	Recovery	1958	Recovery	1958
1.	Finished Nonmetals	FN	5.67	5.28	302.27	372.28	1.98%	1.46%	17.64%	19.06%
2.	Basic Nonmetals	BN	.31	.62	80.29	87.07	0.11	0.17	4.69	4.46
3.	Services	SV	31.67	33.40	1017.64	1025.41	11.04	9.24	59.39	52.49
4.	Finished Metals	FM	94.15	110.82	103.26	217.50	32.83	30.66	6.03	11.13
5.	Basic Metals	BM			3.31	2.81			0.19	0.14
6.	Energy	EN			35.73	47.94			2.09	2.45
7.	Diffuse Residual	DR	154.98	211.32	170.77	200.66	54.04	58.47	9.97	10.27
	TOTAL		286.78	361.44	1713.37	1953.67	100.00	100.00	100.00	100.00

Table C-18

ASSIGNMENT OF INDUSTRIES TO AGGREGATED SECTORS FOR THE U.S. IN 1963
(The 15 sectors used in the 1972 runs)

Aggregated Sector	Descriptor	BEA Sectors Included: Numbers	BEA Sectors Included: Coverage
1	Diffuse	1-10	Agriculture, forestry, fisheries and Mining
		11-12	Construction
		65-68	Transportation, communication, electric, gas and sanitary services
		80-85	Imports and dummy industries, government, rest of the world
		87	Inventory valuation adjustment
2	Food and Clothing	14-19	Food, tobacco, textiles, apparel
3	Wood and Paper	20-26	Lumber, wood, paper, printing and publishing
4	Chemicals	27-30	Chemicals
5	Petroleum Refining	31	Petroleum refining and related industries
6	Rubber and Leather	32-34	Rubber, leather, footwear
7	Stone, Clay and Glass	35,36	Stone, clay and glass
8	Primary Metals	37,38	Primary metals
9	Fabricated Metals	39-42	Fabricated metal products
10	Machinery except Electrical	43-52	Machinery except electrical machinery
11	Electrical Equip. and Miscellaneous	53-58	Electrical machinery and equipment
		64	Miscellaneous manufacturing
12	Motor Vehicles	59	Motor vehicles and equipment
13	A/C, Ordnance and other Trans. Equipment	13	Ordnance
		60,61	Aircraft and parts and other transportation equipment
14	Instruments	62,63	Instruments and optics
15	Trade and Services	69-73	Trade, finance and services
		75-79	Auto repair, amusements, medical and government enterprises
		86	Household industry

Table C-19

ASSIGNMENT OF INDUSTRIES TO AGGREGATED SECTORS FOR THE USSR - 1966

Aggregated Sector	Designator	Numbers[1/]	Industries Included From I-O Table: Coverage
1	Ores and Metals	1	Ores and metals
2	Diffuse	2-10	Fuels
		70	Construction
		71-73	Agriculture, forestry
		74-75	Transportation, communication, trade and distribution
		76	Other branches
3	Electric Power	11	Electric power
4	Machine Building and Metal Working Except as specified below	12-14	Electrical equipment
		17-26	Industrial equipment
		28	Construction equipment
		32-38	Bearings and other equipment, repair and abrasives
5	Machine Tools	15	Machine tools
6	Forging, Pressing Equipment	16	Forging, pressing machinery and equipment
7	Construction Machinery and Equipment	27	Construction machinery and equipment
8	Transportation Equip. except Autos	29	Transportation machinery and equipment
9	Autos	30	Autos
10	Agricultural Equipment	31	Agricultural machinery and equipment
11	Mineral Chemicals	39	Mineral chemicals
12	Basic Chemicals	40	Basic chemicals
13	Synthetic Rubber	44	Synthetic rubber
14	Rubber Products	47	Rubber products
15	Light Industry including Wood, Paper, Construction Materials, Food and Clothing	49-54	Wood and paper
		55-57	Construction materials
		58	Glass and pottery
		59-61	Textiles and other light industry
		62-68	Food
		69	Industries not elsewhere
16	Dyes, Synthetics, Paints	41-43	Dyes and synthetics
		45,46	Organic synthetics and paints
		48	Other chemicals

1/ Numbers are as given in, "The Structure of the Soviet Economy, Analysis and Reconstruction of the 1966 Input-Output Tables", by V. G. Treml, D. M. Gallik, B. L. Kostinsky, K. W. Kruger, Nov. 1966

Table C-20

FIFTEEN SECTOR AGGREGATION OF U.S. INTERINDUSTRY TRANSACTION TABLE FOR 1963

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	53355118	39836277	6640772	3545117	12420429	1019389	2393040	8596950	1811178	1692395	2242944	1231942	997958	387132	33728445
2	4420724	31107069	487549	729740	29949	1113400	69994	99436	79781	53732	244966	957432	94236	82428	1073918
3	7259449	3184232	14627227	954275	108012	380346	440886	121238	589533	219309	1110936	40650	309840	127678	10297231
4	3443896	3107572	1520190	8358259	447121	2275467	405626	692376	967134	179773	794934	249636	129346	231875	2213999
5	4847376	261338	241101	1332338	1622349	27702	120390	239700	80117	126748	132628	69462	74343	12290	2549186
6	1209812	551485	639253	435657	3718	1675796	166128	38244	229462	456200	1040433	894187	262872	154256	965213
7	4425738	826617	297045	249441	54980	100219	1333443	81537	291530	252906	547519	445637	74546	71899	914745
8	4461579	8726	453169	471451	51306	82146	156104	10443462	7471372	4186304	3110140	4002242	1975934	383375	145273
9	8649054	2959925	872539	712434	144351	144727	132038	894915	1522138	1759450	1719499	2524234	831041	194628	643049
10	2429179	155383	173453	193221	6799	32812	129408	754123	759779	5957552	1946164	1734891	1544757	130346	1380438
11	3439453	433240	99488	72949	4124	159318	72249	332448	344201	1922721	6592026	849725	1529251	539928	2391931
12	350120	18554	10081	3087	782	4899	8545	147785	187242	453784	171421	13165782	76765	35209	1012118
13	552158	576	12722	356	67	34741	358	6126	208447	329812	437441	37386	4934677	78772	[illegible]
14	486115	38726	185515	444493	1421	39553	5384	29185	117472	178593	367252	254445	384179	444818	878751
15	35186743	8914493	4429162	3591267	1994944	1017718	844922	2118228	1649519	2331647	3290445	2052436	1411134	645648	59046289
16	179134598	84535387	38203909	29598479	16735449	81116384	62786875	24457753	15173085	20071434	22893448	28138393	14597738	3525849	117772948
17	318143120	119489716	51213953	34749995	21834923	142984726	124779539	38889798	25359584	34943814	46468716	40030937	25512938	6814131	358142894
18	179029522	35194329	21009954	14051506	5100374	61684422	62060864	14432045	10186499	14852380	17715048	11892544	10915208	3299571	240391996

NOTES:

The numbers listed at the head of the first 15 columns and the first 15 rows are the same 15 sectors identified in Table C-18.

Rows 1 through 15 show sales by the sector designated for that row to the sector indicated in the first 15 column headings.

Columns 1 through 15 show purchases of intermediates by the sector designated by that column from the sectors indicated in the headings for the first 15 rows.

Row 16 is the total for intermediate purchases.
Row 17 is the total for sector sales
Row 18 is the value added.

Table C-20 (concluded)

	16	17	18	19	20	21	22	23	24	25
1	35465580	46404597	737419	-13409323	33939852	52178238	162846757	318163120	155316363	108911766
2	71682988	62520	827986	2648945	498499	585825	43382953	119689716	76306763	76244243
3	7862116	1255960	381428	860327	244286	781308	39828528	51213953	11385425	10129465
4	5857661	0	312571	2079391	1153978	564369	24782015	34749985	9967970	9967970
5	8232113	0	177144	678182	711103	301173	11737108	21836823	10099715	10099715
6	4895452	18106	50144	334486	175104	101548	8709886	14284726	5574840	5556734
7	455109	0	139975	223911	35050	45692	11580802	12479539	898737	898737
8	22002	22155	223947	983777	34270	2850	37600797	38889798	1289001	1266846
9	933854	787639	262648	579614	132184	19649	22643996	25359584	2715588	1927949
10	659186	12528808	362857	3507323	1246484	318059	16321097	34943814	18622717	6093909
11	9196391	4751997	480736	1382552	5647679	365112	18784249	40608716	21824467	17072470
12	15380551	5671438	611257	1386470	662906	644469	15673855	40030937	24357082	18685644
13	1210267	1911419	361345	1219018	13955856	32652	6822391	25512938	10690557	16779138
14	1006171	1012861	69782	530445	552187	183081	3459604	6814131	3354527	2341666
15	212680847	6082254	330761	2806882	5125962	2958204	128177894	358162804	229984910	223902656
16	0	0	0	0	0	0	552351922	0	0	0
17	0	0	0	0	0	0		01142740584	0	0
18	375540288	80509754	5329000	5812000	64[illegible]15400	59082220	0	0	590388662	509878908

NOTES:

Column 16 is personal consumption expenditures.
Column 17 is gross private fixed capital formation.
Column 18 is net inventory change.
Column 19 is net exports.
Column 20 is Federal Government purchases.
Column 21 is State and Local Government purchases.
Column 22 is total sales of intermediates.
Column 23 is total sector sales.
Column 24 is total final demand.
Column 25 is total noninvestment final demand which is column 24 minus column 17.

Table C-21

SIXTEEN SECTOR AGGREGATION OF USSR INTERINDUSTRY TRANSACTION FOR 1966

-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	6572969	2445299	10267	4469579	74647	22428	75390	463635	899314	729359	3484	51488	0	12223	1576962	155675
2	4294499	17388964	2689915	3225421	114628	17199	75355	159783	537965	459134	110945	534506	198300	204497	5954327	1232742
3	7254477	1720497	11456	825865	10968	5458	12877	68419	62835	92136	22494	334347	69300	65992	1344777	242109
4	5802142	4990675	97393	6775834	178499	31541	98533	1327974	319096	362559	11944	57041	3142	34058	1451498	97577
5	1299	8472	13	27931	14895	159	1621	2721	5678	6553	29	101	0	55	12621	734
6	1494	1502	1	4424	21	1068	5	552	2122	2182	22	34	0	48	1509	94
7	9144	101630	21	79084	0	0	19964	129	73	4	426	202	0	3	18147	12
8	6443	139371	195	133475	20	9	45	79849	263	306	244	139	0	96	15737	33
9	144344	635229	1230	615056	348	102	37543	9816	962299	51784	1632	1332	210	853	147448	473
10	5944	460524	559	734494	215	94	210392	1101	1370	896683	566	201	0	145	118372	124
11	7294	69566	473	2875	22	54	35	54	237	58	3732	194924	7432	3737	87964	17645
12	225179	1491575	13866	173913	1376	529	1836	13848	10893	8388	21425	303394	69845	20075	472621	334754
13	240	100	0	55430	0	3	0	0	0	0	4	0	900	863336	174060	65050
14	65342	602522	3025	312373	3425	1654	25667	17529	461187	179986	2742	10329	7601	70673	447545	14494
15	344991	2003614	42175	1755449	23467	4729	10051	176753	178018	135373	14334	179674	191940	476073	6349558	1132744
16	31029	809210	4007	767483	9672	1272	5319	40509	57364	41184	8467	74700	142522	424445	2319533	1529424
MAT. PURCH	14757844	6106644	2052055	20169651	336139	73820	538463	2231161	2704090	2629450	116611	1463795	627003	2835214	11161247	4060967
TOT. PURCH	13076734	71132489	2898574	22156276	433443	85444	592842	2302273	3197114	2964773	201839	1794619	711400	2148654	13619554	4950336
DEPREC.	1446683	11992296	1159410	1735958	98532	14420	27130	155839	140862	189625	63494	291331	373940	53844	4008456	275713
WAGES	2421627	8261904	830367	8785419	258871	46647	132145	534459	691142	833384	74474	423494	415124	269145	13714216	4013764
OTH. OF INC	3845150	41713771	2676969	1097228	234354	61289	245875	867430	1329462	772816	424471	920384	140049	109352	42547934	1915493
NET. INC.	6466783	12439357	3511318	1959546	487225	107936	370820	1341809	2021624	1604202	157467	1341348	1422242	1362672	55784144	2522351
TOT OUTLAY	25387000	18753051	7527300	43587400	977200	209200	998200	38000000	5365000	4740000	423000	3423000	914000	3615000	18999544	7627300
CAP REPAIR	1446	98474	615	6865	196	36	103	418	940	652	56	319	44	203	12795	434
TOT. CAP.	19445944	161651846	2366142	2291530	743840	189740	359714	2853497	1932290	2687177	884637	444629	547200	863944	52462962	3971630
HOUS/STRUC	10424471	92104458	15420323	12658190	961728	95447	194368	1300353	685415	1124294	619443	2310495	322400	442036	31420400	2231496
AGR. MAC	382234	1168664	5203858	4077153	7066	1893	7986	27880	44252	53738	12650	52014	30400	9485	13931421	54132
ELE. MAC	1340977	11530573	2420135	7161683	319407	78002	142209	494208	870543	1109778	36400	330177	214000	52241	3867986	212195
SPEC. MAC	6309557	25103087	459667	1449337	38851	11499	24097	186079	98937	163166	181174	1284296	141000	344415	11329477	1325924
TRANS. MAC	4177230	12944229	119253	311767	3571	702	2122	11567	12367	15426	34679	38844	5200	3448	5616951	20030
OTH. CAP.	153007	19105285	49193	452798	13017	2087	4172	39598	20676	23877	2631	72255	4600	12519	6546917	25147
VAL. ADDED	7912256	11037587	4678726	2143104	843757	122356	469358	1497727	2167086	1795227	221161	1632381	241400	1426316	59784658	2561954

NOTE: The description of the columns and rows follow this table.

Table C-21 (concluded)

	17	18	19	20	21	22
1	19446919	4600	829300	506181	1340081	20787000
2	109761117	23129800	2733400	51883843	77747043	187508160
3	5638252	1156400	684100	48548	1889048	7527300
4	16420290	4522500	1239100	21406010	27167610	43587900
5	80447	0	0	896553	896553	977200
6	17588	0	0	190612	190612	208200
7	230243	0	0	767957	767957	998200
8	377079	0	40600	3382321	3422921	3800000
9	2481836	960900	157800	1764464	2883164	5365000
10	2770330	0	0	1989670	1989670	4760000
11	396156	0	0	26844	26844	423000
12	2772819	44200	60000	539981	650181	3423000
13	1100900	0	0	-187900	-187900	913000
14	2534213	73800	344300	662687	1080787	3615000
15	88197827	96767700	5876100	-851087	101792713	189990540
16	6283784	555700	813700	-25884	1343516	7627300
NAT. PURCH	223360000	0	0	0	0	0
TOT. PURCH	258510000	127215600	12784400	83000800	223000800	481510800
DEPREC.	21658400	5984400	4015600	0	10000000	31658400
WAGES	92763162	0	0	0	0	0
OTH NT INC	108579238	0	0	0	0	0
NAT. INC.	201342400	0	0	0	0	0
TOT OUTLAY	481510800	0	0	0	0	0
EMP K-MNTH	81153	0	0	0	0	0
TOT. CAP.	298080000	0	0	0	0	0
BLDG/STRUC	172529890	0	0	0	0	0
POR. M+E	8864747	0	0	0	0	0
GEN. M+E	29976514	0	0	0	0	0
SPEC. M+E	48870390	0	0	0	0	0
TRANS. M+E	17254616	0	0	0	0	0
OTH. CAP.	20583863	0	0	0	0	0
VAL. ADDED	223000800	5984400	4015600	0	10000000	31658400

NOTES FOR TABLE C-21:

The numbers 1 to 16 at the left of the first 16 rows and at the top of the first 16 columns identify aggregate sectors as described in Table C-19.

The first 16 rows and columns comprising the 16 x 16 sqare in the upper left hand corner show in each row the intermediate sales of one sector (identified by the number at the left of the row) to the 16 possible purchasing sectors (as identified in the column headings). Entries in columns 17 to 22 are either total or sales to final demand. Specifically

Column 17 is total sales of intermediates

Column 18 is private consumption

Column 19 is public consumption

Column 20 is other final demand

Column 21 is total final demand

Column 22 is total sales of the sector including all intermediate sales and all sales to final demand.

The rows below row 16 show elements of value added and other data for the sectors identified in the column headings. The row labelled MAT. PURCH is the material portion of intermediate purchases. The row labelled TOT. PURCH is the sum of the entries in the first 16 rows (for each column) and is total intermediate purchases including services as well as material goods. The row labelled DEPREC gives total depreciation allowances for each sector. The row labelled WAGES gives the sector wage bill. The row labelled OTH NI INC gives contributions to national income (net material product) other than wages. The row labelled NAT. INC. is national income (or net material product). The row labelled TOT OUTLAYS is the sum of TOT PURCH, NAT. INC and DEPREC and also represents total outlays of the sector for the column in question. This is also equal to total sales of that sector as shown for the appropriate row in column 22.

The row labelled EMP K-MNYR gives total employment in thousands of man-years for each sector.

The row labelled TOT. CAP. gives the total capital investment in each sector. The row labelled BLDG/STRUC gives the total investment in building and structures by sector.

The row labelled POW. M&E gives the total investment in power machinery and equipment.

The row labelled GEN. M&E gives the total investment in power machinery and equipment.

The row labelled GEN. M & E gives the total investment in general purpose machinery and equipment.

The row labelled SPEC. M&E gives the investment in special machinery and equipment.

The row labelled TRANS. M&E gives the investment in transportation machinery and equipment.

The row labelled OTH. CAP. gives the rest of the capital investment.

The final row labelled VAL. ADDED is simply value added in the sense of net material product as is the difference between TOT. OUTLAYS and TOT. PURCH. that is the difference between total outlays and the total purchases of intermediates.

Table C-22

THE FIFTEEN SECTOR INPUT-OUTPUT E MATRIX FOR THE U.S.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.479139	-.962507	-.287520	-.252294	-2.436768	-.165259	-.305924	-.602614	-.118900	-.113948	-.128870	-.103564	-.091424	-.117703	-.140306
2	-.036981	2.519822	-.032725	-.051293	-.005464	-.180514	-.011128	-.004118	-.007632	-.003618	-.013828	-.046839	-.007717	-.025059	-.007795
3	-.040549	-.090579	1.741400	-.067913	-.032941	-.059715	-.071101	-.008401	-.057776	-.014766	-.063044	-.005100	-.027910	-.039816	-.042794
4	-.019219	-.088398	-.072736	1.878213	-.130798	-.368890	-.06541`	-.047975	-.049785	-.012104	-.044873	-.020991	-.011850	-.079499	-.009210
5	-.027076	-.007434	-.011476	-.094818	3.943324	-.004491	-.019415	-.016609	-.007865	-.008534	-.007487	-.005841	-.006811	-.003737	-.010604
6	-.006707	-.015688	-.030417	-.031019	-.000733	2.044109	-.026791	-.002650	-.021656	-.030716	-.058732	-.075189	-.024083	-.047511	-.004929
7	-.037009	-.023514	-.009855	-.017111	-.010780	-.016247	1.797507	-.005650	-.019784	-.017028	-.030907	-.037472	-.007013	-.021860	-.002141
8	-.026038	-.000248	-.021569	-.033566	-.010059	-.013317	-.025175	1.971054	-.733458	-.281861	-.175566	-.336366	-.181026	-.116560	-.000604
9	-.048316	-.059478	-.041435	-.050702	-.028302	-.026705	-.021293	-.048151	2.340102	-.117857	-.097019	-.212253	-.076136	-.059172	-.002475
10	-.013569	-.004420	-.008256	-.013737	-.001333	-.005319	-.017643	-.052392	-.073703	1.951624	-.059055	-.145881	-.141523	-.039630	-.005410
11	-.019207	-.012324	-.004688	-.005192	-.000809	-.025828	-.011651	-.023035	-.033986	-.129455	1.920214	-.072375	-.140112	-.164158	-.009908
12	-.002124	-.000471	-.000480	-.000220	-.000153	-.000793	-.001386	-.010240	-.018385	-.030553	-.009654	2.258991	-.007033	-.010644	-.004210
13	-.003084	-.000016	-.000606	-.000025	-.000013	-.005632	-.000058	-.000424	-.020463	-.020859	-.024704	-.003144	1.885283	-.024254	-.000963
14	-.002715	-.001102	-.008830	-.004746	-.000279	-.006412	-.000870	-.002022	-.011532	-.011991	-.020731	-.021395	· 933364	1.935903	-.003455
15	-.196543	-.253644	-.210810	-.255579	-.304491	-.164987	-.139658	-.146773	-.164975	-.158335	-.185743	-.172582	-.129281	-.196381	1.244204

Table C-23

THE SIXTEEN SECTOR INPUT-OUTPUT E MATRIX FOR THE USSR

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1.796493	-.021012	-.002198	-.311203	-.137648	-.183236	-.186003	-.269098	-.275990	-.406277	-.015392	-.060947	0.000000	-.004570	-.026340	-.055559
2	-.541526	1.249951	-.571627	-.150908	-.213382	-.140565	-.185897	-.106684	-.248152	-.255753	-.501467	-.327439	-.983631	-.144910	-.079073	-.439970
3	-.091590	-.014786	1.609138	-.038302	-.034773	-.045242	-.031767	-.045682	-.028984	-.051319	-.101320	-.204922	-.343750	-.046257	-.022924	-.085467
4	-.373322	-.042894	-.020852	1.717691	-.313557	-.257781	-.243076	-.886660	-.147189	-.201957	-.054006	-.035434	-.015704	-.024504	-.024442	-.034925
5	-.000177	-.000056	-.000003	-.001303	1.769899	-.001299	-.002519	-.002494	-.002342	-.003622	-.000131	-.000062	0.000009	-.000039	-.000211	-.000264
6	-.000215	-.000013	-.000000	-.000319	-.000039	1.692863	-.000012	-.000369	-.000979	-.001160	-.000099	-.000022	0.000000	-.000034	-.000025	-.000035
7	-.361156	-.000885	-.000009	-.003690	0.000000	0.000000	2.413259	-.000086	-.000034	-.000002	-.001925	-.000124	0.000000	0.000000	-.000303	-.000004
8	-.030460	-.001198	-.000042	-.006251	-.000037	-.000074	-.000111	2.483865	-.000121	-.000170	-.001103	-.000085	0.000000	-.000053	-.000743	-.000812
9	-.002124	-.005458	-.000259	-.028579	-.000625	-.000834	-.092617	-.006020	2.030873	-.028845	-.007370	-.000814	-.001041	-.000598	-.002456	-.005347
10	-.000746	-.006879	-.000120	-.034286	-.000395	-.000409	-.519028	-.000735	-.000636	2.152328	-.002261	-.000123	0.000000	-.000102	-.001980	-.000045
11	-.000914	-.000598	-.000101	-.000135	-.000040	-.000441	-.000086	-.000036	-.000109	-.000032	1.095759	-.119412	-.036865	-.002579	-.001459	-.005369
12	-.024459	-.009380	-.002969	-.008115	-.002527	-.004323	-.004529	-.009246	-.005025	-.004672	-.190875	1.911077	-.346453	-.021015	-.007894	-.119473
13	-.000025	-.000001	0.000000	-.002545	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	4.524396	-.635256	-.001940	-.023194
14	-.008258	-.007733	-.000648	-.014575	-.006667	-.008614	-.007989	-.011704	-.212736	-.100214	-.012398	-.004327	-.038695	2.494452	-.007495	-.005314
15	-.093095	-.172137	-.009030	-.081910	-.042422	-.038650	-.046505	-.118014	-.082116	-.075407	-.064835	-.109704	-.951995	-.333745	2.115491	-.404294
16	-.003922	-.006928	-.001266	-.035811	-.017797	-.010396	-.013119	-.027047	-.026461	-.022896	-.036566	-.045761	-.806161	-.297301	-.038775	2.175105

Table C-24

THE INVERSE, E^{-1} OF THE FIFTEEN SECTOR INPUT-OUTPUT E MATRIX FOR THE U.S.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	.729447	.308208	.159411	.162788	.465451	.136610	.192648	.248924	.142551	.115048	.115365	.120897	.100117	.107256	.098758
2	.012280	.403535	.011954	.015305	.009191	.040482	.007506	.005970	.005735	.004817	.007567	.013045	.005381	.009767	.004933
3	.023559	.034886	.584941	.031657	.022610	.030988	.032984	.014089	.024457	.014887	.029207	.013430	.018481	.023084	.024041
4	.012781	.027362	.029369	.541497	.026916	.103800	.027061	.019573	.022091	.013271	.023017	.017694	.012687	.029458	.017486
5	.005987	.004225	.004070	.014824	.256828	.004666	.005275	.004876	.003654	.003223	.003267	.003076	.002852	.002839	.003235
6	.004234	.006129	.010705	.010366	.003458	.493061	.009747	.003356	.007570	.011148	.017891	.019916	.010152	.015659	.002933
7	.016220	.012827	.007657	.009727	.012278	.009430	.561521	.007976	.009607	.009453	.013169	.014294	.006604	.010871	.003602
8	.019525	.014268	.016957	.070558	.015913	.014767	.017329	.522627	.172067	.095230	.065161	.105441	.072451	.049290	.005348
9	.017900	.019302	.016052	.017796	.015338	.013792	.011999	.018775	.437806	.034354	.029123	.049796	.026682	.021571	.004401
10	.007583	.005485	.005740	.007242	.005683	.005215	.008417	.017805	.024179	.520101	.021406	.040585	.044673	.016539	.003930
11	.009716	.007901	.005380	.005628	.006970	.010551	.007453	.011475	.014767	.040115	.527135	.024741	.046078	.049381	.006148
12	.001352	.001018	.000881	.000895	.001077	.000891	.001085	.003291	.005146	.008305	.003506	.444619	.003363	.003674	.001904
13	.001712	.001005	.000905	.000771	.001197	.002155	.000768	.001172	.005630	.007030	.007881	.002481	.532221	.008041	.000762
14	.001770	.001480	.003511	.002305	.001425	.002786	.001240	.001651	.003876	.004498	.006860	.006467	.010713	.518190	.002306
15	.135934	.152359	.142468	.158642	.155664	.130607	.114968	.118440	.120804	.118321	.129447	.123516	.107542	.134168	.830782

Table C-25

THE INVERSE, E^{-1} OF THE SIXTEEN SECTOR INPUT-OUTPUT E MATRIX FOR THE USSR

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.567931	.015935	.000424	.110753	.066811	.080789	.087277	.103532	.090050	.122729	.015467	.026647	.015069	.013424	.017159	.024964
2	.295559	.051374	.309242	.173299	.176536	.150968	.102572	.161611	.207717	.212956	.283904	.240751	.370102	.240543	.411138	.244719
3	.039432	.011814	.620299	.025298	.022163	.027069	.023715	.026828	.022474	.029035	.043067	.075354	.000144	.035791	.014223	.035368
4	.033745	.024401	.016630	.595801	.112265	.097725	.082769	.219294	.054162	.068332	.027394	.021531	.018558	.017609	.019521	.021146
5	.003104	.000064	.000033	.000500	.565114	.000532	.000911	.000767	.000724	.001044	.000089	.000061	.000067	.000053	.000100	.000117
6	.000094	.000019	.000009	.000141	.000048	.590749	.000115	.000150	.000312	.000356	.000045	.000021	.000016	.000021	.000020	.000023
7	.000439	.000364	.000148	.001034	.000273	.000248	.414619	.000466	.000217	.000249	.000594	.000195	.000200	.000141	.000294	.000171
8	.000430	.000497	.000208	.001628	.000404	.000369	.000359	.403271	.000300	.000356	.000454	.000220	.000254	.000192	.000309	.000220
9	.001976	.002013	.001218	.009258	.002406	.002206	.022177	.004994	.493947	.000381	.003226	.001419	.001644	.001274	.002073	.001349
10	.001426	.003274	.001352	.010390	.002580	.002271	.101965	.004347	.001810	.466535	.002094	.001298	.001649	.001232	.032159	.001439
11	.001109	.000709	.000367	.000669	.000432	.000578	.000640	.000634	.000850	.000694	.329572	.033456	.007974	.003425	.000938	.003951
12	.010739	.005379	.004052	.006447	.003990	.004471	.005574	.006453	.006841	.006129	.029431	.528009	.049178	.021533	.005450	.032253
13	.000922	.000541	.000239	.001212	.000581	.000610	.003100	.000858	.006022	.002966	.000688	.000494	.222338	.054549	.000735	.002922
14	.003445	.003499	.001522	.005858	.003417	.003790	.022259	.004871	.043955	.021258	.004387	.002876	.005825	.404955	.003325	.002797
15	.039443	.072994	.024640	.044703	.034380	.031189	.040912	.050442	.053505	.046936	.040112	.053249	.152265	.125691	.510906	.117580
16	.004206	.305331	.002569	.013018	.008611	.006537	.011016	.011483	.017114	.012047	.012682	.014439	.080638	.079455	.011684	.465176

Table C-26

NORMALIZED FINAL DEMAND VECTORS, H AND G FOR THE U.S.
(In Percent)

Aggregated Sector	(1) Noninvestment Final Demand (H)	(2) Gross Investment Final Demand (G) 1963	(3) 1963*	(4) 1958
1. Diffuse	21.36031992%	57.63847818%	57.6%	42.7%
2. Food and Clothing	14.95340203	00.07765519	00.1	00.1
3. Wood and Paper	01.98664131	01.56000973	01.6	02.2
4. Chemicals	01.95496810	00.00000000	-	-
5. Petroleum Refining	01.39080659	00.00000000	-	-
6. Rubber and Leather	01.08981445	00.02248920	-	00.1
7. Stone, Clay and Glass	00.17626479	00.00000000	-	-
8. Primary Metals	00.24846017	00.02751840	-	-
9. Fabricated Metals	00.37811899	00.97831500	01.0	02.1
10. Machinery except Electrical	01.19516789	15.56185105	15.6	22.7
11. Electrical Equipment and Miscellaneous	03.34833815	05.90238668	05.9	07.4
12. Motor Vehicles	03.66472190	07.04441104	07.0	08.5
13. A/C, Ordnance, Other Transportation Equipment	03.29080841	02.37414587	02.4	03.6
14. Instruments	00.45925924	01.25805999	01.3	01.6
15. Trade and Services	43.91290803	07.55467965	07.6	08.9
TOTAL	99.99999997%	99.99999998%	100.0%	100.0%

*Column 3 is merely column 2 rounded for comparison with column 4.

Table C-27

THE AGGREGATED CAPITAL FLOW MATRIX G FOR THE U.S. IN 1958

Capital Investing Sector	Capital Producing Sector: 1	2	3	6	9	10	11	12	13	14	15	Total
1. Diffuse	.469	*	.006	*	.025	.195	.100	.063	.066	.003	.071	1.000
2. Food and Clothing	.297	.001	.018	.003	.027	.362	.031	.116	.011	.031	.105	1.000
3. Wood and Paper	.309	.001	.017	.001	.027	.475	.016	.044	.009	.017	.084	1.000
4. Chemicals	.301	.001	.017	.002	.047	.424	.013	.024	.031	.047	.094	1.000
5. Petroleum Refining	.634	*	.007	*	.092	.130	.028	.019	.027	.010	.053	1.000
6. Rubber and Leather	.222	*	.028	.004	.028	.563	.016	.020	.004	.012	.103	1.000
7. Stone, Clay and Glass	.362	*	.021	*	.013	.391	.021	.078	.016	.008	.088	1.000
8. Primary Metals	.359	*	.009	.001	.029	.450	.039	.009	.009	.016	.078	1.000
9. Fabricated Metals	.317	*	.030	.002	.013	.410	.067	.027	.002	.010	.090	1.000
10. Machinery except Electrical	.313	.001	.039	.003	.009	.395	.100	.018	.004	.005	.113	1.000
11. Electrical Equip. and Miscellaneous	.348	.002	.029	.002	.014	.380	.110	.019	.002	.008	.088	1.000
12. Motor Vehicles	.239	*	.035	*	.019	.414	.140	.029	.003	.013	.108	1.000
13. A/C Ordnance and Other Trans. Equip.	.393	.003	.024	.003	.011	.255	.144	.022	.049	.019	.079	1.000
14. Instruments	.338	*	.023	*	.008	.391	.068	.015	*	.060	.098	1.000
15. Trade and Services	.424	.002	.049	.003	.007	.149	.054	.154	.007	.034	.116	1.000
Weighted Average	.427	.001	.022	.001	.021	.227	.074	.085	.036	.016	.089	1.000

Note: The entries along each line show for one investing sector the allocation of a dollar of investment among the various capital producing sectors.

* Entries less than 0.0005.

Source: Capital Flow Matrix, 1958, Department of Labor, Bureau of Labor Statistics, Washington, D.C., October 1968.

Table C-28

NORMALIZED FINAL DEMAND VECTORS H AND G
FOR THE USSR IN 1966

	Estimated Final Demand (In Millions of Rubles)		Normalized Final Demand Vectors (In Percent)	
	Gross Investment	Noninvestment	Gross Investment(G)	Noninvestment(H)
1. Ores and Metals	202.716	1137.365	0.25864%	0.78643%
2. Diffuse	45493.527	32253.516	58.04394	22.30178
3. Electric Power	48.548	1840.500	0.06194	1.27262
4. Machine Building and Metalworking except as specified below	18625.117	8542.493	23.76327	5.90573
5. Machine Tools	896.553	0.000	1.14389	0.00000
6. Forging, Pressing Equipment	190.612	0.000	0.24320	0.00000
7. Construction Machinery and Equipment	767.957	0.000	0.97982	0.00000
8. Trans. Equip. except Autos	3159.613	263.308	4.03126	0.18207
9. Autos	1525.106	1358.058	1.94584	0.93903
10. Agricultural Equip.	1857.172	132.498	2.36951	0.09162
11. Mineral Chemicals	3.697	23.147	0.00472	0.01601
12. Basic Chemicals	89.553	560.628	0.11426	0.38765
13. Synthetic Rubber	0.000	-187.900	0.00000	-0.12992
14. Rubber Products	305.652	775.135	0.38997	0.53597
15. Light Industry including wood, paper, construction materials, food and clothing	4961.891	96830.822	6.33074	66.95393
16. Dyes, Synthetics and Paints	250.022	1093.494	0.31900	0.75610
TOTAL	78377.736	144623.064	100.00000%	100.00002%

Table C-29

U.S. COBB-DOUGLAS COEFFICIENTS AND LABOR REQUIREMENTS
FOR 1963

Aggregated Sector	(1) Compensation of Employees	(2) Value Added	(3) Cobb-Douglas Coefficient S S=(1)/(2)	(4) Number of Full Time Equivalent Employees	(5) Employment Required per Dollar of Value Added (5)=(4)/(2)
1. Diffuse	112932	179029	.63080	19550	.10920
2. Food and Clothing	19940	35154	.56721	4002	.11384
3. Wood and Paper	15088	21010	.71813	2529	.12037
4. Chemicals	6939	14052	.49380	865	.06155
5. Petroleum Refining	2068	5100	.40549	192	.03764
6. Rubber and Leather	4225	6168	.68498	764	.12386
7. Stone, Clay and Glass	3904	6201	.62957	600	.09675
8. Primary Metals	9492	14432	.65770	1176	.08148
9. Fabricated Metals	7814	10186	.76713	1146	.11250
10. Machinery Except Electrical	11383	14852	.76642	1533	.10321
11. Electrical Equip. and Miscellaneous	12818	17715	.72356	1949	.11001
12. Motor Vehicles	7095	11893	.59656	744	.06255
13. A/C Ordnance Other Trans. Equip.	9445	10915	.86532	1133	.10380
14. Instruments	2677	3289	.81392	362	.11006
15. Trade and Services	115184	240392	.47915	22788	.09480
TOTAL	341004	590388		59333	

Table C-30

COBB-DOUGLAS COEFFICIENTS AND DEPRECIATION RATES FOR THE USSR - 1966

Aggregated Sector	(1) (Millions of Rubles) Wages	(2) Value Added	(3) Cobb-Douglas Coefficient S	(4) (Millions of Rubles) Depreciation Allowance	(5) Total Capital	(6) Depreciation Rate, δ (In Precent)
1. Ores and Metals	2821.6	7912	.3566	1445.5	19466	7.426%
2. Diffuse	62679.8	116376	.5386	11982.3	161652	7.412
3. Electric Power	836.4	4671	.1791	1159.4	23661	4.900
4. Machine Building and Metal Working except as specified below	8788.4	21432	.4101	1736.0	22842	7.600
5. Machine Tools	250.9	544	.4612	56.5	744	7.594
6. Forging, Pressing Equip.	46.6	122	.3820	14.4	190	7.578
7. Construction Machinery and Equip.	132.1	405	.3262	27.3	360	7.583
8. Trans. Equip. except Autos	534.5	1498	.3568	155.8	2050	7.600
9. Autos	691.1	2168	.3188	146.9	1932	7.603
10. Agricultural Equip.	833.4	1795	.4643	189.0	2487	7.600
11. Mineral Chemicals	75.0	221	.3394	63.7	885	7.198
12. Basic Chemicals	420.7	1632	.2578	291.3	4046	7.200
13. Synthetic Rubber	61.5	202	.3045	39.4	547	7.203
14. Rubber Products	269.1	1426	.1887	63.6	884	7.195
15. Light Industry including Wood, Paper, Construction Materials, Food and Clothing	13718.2	59795	.2294	4008.5	52463	7.641
16. Dyes, Synthetics, Paints	603.8	2802	.2155	278.7	3871	7.200
TOTAL	92763.1	223001	.41598	21658.3	298080	7.266%

Appendix D

INVESTMENT SCHEDULES AND OTHER RESULTS FROM THE RECOVERY RUNS

Results from the 1971 runs

This appendix presents recovery schedules obtained from a selection of runs of the recovery model, including those summarized in Chapter II. The tables show a run number and the parameters used including:

1) the value of k (either $1.50 or $2.00 investment per dollar of capacity),
2) the initial level of noninvestment demand that had to be met in the first two years,
3) the percentage increase in this initial level permitted for each year from the second year to the end of the planning period, and
4) the growth rate assumed for the economy after the fifth year.

The attack parameters specify the sector attacked and the number of weapons reliably delivered. The recovery objective was to maximize the present values of the future stream of GNP discounted by a 10% discount factor.

Investment and noninvestment allocations by year are expressed as percentages of preattack total GNP. They sum to postattack GNP also expressed as a percentage of preattack GNP.

The tables show the most significant runs completed, but many other runs made to determine maximum values of the permissable noninvestment demand or other experimental parameters are available in work sheets.

Results from the 1972 runs

Recovery schedules from a representative selection of 1972 runs are also shown including those summarized in Chapter II. Most of these runs were based on a five-year planning period but some were repeated for a nine-year period. Again many other runs made to determine maximum values for the possible levels of noninvestment are available.

One set of runs shown in Tables D-10 to D-14 used a hybrid objective function for which investment in the fifth and subsequent years is ignored. This optimizes the present value of noninvestment demand plus the investment for the first four years subject to the constraint that initial noninvestment demand (for the first two years) be at least equal to a stipulated level and that this lower limit be permitted to grow at a specified rate (4% was used) from the second to the fifth year. For these runs, noninvestment exceeded the stipulated limits in the fourth and fifth year and thus reached a high value in the fifth year as the take-off point for uniform growth thereafter.

In interpreting all the runs it should be remembered that the variables determined by the optimizing program are the total amount and sector distribution of investment in each year of the planning period and the actual level of noninvestment demand met by the economy. The stipulated lower limits on noninvestment demand are in fact exceeded only in the case of the hybrid objective function or in case investment is excluded from the objective function altogether. Because investment in the postplanning period need be no greater than required to maintain the specified rate of growth, there is some economic sense in excluding it from the function to be maximized. Over the long run investment is an intermediate good. It has significance only to the extent that it enhances future welfare measured ultimately by the noninvestment portions of GNP. The asterisks (*) in the following tables indicates a value less than .005.

Table D-1

INVESTMENT SCHEDULES AND OTHER DATA FROM
THE RECOVERY 1971 COMPUTER RUNS - U.S.
(Five-Year Planning)

Run Number: 7-1

Parameters

Capital cost per incremental dollar of postattack GNP: $1.50

Initial noninvestment demand required: 20%

Annual percentage growth allowed in noninvestment demand after the second year: 48.75%

Attack level: 250

Attack objective: Energy

Recovery objective function: Present value of GNP

Growth rate after the fifth year: 4%

Year	D+1	D+2	D+3	D+4	D+5
Investment in					
Finished nonmetals	*	*	2.25	0.94	0.99
Basic nonmetal	*	*	2.93	1.99	2.10
Services	*	*	16.42	11.11	11.69
Finished metals	0.93	0.27	3.23	4.58	4.86
Basic metals	0.15	0.13	0.75	0.92	0.98
Energy	0.39	0.20	0.36	0.18	0.18
Diffuse Residual	2.27	1.16	5.67	6.66	7.07
Total Investment	3.74	1.76	31.61	26.38	27.87
Noninvestment	20.00	20.00	29.75	44.25	65.82
Total GNP	23.74	21.76	61.36	70.63	93.69

Table D-1 (Continued)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE RECOVERY 1971 COMPUTER RUNS - U.S.
(Five-Year Planning)

Run Number: 7-2

Parameters

Capital cost per incremental dollar of postattack GNP: $1.50

Initial noninvestment demand required: 45%

Annual percentage growth allowed in non-investment demand after the second year: 9.5%

Attack level: 250

Attack objective: Weighted composite

Recovery objective function: Present value of GNP

Growth rate after the fifth year: 4%

Year	D+1	D+2	D+3	D+4	D+5
Investment in					
Finished nonmetals	0.97	0.93	1.21	1.08	1.30
Basic nonmetal	1.69	1.53	2.51	2.75	3.63
Services	4.17	9.54	14.14	14.24	18.23
Finished metals	5.65	2.69	5.65	7.23	10.02
Basic metals	1.13	0.56	1.14	1.43	1.98
Energy	0.19	0.15	0.23	0.23	0.30
Diffuse Residual	7.36	4.09	8.25	10.33	14.22
Total Investment	21.16	19.49	33.13	37.29	49.68
Noninvestment	45.00	45.00	49.28	53.97	59.11
Total GNP	66.16	64.49	82.41	91.26	108.79

Table D-1 (Continued)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE RECOVERY 1971 COMPUTER RUNS - U.S. (Five-Year Planning)

Run Number: 7-3

Parameters

Capital cost per incremental dollar of postattack GNP: $1.50

Initial noninvestment demand required: 37.5%

Annual percentage growth allowed in non-investment demand after the second year: 10.6%

Attack level: 500

Attack objective: Weighted composite

Recovery objective function: Present value of GNP

Growth rate after the fifth year: 4%

Year	D+1	D+2	D+3	D+4	D+5
Investment in					
Finished nonmetals	0.89	0.80	1.09	0.91	1.11
Basic nonmetal	1.52	1.24	2.20	2.32	3.08
Services	3.06	7.99	12.54	12.06	15.48
Finished metals	5.36	1.96	4.88	6.09	8.48
Basic metals	1.09	0.41	0.99	1.21	1.67
Energy	0.19	0.12	0.20	0.20	0.25
Diffuse Residual	4.96	3.04	7.14	8.69	12.03
Total Investment	17.07	15.56	29.04	31.48	39.02
Noninvestment	37.50	37.50	41.49	45.89	50.77
Total GNP	54.57	53.06	70.53	77.37	89.79

Table D-1 (Continued)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE RECOVERY 1971 COMPUTER RUNS - U.S. (Five-Year Planning)

Run Number: 7-4

Parameters

Capital cost per incremental dollar of postattack GNP: $1.50

Initial noninvestment demand required: 30%

Annual percentage growth allowed in noninvestment demand after the second year: 11.5%

Attack level: 1000

Attack objective: Weighted composite

Recovery objective function: Present value of GNP

Growth rate after the fifth year: 4%

Year	D+1	D+2	D+3	D+4	D+5
Investment in					
Finished nonmetals	0.76	0.64	0.93	0.73	0.90
Basic nonmetal	1.27	0.87	1.86	1.84	2.48
Services	2.34	6.00	10.65	9.61	12.49
Finished metals	4.88	1.08	4.10	4.78	6.80
Basic metals	1.01	0.24	0.83	0.95	1.34
Energy	0.19	0.09	0.17	0.16	0.20
Diffuse Residual	2.55	1.77	6.00	6.84	9.65
Total Investment	13.00	10.69	24.54	24.91	33.86
Noninvestment	30.00	30.00	33.46	37.32	41.62
Total GNP	43.00	40.69	58.00	62.23	75.48

Table D-1 (Continued)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE RECOVERY 1971 COMPUTER RUNS - U.S. (Five-Year Planning)

Run Number: 7-5

Parameters

Capital cost per incremental dollar of postattack GNP: $1.50

Initial noninvestment demand required: 25%

Annual percentage growth allowed in non-investment demand after the second year: 18.5%

Attack level: 1000

Attack objective: Weighted composite

Recovery objective function: Present value of GNP

Growth rate after the fifth year: 4%

Year	D+1	D+2	D+3	D+4	D+5
Investment in					
Finished nonmetals	0.47	0.81	1.19	0.82	1.00
Basic nonmetal	1.32	1.10	2.26	2.21	2.91
Services	1.05	7.59	13.22	11.25	14.43
Finished metals	6.23	1.38	4.72	5.98	8.22
Basic metals	1.25	0.30	0.96	1.18	1.62
Energy	0.17	0.12	0.21	0.18	0.24
Diffuse Residual	4.25	2.26	6.98	8.51	11.63
Total Investment	14.84	13.56	29.54	30.13	40.05
Noninvestment	25.00	25.00	29.63	35.12	41.62
Total GNP	39.84	38.56	59.17	65.25	81.67

Table D-1 (Continued)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE RECOVERY 1971 COMPUTER RUNS - U.S. (Five-Year Planning)

Run Number: 7-6

Parameters

Capital cost per incremental dollar of postattack GNP: $2.00

Initial noninvestment demand required: 45%

Annual percentage growth allowed in noninvestment demand after the second year: 9.5%

Attack level: 250

Attack objective: Weighted composite

Recovery objective function: Present value of GNP

Growth rate after the fifth year: 4%

Year	D+1	D+2	D+3	D+4	D+5
Investment in					
Finished nonmetals	1.17	1.13	1.37	1.11	1.23
Basic nonmetal	1.17	1.58	2.31	2.32	2.71
Services	3.34	10.68	14.29	13.03	14.86
Finished metals	5.92	2.09	4.19	5.28	6.45
Basic metals	1.19	0.45	0.87	1.06	1.29
Energy	0.22	0.16	0.22	0.21	0.24
Diffuse Residual	7.56	3.38	6.34	7.69	9.34
Total Investment	21.15	19.47	29.59	30.70	36.12
Noninvestment	45.00	45.00	49.28	53.97	59.11
Total GNP	66.15	64.47	78.87	84.67	95.23

Table D-1 (Continued)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE RECOVERY 1971 COMPUTER RUNS - U.S. (Five-Year Planning)

Run Number: 7-7

Parameters

Capital cost per incremental dollar of postattack GNP: $2.00

Initial noninvestment demand required: 37.5%

Annual percentage growth allowed in non-investment demand after the second year: 10.6%

Attack level: 500

Attack objective: Weighted composite

Recovery objective function: Present value of GNP

Growth rate after the fifth year: 4%

Year	D+1	D+2	D+3	D+4	D+5
Investment in					
Finished nonmetals	1.09	0.98	1.24	0.95	1.05
Basic nonmetal	1.63	1.28	2.05	1.98	2.31
Services	2.29	9.02	12.80	11.13	12.69
Finished metals	5.84	1.42	3.63	4.49	5.49
Basic metals	1.20	0.32	0.75	0.90	1.10
Energy	0.22	0.14	0.20	0.18	0.20
Diffuse Residual	4.80	2.40	5.52	6.55	7.95
Total Investment	17.07	15.56	26.19	26.18	30.79
Noninvestment	37.50	37.50	41.49	45.89	50.77
Total GNP	54.57	53.06	67.68	72.07	81.56

Table D-1 (Continued)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE RECOVERY 1971 COMPUTER RUNS - U.S. (Five-Year Planning)

Run Number: 7-8

Parameters

Capital cost per incremental dollar of postattack GNP: $2.00

Initial noninvestment demand required: 30%

Annual percentage growth allowed in non-investment demand after the second year: 11.5%

Attack level: 1000

Attack objective: Weighted composite

Recovery objective function: Present value of GNP

Growth rate after the fifth year: 4%

Year	D+1	D+2	D+3	D+4	D+5
Investment in					
Finished nonmetals	0.94	0.80	1.06	0.77	0.86
Basic nonmetal	1.39	0.91	1.75	1.59	1.88
Services	1.76	6.89	10.96	9.00	10.34
Finished metals	5.51	0.62	3.09	3.59	4.45
Basic metals	1.15	0.16	0.64	0.72	0.89
Energy	0.22	0.10	0.17	0.14	0.17
Diffuse Residual	2.02	1.23	4.70	5.24	6.45
Total Investment	12.99	10.71	22.37	21.05	25.04
Noninvestment	30.00	30.00	33.46	37.32	41.62
Total GNP	42.99	40.71	55.83	58.37	66.66

Table D-1 (Concluded)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE RECOVERY 1971 COMPUTER RUNS - U.S. (Five-Year Planning)

Run Number: 7-9

Parameters

Capital cost per incremental dollar of postattack GNP: $2.00

Initial noninvestment demand required: 25%

Annual percentage growth allowed in non-investment demand after the second year: 18.5%

Attack level: 1000

Attack objective: Weighted composite

Recovery objective function: Present value of GNP

Growth rate after the fifth year: 4%

Year	D+1	D+2	D+3	D+4	D+5
Investment in					
Finished nonmetals	0.54	1.01	1.38	0.85	0.93
Basic nonmetal	1.39	1.17	2.14	1.91	2.19
Services	*	8.57	13.74	10.40	11.74
Finished metals	7.14	0.84	3.45	4.62	5.48
Basic metals	1.44	0.21	0.73	0.92	1.09
Energy	0.20	0.13	0.21	0.17	0.19
Diffuse Residual	4.03	1.63	5.34	6.67	7.87
Total Investment	14.74	13.56	26.99	25.54	29.49
Noninvestment	25.00	25.00	29.63	35.12	41.62
Total GNP	39.74	38.56	56.62	60.66	71.11

Table D-2

INVESTMENT SCHEDULES AND OTHER DATA FROM THE RECOVERY 1972 COMPUTER RUNS - U.S. (Five-Year Planning)

Run Number: 21E

Parameters

Capital cost per incremental dollar of postattack GNP: $2.00

Initial noninvestment demand required: 50.0%

Annual percentage growth allowed in non-investment demand after the second year: 4.0%

Attack level: 250 weapon

Attack objective: Gross MVA

Recovery objective function: Hybrid

Growth rate after the fifth year: 4.0%

Depreciation Rate: 6.0%

Descriptor	Year 1	2	3	4	5
Diffuse	3.34	1.38	7.15	5.29	5.51
Food and Clothing	*	1.06	1.38	.92	.96
Wood and Paper	.40	.48	.83	.59	.61
Chemicals	.26	.41	.55	.38	.40
Petroleum Refining	.05	.15	.20	.13	.13
Rubber and Leather	.11	.16	.24	.17	.18
Stone, Clay and Glass	.24	.08	.25	.18	.19
Primary Metals	1.11	.05	.58	.43	.45
Fabricated Metals	.60	.08	.41	.30	.31
Machinery except electrical	2.40	*	.07	.51	.53
Electrical Equip. and Misc.	1.14	.13	.71	.52	.55
Motor Vehicles	1.16	.06	.48	.36	.37
A/C, Ordnance and other Trans. Equipment	.15	.25	.43	.30	.32
Instruments	.23	.01	.13	.10	.10
Trade and Services	*	4.62	9.47	6.48	6.75
TOTAL INVESTMENT	11.19	8.93	22.87	16.66	17.38
NONINVESTMENT	50.00	50.00	52.00	59.55	65.96
GNP	61.19	58.93	74.87	76.21	83.34
PERCENT OF GNP INVESTED	18.29%	15.15%	30.55%	21.86%	20.85%

Table D-2 (continued)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE
RECOVERY 1972 COMPUTER RUNS - U.S.
(Five-Year Planning)

Run Number: 21D

Parameters

Capital cost per incremental dollar of postattack GNP: $2.00

Initial noninvestment demand required: 41.0%

Annual percentage growth allowed in non-investment demand after the second year: .4%

Attack level: 500 weapons

Attack objective: Gross MVA

Recovery objective function: Hybrid

Growth rate after the fifth year: 4.0%

Depreciation Rate: 6.0%

Descriptor	Year 1	2	3	4	5
Diffuse	1.43	.71	7.18	4.77	4.98
Food and Clothing	*	1.08	1.39	.83	.87
Wood and Paper	.29	.51	.84	.53	.55
Chemicals	.18	.45	.56	.35	.36
Petroleum Refining	.04	.17	.20	.11	.12
Rubber and Leather	.10	.17	.25	.15	.16
Stone, Clay and Glass	.22	.07	.25	.16	.17
Primary Metals	1.16	*	.56	.39	.41
Fabricated Metals	.61	.04	.41	.27	.28
Machinery except electrical	2.56	*	*	.29	.48
Electrical Equip. and Misc.	1.14	.06	.71	.47	.49
Motor Vehicles	1.23	*	.48	.32	.34
A/C, Ordnance and other Trans. Equipment	.10	.27	.43	.67	.29
Instruments	.23	*	.13	.09	.09
Trade and Services	*	3.90	9.52	5.84	6.10
TOTAL INVESTMENT	9.29	7.43	22.90	14.86	15.68
NONINVESTMENT	41.00	41.00	42.64	52.64	59.53
GNP	50.29	48.43	65.54	67.56	75.21
PERCENT OF GNP INVESTED	18.48%	15.35%	34.94%	22.10%	20.85%

Table D-2 (Continued)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE
RECOVERY 1972 COMPUTER RUNS - U.S.
(Five-Year Planning)

Run Number: 21C

Parameters

Capital cost per incremental dollar of postattack GNP: $2.00

Initial noninvestment demand required: 36.0%

Annual percentage growth allowed in non-investment demand after the second year: 4.0%

Attack level: 750 weapons

Attack objective: Gross MVA

Recovery objective function: Hybrid

Growth rate after the fifth year: 4.0%

Depreciation Rate: 6.0%

Descriptor	Year 1	2	3	4	5
Diffuse	.64	.23	7.21	4.47	4.66
Food and Clothing	*	1.06	1.39	.78	.83
Wood and Paper	.25	.57	.84	.35	.37
Chemicals	.12	.47	.56	.09	.09
Petroleum Refining	.02	.17	.20	.02	.02
Rubber and Leather	.09	.18	.25	.07	.08
Stone, Clay and Glass	.21	.06	.25	.21	.22
Primary Metals	1.17	*	.52	.37	.38
Fabricated Metals	.61	.01	.41	.47	.49
Machinery except electrical	2.74	*	*	.12	.45
Electrical Equip. and Misc.	1.14	.01	.71	.83	.46
Motor Vehicles	1.25	*	.44	.61	.64
A/C, Ordnance and other Trans. Equipment	.09	.27	.44	.18	.19
Instruments	.24	*	.12	.18	.18
Trade and Services	*	3.84	9.53	5.48	5.71
TOTAL INVESTMENT	8.46	6.81	22.86	14.23	14.77
NONINVESTMENT	36.00	36.00	37.44	48.65	55.77
GNP	44.46	42.81	60.30	62.88	70.55
PERCENT OF GNP INVESTED	19.04%	15.19%	37.91%	22.63%	20.94%

Table D-2 (Continued)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE
RECOVERY 1972 COMPUTER RUNS - U.S.
(Five-Year Planning)

Run Number: 21B

Parameters

Capital cost per incremental dollar of postattack GNP: $2.00

Initial noninvestment demand required: 32.0%

Annual percentage growth allowed in non-investment demand after the second year: 4.0%

Attack level: 1000 weapons

Attack objective: Gross MVA

Recovery objective function: Hybrid

Growth rate after the fifth year: 4.0%

Depreciation Rate: 6.0%

Descriptor	Year 1	2	3	4	5
Diffuse	.57	*	7.41	4.34	4.53
Food and Clothing	*	1.07	1.44	.76	.79
Wood and Paper	.21	.54	.87	.48	.50
Chemicals	.07	.51	.58	.31	.33
Petroleum Refining	.01	.19	.21	.11	.12
Rubber and Leather	.08	.19	.25	.14	.15
Stone, Clay and Glass	.22	.06	.26	.15	.15
Primary Metals	1.20	*	.51	.35	.37
Fabricated Metals	.60	*	.42	.25	.26
Machinery except electrical	2.80	*	*	*	.44
Electrical Equip. and Misc.	1.16	*	.72	.43	.45
Motor Vehicles	1.28	*	.43	.29	.30
A/C, Ordnance and other Trans. Equipment	.08	.29	.45	.25	.26
Instruments	.24	*	.12	.08	.08
Trade and Services	*	4.18	9.85	5.32	5.55
TOTAL INVESTMENT	8.51	7.02	23.51	13.27	14.29
NONINVESTMENT	32.00	32.00	33.73	46.56	54.15
GNP	40.51	39.02	57.24	59.83	68.44
PERCENT OF GNP INVESTED	21.01%	17.99%	41.07%	22.17%	20.87%

Table D-2 (Continued)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE
RECOVERY 1972 COMPUTER RUNS - U.S.
(Five-Year Planning)

Run Number: 21A

Parameters

Capital cost per incremental dollar of postattack GNP: $2.00

Initial noninvestment demand required: 30.0%

Annual percentage growth allowed in non-investment demand after the second year: 4.0%

Attack level: 1250 weapons

Attack objective: Gross MVA

Recovery objective function: Hybrid

Growth rate after the fifth year: 4.0%

Depreciation Rate: 6.0%

Descriptor	Year 1	2	3	4	5
Diffuse	.48	*	6.65	4.17	4.35
Food and Clothing	*	1.09	1.36	.73	.76
Wood and Paper	.35	.43	.78	.46	.48
Chemicals	.18	.40	.52	.30	.32
Petroleum Refining	.05	.15	.19	.11	.11
Rubber and Leather	.16	.15	.23	.13	.14
Stone, Clay and Glass	.23	.05	.23	.14	.15
Primary Metals	1.18	*	.46	.34	.36
Fabricated Metals	.64	*	.38	.24	.25
Machinery except electrical	2.53	*	*	.10	.42
Electrical Equip. and Misc.	1.16	*	.65	.41	.43
Motor Vehicles	1.25	*	.40	.28	.29
A/C, Ordnance and other Trans. Equipment	.12	.23	.41	.24	.25
Instruments	.24	*	.11	.08	.08
Trade and Services	*	4.61	8.93	5.11	5.33
TOTAL INVESTMENT	8.58	7.11	21.24	12.84	13.72
NONINVESTMENT	30.00	30.00	35.58	45.31	52.00
GNP	38.58	37.11	56.82	58.16	65.72
PERCENT OF GNP INVESTED	22.24%	19.16%	37.38%	22.09%	20.87%

Table D-2 (Continued)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE
RECOVERY 1972 COMPUTER RUNS - U.S.
(Five-Year Planning)

Run Number: 28G

Parameters

Capital cost per incremental dollar of postattack GNP: $2.00

Initial noninvestment demand required: 54.0%

Annual percentage growth allowed in non-investment demand after the second year: 4.0%

Attack level: 250 weapons

Attack objective: Gross MVA

Recovery objective function: Present value of future GNP

Growth rate after the fifth year: 4.0%

Depreciation Rate: 6.0%

Descriptor	Year 1	2	3	4	5
Diffuse	1.93	1.41	5.89	5.11	5.26
Food and Clothing	.19	.72	1.10	.88	.92
Wood and Paper	.46	.30	.68	.56	.58
Chemicals	.36	.23	.45	.37	.38
Petroleum Refining	.09	.09	.16	.13	.14
Rubber and Leather	.14	.09	.20	.16	.17
Stone, Clay and Glass	.21	.06	.20	.17	.18
Primary Metals	.95	.09	.48	.41	.43
Fabricated Metals	.52	.08	.34	.29	.30
Machinery except electrical	1.79	*	.37	.49	.51
Electrical Equip. and Misc.	.99	.14	.58	.50	.52
Motor Vehicles	1.04	.08	.39	.34	.35
A/C, Ordnance and other Trans. Equipment	.19	.16	.35	.29	.30
Instruments	.20	.02	.11	.09	.10
Trade and Services	*	3.35	7.62	6.17	6.43
TOTAL INVESTMENT	9.07	6.81	18.91	15.96	16.58
NONINVESTMENT	54.00	54.00	56.16	58.41	62.86
GNP	63.07	60.81	75.07	74.37	79.44
PERCENT OF GNP INVESTED	14.38%	11.20%	25.19%	21.46%	20.87%

Table D-2 (Continued)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE RECOVERY 1972 COMPUTER RUNS - U.S. (Five-Year Planning)

Run Number: 28D

Parameters

Capital cost per incremental dollar of postattack GNP: $2.00

Initial noninvestment demand required: 47.0%

Annual percentage growth allowed in non-investment demand after the second year: 4.0%

Attack level: 500 weapons

Attack objective: Gross MVA

Recovery objective function: Present value of future GNP

Growth rate after the fifth year: 4.0%
Depreciation Rate: 6.0%

Descriptor	Year 1	2	3	4	5
Diffuse	*	.24	4.95	4.57	4.58
Food and Clothing	.20	.64	.94	.76	.80
Wood and Paper	.33	.29	.57	.49	.51
Chemicals	.31	.22	.38	.32	.33
Petroleum Refining	.09	.08	.14	.11	.12
Rubber and Leather	.13	.09	.17	.14	.15
Stone, Clay and Glass	.16	.07	.17	.15	.15
Primary Metals	.85	.12	.40	.36	.37
Fabricated Metals	.44	.09	.28	.25	.26
Machinery except electrical	1.49	*	.37	.42	.44
Electrical Equip. and Misc.	.83	.16	.49	.43	.45
Motor Vehicles	.99	.10	.33	.29	.31
A/C, Ordnance and other Trans. Equipment	.12	.15	.30	.25	.26
Instruments	.16	.03	.09	.08	.09
Trade and Services	*	1.98	6.48	5.36	5.59
TOTAL INVESTMENT	6.12	4.26	16.07	14.00	14.41
NONINVESTMENT	47.00	47.00	48.88	50.84	54.59
GNP	53.12	51.26	64.95	64.83	69.00
PERCENT OF GNP INVESTED	11.52%	8.31%	24.74%	21.59%	20.88%

Table D-2 (Continued)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE RECOVERY 1972 COMPUTER RUNS - U.S. (Five-Year Planning)

Run Number: 28C

Parameters

Capital cost per incremental dollar of postattack GNP: $2.00

Initial noninvestment demand required: 43.0%

Annual percentage growth allowed in noninvestment demand after the second year: 4.0%

Attack level: 750 weapons

Attack objective: Gross MVA

Recovery objective function: Present value of future GNP

Growth rate after the fifth year: 4.0%

Depreciation Rate: 6.0%

Descriptor	Year 1	2	3	4	5
Diffuse	*	*	3.48	3.26	4.11
Food and Clothing	.15	.58	.78	.69	.72
Wood and Paper	.21	.27	.52	.44	.46
Chemicals	.23	.20	.33	.29	.30
Petroleum Refining	.06	.07	.12	.10	.11
Rubber and Leather	.10	.08	.15	.13	.13
Stone, Clay and Glass	.11	.07	.16	.13	.14
Primary Metals	.69	.12	.46	.32	.34
Fabricated Metals	.34	.09	.28	.22	.23
Machinery except electrical	1.14	*	.48	.38	.40
Electrical Equip. and Misc.	.65	.16	.48	.39	.41
Motor Vehicles	.87	.10	.33	.26	.28
A/C, Ordnance and other Trans. Equipment	.07	.14	.27	.23	.24
Instruments	.13	.03	.09	.07	.08
Trade and Services	*	1.20	5.59	4.83	5.04
TOTAL INVESTMENT	4.76	3.11	13.48	11.76	12.97
NONINVESTMENT	43.00	43.00	44.72	46.51	49.24
GNP	47.76	46.11	58.20	58.26	62.21
PERCENT OF GNP INVESTED	9.96%	6.74%	23.16%	20.18%	20.85%

Table D-2 (Continued)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE RECOVERY 1972 COMPUTER RUNS - U.S. (Five-Year Planning)

Run Number: 28B

Parameters

Capital cost per incremental dollar of postattack GNP: $2.00

Initial noninvestment demand required: 40.0%

Annual percentage growth allowed in non-investment demand after the second year: 4.0%

Attack level: 1000 weapons

Attack objective: Gross MVA

Recovery objective function: Present value of future GNP

Growth rate after the fifth year: 4.0%
Depreciation Rate: 6.0%

Descriptor	Year 1	2	3	4	5
Diffuse	*	*	2.33	3.71	3.93
Food and Clothing	.05	.55	.89	.66	.69
Wood and Paper	.15	.28	.55	.42	.44
Chemicals	.17	.20	.36	.27	.29
Petroleum Refining	.05	.07	.13	.10	.11
Rubber and Leather	.09	.08	.16	.12	.13
Stone, Clay and Glass	.09	.07	.16	.13	.13
Primary Metals	.66	.15	.39	.31	.32
Fabricated Metals	.32	.11	.27	.21	.22
Machinery except electrical	1.11	.05	.42	.37	.38
Electrical Equip. and Misc.	.61	.19	.47	.37	.39
Motor Vehicles	.85	.12	.32	.25	.27
A/C, Ordnance and other Trans. Equipment	.05	.15	.28	.22	.23
Instruments	.12	.03	.09	.07	.07
Trade and Services	*	.73	6.18	4.63	4.82
TOTAL INVESTMENT	4.31	2.78	13.02	11.83	12.41
NONINVESTMENT	40.00	40.00	41.60	43.26	47.12
GNP	44.31	42.78	54.62	55.10	59.53
PERCENT OF GNP INVESTED	9.73%	6.50%	23.84%	21.48%	20.85%

Table D- 2 (Concluded)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE RECOVERY 1972 COMPUTER RUNS - U.S. (Five-Year Planning)

Run Number: 28A

Parameters

Capital cost per incremental dollar of postattack GNP: $2.00

Initial noninvestment demand required: 39.0%

Annual percentage growth allowed in noninvestment demand after the second year: 4.0%

Attack level: 1250 weapons

Attack objective: Gross MVA

Recovery objective function: Present value of future GNP

Growth rate after the fifth year: 4.0%
Depreciation Rate: 6.0%

Descriptor	Year 1	2	3	4	5
Diffuse	*	*	.90	3.55	3.70
Food and Clothing	.09	.52	.68	.62	.65
Wood and Paper	.12	.23	.49	.39	.41
Chemicals	.16	.18	.30	.26	.27
Petroleum Refining	.05	.06	.21	*	.10
Rubber and Leather	.08	.07	.14	.11	.12
Stone, Clay and Glass	.07	.05	.16	.12	.13
Primary Metals	.58	.09	.41	.29	.30
Fabricated Metals	.29	.07	.28	.20	.21
Machinery except electrical	.92	*	.51	.34	.36
Electrical Equip. and Misc.	.52	.12	.86	*	.37
Motor Vehicles	.78	.07	.33	.24	.25
A/C, Ordnance and other Trans. Equipment	.04	.12	.25	.20	.21
Instruments	.10	.02	.16	*	.07
Trade and Services	*	.73	5.92	3.50	4.53
TOTAL INVESTMENT	3.81	2.34	11.60	9.83	11.67
NONINVESTMENT	39.00	39.00	40.56	42.18	44.31
GNP	42.81	41.34	52.16	52.01	55.98
PERCENT OF GNP INVESTED	8.90%	5.67%	22.23%	18.90%	20.85%

Table D-3

INVESTMENT SCHEDULES AND OTHER DATA FROM THE RECOVERY 1972 COMPUTER RUNS - U.S.
(Nine-Year Planning)

Run Number: 29E

Parameters:

Capital cost per incremental dollar of postattack GNP: $2.00
Initial noninvestment demand required: 54%
Annual percentage growth allowed in noninvestment demand after the second year: 4%
Attack level: 250 Weapons
Attack objective: Gross MVA
Recovery objective function: Present value of GNP
Growth rate after the ninth year: 4%
Depreciation Rate: 6%

Descriptor	Year 1	2	3	4	5	6	7	8	9
Diffuse	1.93%	1.41%	6.70%	5.15%	6.34%	6.61%	5.45%	6.15%	6.43%
Food and Clothing	.19	.72	.86	.86	.91	.95	1.57	1.07	1.12
Wood and Paper	.46	.30	.65	.56	.64	.67	.79	.68	.71
Chemicals	.36	.23	.40	.36	.41	.42	.57	.44	.46
Petroleum Refining	.09	.09	.14	.13	.15	.15	.21	.16	.17
Rubber and Leather	.14	.09	.18	.16	.18	.19	.24	.20	.21
Stone, Clay and Glass	.21	.06	.22	.17	.21	.22	.21	.21	.22
Primary Metals	.95	.09	.56	.42	.53	.55	.41	.50	.53
Fabricated Metals	.52	.08	.38	.29	.36	.38	.31	.35	.37
Machinery except Electrical	1.79	*	.69	.53	.74	.77	.13	4.48	1.02
Electrical Equip. and Misc.	.99	.14	.67	.51	.63	.66	.53	.61	.64
Motor Vehicles	1.04	.08	.46	.35	.43	.45	.34	.41	.43
A/C, Ordnance & Other Trans. Equipment	.19	.16	.34	.29	.33	.35	.41	.35	.37
Instruments	.20	.02	.13	.10	.12	.13	.09	.11	.12
Trade and Services	*	3.35	6.53	6.08	6.70	6.98	10.07	7.49	7.83
TOTAL INVESTMENT	9.07	6.81	18.91	15.96	18.70	19.48	21.34	23.23	20.62
NONINVESTMENT	54.00	54.00	56.16	58.41	60.74	63.17	65.70	68.33	76.11
GNP	63.07	60.81	75.07	74.37	79.44	82.65	87.04	91.56	96.74
PERCENT OF GNP INVESTED	14.38%	11.20%	25.19%	21.46%	23.54%	23.57%	24.52%	25.37%	21.32%

Table D-3 (Continued)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE RECOVERY 1972 COMPUTER RUNS - U.S.
(Nine-Year Planning)

Run Number: 29D

Parameters:

Capital cost per incremental dollar of postattack GNP: $2.00
Initial noninvestment demand required: 47%
Annual percentage growth allowed in noninvestment demand after the second year: 4%
Attack level: 500 Weapons
Attack objective: Gross MVA
Recovery objective function: Present value of future GNP
Growth rate after the ninth year: 4%
Depreciation rate: 6%

Descriptor	Year 1	2	3	4	5	6	7	8	9
Diffuse	* %	.24%	5.61%	4.53%	5.46%	5.72%	4.74%	5.34%	5.58%
Food and Clothing	.20	.64	.75	.75	.79	.83	1.35	.93	.97
Wood and Paper	.33	.29	.55	.49	.56	.58	.68	.59	.62
Chemicals	.31	.22	.34	.32	.35	.37	.49	.39	.40
Petroleum Refining	.09	.08	.12	.11	.13	.13	.18	.14	.15
Rubber and Leather	.13	.09	.16	.14	.16	.17	.21	.17	.18
Stone, Clay and Glass	.16	.07	.18	.15	.18	.19	.18	.18	.19
Primary Metals	.85	.12	.47	.37	.45	.48	.36	.44	.46
Fabricated Metals	.44	.09	.32	.26	.31	.33	.27	.30	.32
Machinery except Electrical	1.49	*	.64	.47	.63	.67	.12	.52	.55
Electrical Equip. and Misc.	.83	.16	.56	.45	.54	.57	.47	.53	.55
Motor Vehicles	.99	.10	.38	.31	.37	.39	.30	.36	.38
A/C, Ordnance & Other Trans. Equipment	.12	.15	.29	.25	.29	.30	.36	.31	.32
Instruments	.16	.03	.11	.09	.10	.11	.08	3.35	.43
Trade and Services	*	1.98	5.59	5.31	5.81	6.06	8.65	6.50	6.80
TOTAL INVESTMENT	6.12	4.26	16.07	14.00	16.13	16.88	18.43	20.05	17.88
NONINVESTMENT	47.00	47.00	48.88	50.84	52.87	54.98	57.18	59.47	66.08
GNP	53.12	51.26	64.95	64.83	69.00	71.86	75.61	79.52	83.96
PERCENT OF GNP INVESTED	11.52%	8.31%	24.74%	21.59%	23.38%	23.48%	24.38%	25.21%	21.30%

Table D-3 (continued)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE RECOVERY 1972 COMPUTER RUNS - U.S.
(Nine-Year Planning)

Run Number: 29C

Parameters:

Capital cost per incremental dollar of postattack GNP: $2.00
Initial noninvestment demand required: 43%
Annual percentage growth allowed in noninvestment demand after the second year: 4%
Attack level: 750 weapons
Attack objective: Gross MVA
Recovery objective function: Present value of future GNP
Growth rate after the ninth year: 4%
Depreciation rate: 6%

Descriptor	Year 1	2	3	4	5	6	7	8	9
Diffuse	*	*	3.43	3.66	4.73	4.75	4.37	4.74	4.95
Food and Clothing	.15	.58	.69	.67	.72	.75	1.04	.82	.86
Wood and Paper	.21	.27	.53	.42	.49	.50	.57	.52	.55
Chemicals	.23	.20	.32	.27	.31	.32	.39	.34	.36
Petroleum Refining	.06	.07	.12	.10	.11	.12	.14	.09	.09
Rubber and Leather	.10	.08	.15	.12	.14	.14	.17	.15	.16
Stone, Clay and Glass	.11	.07	.18	.13	.16	.16	.16	.16	.17
Primary Metals	.69	.12	.47	.30	.39	.39	.34	.39	.41
Fabricated Metals	.34	.09	.32	.21	.27	.27	.25	.27	.28
Machinery except Electrical	1.14	*	.68	.33	.53	.51	.25	.46	.48
Electrical Equip. and Misc.	.65	.16	.55	.36	.47	.47	.43	.47	.49
Motor Vehicles	.87	.10	.38	.24	.32	.32	.28	.32	.33
A/C, Ordnance & Other Trans. Equipment	.07	.14	.27	.22	.26	.26	.29	.27	.28
Instruments	.13	.03	.11	.07	.09	.09	.08	1.81	.27
Trade and Services	*	1.20	5.28	4.66	5.21	5.35	6.84	5.78	6.05
TOTAL INVESTMENT	4.76	3.11	13.48	11.76	14.21	14.40	15.61	16.61	15.75
NONINVESTMENT	43.00	43.00	44.72	46.51	48.37	50.30	52.32	54.41	58.83
GNP	47.76	46.11	58.20	58.26	62.58	64.70	67.93	71.02	74.56
PERCENT OF GNP INVESTED	9.96%	6.74%	23.16%	20.18%	22.71%	22.25%	22.98%	23.39%	21.10%

Table D-3 (continued)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE RECOVERY 1972 COMPUTER RUNS - U.S.
(Nine-Year Planning)

Run Number: 29B

Parameters:

Capital cost per incremental dollar of postattack GNP: $2.00
Initial noninvestment demand required: 40%
Annual percentage growth allowed in noninvestment demand after the second year: 4%
Attack level: 1000 weapons
Attack objective: Gross MVA
Recovery objective function: Present value of future GNP
Growth rate after the ninth year: 4%
Depreciation rate: 6%

Descriptor	Year 1	2	3	4	5	6	7	8	9
Diffuse	*	*	3.10	3.82	5.04	5.20	4.04	4.67	4.88
Food and Clothing	.05	.55	.65	.64	.68	.72	1.32	.81	.85
Wood and Paper	.15	.28	.53	.41	.50	.52	.63	.52	.54
Chemicals	.17	.20	.32	.27	.31	.32	.46	.34	.35
Petroleum Refining	.05	.07	.11	.10	.11	.12	.17	.12	.13
Rubber and Leather	.09	.08	.15	.12	.14	.15	.19	.15	.16
Stone, Clay and Glass	.09	.07	.18	.13	.16	.17	.16	.16	.17
Primary Metals	.66	.15	.48	.31	.42	.44	.30	.38	.40
Fabricated Metals	.32	.11	.32	.22	.29	.30	.23	.27	.28
Machinery except Electrical	1.11	.05	.76	.39	.61	.63	*	.46	.48
Electrical Equip. and Misc.	.61	.19	.56	.38	.50	.52	.40	.46	.48
Motor Vehicles	.85	.12	.39	.26	.35	.36	.25	.31	.33
A/C, Ordnance & Other Trans. Equipment	.05	.15	.27	.21	.26	.27	.33	.27	.28
Instruments	.12	.03	.11	.07	.10	.10	.07	3.85	.47
Trade and Services	*	.73	5.09	4.50	5.10	5.32	8.28	5.68	5.94
TOTAL INVESTMENT	4.31	2.78	13.02	11.83	14.57	15.12	16.81	18.44	15.72
NONINVESTMENT	40.00	40.00	41.60	43.26	44.99	46.79	48.67	50.67	57.65
GNP	44.31	42.78	54.62	55.10	59.57	61.91	65.48	69.11	73.37
PERCENT OF GNP INVESTED	9.73%	6.50%	23.84%	21.48%	24.46%	24.42%	25.68%	26.68%	21.43%

Table D-3 (concluded)

INVESTMENT SCHEDULES AND OTHER DATA FROM THE RECOVERY 1972 COMPUTER RUNS - U.S. (Nine-Year Planning)

Run Number: 29A

Parameters:

Capital cost per incremental dollar of postattack GNP: $2.00
Initial noninvestment demand required: 39%
Annual percentage growth allowed in noninvestment demand after the second year: 4%
Attack level: 1250 weapons
Attack objective: Gross MVA
Recovery objective function: Present value of future GNP
Growth rate after the ninth year: 4%
Depreciation rate: 6%

Descriptor	Year 1	2	3	4	5	6	7	8	9
Diffuse	*	*	1.77	2.92	4.28	4.09	3.99	4.24	4.43
Food and Clothing	.08	.53	.64	.60	.65	.67	.87	.74	.77
Wood and Paper	.12	.23	.53	.35	.45	.44	.49	.47	.49
Chemicals	.16	.17	.32	.24	.28	.28	.34	.31	.32
Petroleum Refining	.04	.07	.11	.09	.10	.10	.12	.11	.12
Rubber and Leather	.08	.08	.15	.10	.13	.13	.15	.14	.14
Stone, Clay and Glass	.08	.05	.18	.10	.14	.14	.14	.14	.15
Primary Metals	.59	.08	.49	.23	.35	.34	.32	.35	.36
Fabricated Metals	.29	.07	.33	.17	.24	.23	.23	.24	.25
Machinery except Electrical	.93	*	.71	.22	.47	.42	.28	.41	.43
Electrical Equip. and Misc.	.53	.12	.57	.29	.42	.41	.39	.42	.44
Motor Vehicles	.78	.07	.40	.19	.29	.28	.26	.29	.30
A/C, Ordnance & Other Trans. Equipment	.05	.12	.27	.18	.23	.23	.26	.24	.25
Instruments	.10	.03	.11	.05	.08	.08	.07	1.17	.19
Trade and Services	*	.73	5.06	4.08	4.72	4.77	5.81	5.19	5.42
TOTAL INVESTMENT	3.81	2.34	11.63	9.82	12.86	12.61	13.72	14.45	14.08
NONINVESTMENT	39.00	39.00	40.56	42.18	43.87	45.62	47.45	49.35	52.75
GNP	42.81	41.34	52.19	52.01	56.72	58.23	61.17	63.80	66.83
PERCENT OF GNP INVESTED	8.90%	5.67%	22.29%	18.89%	22.66%	21.65%	22.43%	22.65%	21.07%

Table D-4

INVESTMENT SCHEDULES AND RECOVERY FROM MEDIUM UNIFORM DAMAGE, 1972 COMPUTER RUNS - USSR (Five-Year Planning)

Run Number: 32B

Parameters:

Capital cost per incremental ruble of postattack NMP: 2.00 rubles

Initial noninvestment demand required: 38%

Annual percentage growth allowed in noninvestment demand after the second year: 4%

Attack level:

Attack objective:

Recovery objective function: Present value of future NMP

Growth rate after the fifth year: 4%

Depreciation rate: 5%

Descriptor	Year 1	2	3	4	5
Ores and Metals	.70	.24	.87	2.89	.66
Diffuse	*	*	.40	6.58	6.85
Electric Power	.71	.24	.75	.58	.30
Machine Building & Metal Working except as specified below	1.28	.36	1.59	1.01	1.05
Machine Tools	.01	*	*	*	.02
Forging, Pressing Equip.	*	*	*	*	*
Construction Mach. & Equip.	.02	*	*	.01	.01
Trans. Equip. except Autos	.07	*	*	.05	.06
Autos	.21	.06	.22	.11	.12
Agricultural Equipment	.06	.01	.08	.08	.08
Mineral Chemicals	.03	.01	.04	*	.01
Basic Chemicals	.22	.08	.26	.10	.10
Synthetic Rubber	.02	.01	.02	.01	.01
Rubber Products	.20	.06	.19	.08	.08
Light Industry including Wood, Paper, Construction Materials, Food & Clothing	*	*	12.31	4.06	4.23
Dyes, Synthetics, Paints	.41	.15	.46	.17	.18
TOTAL INVESTMENT	3.93	1.23	17.19	15.44	13.78
NONINVESTMENT	38.00	38.00	39.52	43.50	58.46
NMP	41.93	39.23	56.71	58.94	72.24
PERCENT NMP INVESTED	9.37%	3.13%	30.31%	26.30%	19.07%

Table D-5

INVESTMENT SCHEDULES AND RECOVERY FROM HEAVY UNIFORM DAMAGE, 1972 COMPUTER RUNS - USSR (Five-Year Planning)

Run Number: 37C

Parameters:

Capital cost per incremental ruble of postattack NMP: 2.00 rubles

Initial noninvestment demand required: 30%

Annual percentage growth allowed in non-investment demand after the second year: 4%

Attack level:

Attack objective:

Recovery objective function: Present value of future NMP

Growth rate after the fifth year: 4%

Depreciation rate: 5%

Descriptor	Year 1	2	3	4	5
Ores and Metals	.47	.12	1.11	6.06	.90
Diffuse	*	*	*	*	6.05
Electric Power	.58	.18	.83	.24	.26
Machine Building & Metal Working except as specified below	.71	*	2.44	.88	.92
Machine Tools	*	*	*	.02	.02
Forging, Pressing Equip.	*	*	*	.01	*
Construction Mach. & Equip.	.01	*	.01	.01	.01
Trans. Equip. except Autos	.04	*	.05	.05	.05
Autos	.15	.03	.29	.10	.10
Agricultural Equipment	.01	*	.15	.07	.07
Mineral Chemicals	.02	.01	.04	.01	.01
Basic Chemicals	.17	.06	.28	.08	.09
Synthetic Rubber	.02	*	.03	.01	.01
Rubber Products	.16	.04	.23	.07	.07
Light Industry including Wood, Paper, Construction Materials, Food & Clothing	*	*	7.65	3.48	3.63
Dyes, Synthetics, Paints	.32	.11	.50	.15	.15
TOTAL INVESTMENT	2.67	.56	13.63	11.24	12.34
NONINVESTMENT	30.00	30.00	31.20	34.88	50.02
NMP	32.67	30.56	44.82	46.12	62.36
PERCENT NMP INVESTED	8.17%	1.82%	30.39%	24.37%	19.78%