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A Model of Technological Capacity To Support Survivors of Nuclear Attack

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Summary

A MODEL OF TECHNOLOGICAL CAPACITY TO SUPPORT SURVIVORS OF NUCLEAR ATTACK

Bernard Sobin

September 1968

This report was prepared for the Office
of Civil Defense, under OCS Contract
DAHC20-67-C-0137
OCD Work Unit 3534B

RESEARCH ANALYSIS CORPORATION
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SUMMARY

Problem

To describe an economic model that was developed for estimating the ability of surviving productive capacities to support human survivors of direct weapons effects after a major nuclear attack on the US. It covers the principles on which the model is based and enough information on the origins of the numerical estimates to give a reader some idea of the value of its use.

The model is limited to technological possibilities without regard to whether the economy would actually be managed well enough to realize such physical potential. The economy analyzed by the model is as of some date after decontamination and completion of any minor repairs that can restore service of some damaged capacities.

Background

Development of the model was part of the work under a contract to investigate the economic-viability implications of light population casualties but heavy damage to nonhuman productive resources. Results of applications of the model to specific damage assumptions appear in classified documents.

Discussion

Details of the model structure are based on the assumption that a margin between the number of people actually needing support by the economy and the number that potentially could be supported indefinitely is a good index of viability of the economy. A larger favorable margin supports greater confidence that the population will survive despite either errors in the model or inefficiency of the postattack system for managing the economy. A larger margin also implies immediate availability of more slack in the economy for application to growth-producing investments.

The model allows for no relief of bottlenecks by imports. To the extent that imports are available, particularly without having to be paid for immediately by exports, the survival problem will be easier than indicated by the model.

The model is a linear-programming analysis with activities that consist of alternative production processes, support of population, and support of

governmental activities. The amount of the last is a fixed charge on the economy. The model chooses combinations of levels of the various production processes that maximize the number of people who can be supported without violation of any of the capacity constraints or other feasibility conditions of the model. The capacity constraints are capacities surviving an attack (after repair of light damage). In principle the model could be modified to include military and investment activities, and the objective of maximizing the number of people that can be supported could be modified.

Although a number of dynamic elements could be introduced to the model, it is important to note that the model is presently static. It is static in the sense that the calculated rates of delivery of end products of the economy to governments and households are rates that can be maintained for an indefinite period. The rates of delivery do not depend on depletion of inventories of either end products, materials, or goods-in-process. The absence of investment activities as the model is now formulated also implies that the model is static in the sense that there is no provision for changes in the capacity of the economy to make deliveries of end products. As noted earlier, a good margin between requirements and potential for survival production implies the existence of slack for investment in growth of the economy's ability to deliver end products.

It is conceivable that, after an actual attack, investment would be needed very soon to halt depletion of inventories of commodities crucial to survival. Here the investment would be to preserve an existing rate of delivery of end products rather than to expand the rate. The main part of this paper includes some discussion of how the present model might be modified to include some provision for investment activities needed to maintain feasibility of a given rate of delivery of end products.

ECONOMICS AND COSTING DEP RTMENT
TECHNICAL PAPER RAC-TP-313
Published September 1968

This report has been reviewed in the Office of Civil Defense and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Office of Civil Defense.
Contract DAHC20-67-C-0137
OCD Work Unit 3534B

A Model of Technological Capacity To Support Survivors of Nuclear Attack

by
Bernard Sobin

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FOREWORD

This is one of two RAC papers prepared as part of a study of the capability of the US economy to continue to support the immediate survivors of a nuclear attack in which the damage to industrial capacity is large in relation to the population lost to direct weapon effects. The other paper has been issued as Bernard Sobin and David F. Gates, "Economic Implications of High Population and Low Property Survival in Nuclear Attack on the United States (U)," SECRET, RAC-TP-317, August 1968.

The present paper describes a model that was used as one of the inputs to the classified paper. The model is designed to calculate the capability of the economy to support survivors after hypothesized attacks, and it can deal with attacks other than the ones hypothesized for the classified paper.

The model is a static one, with no provision for postattack investment to relieve any capacity bottlenecks that remain after decontamination and repair of light damage. A later publication will describe an augmentation of this model to include a period of investment before the steady state.

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It is conceivable that, after an actual attack, investment would be needed very soon to halt depletion of inventories of commodities crucial to survival. Here the investment would be to preserve an existing rate of delivery of end products rather than to expand the rate. The main part of this paper includes some discussion of how the present model might be modified to include some provision for investment activities needed to maintain feasibility of a given rate of delivery of end products.

A Model of Technological Capacity

To Support Survivors of Nuclear Attack

INTRODUCTION

Development of the model described here was part of a project to determine whether civil defense measures directed at saving lives but not property from direct weapons effects have any significant likelihood of being defeated ultimately by inability of surviving production capacity to support all the surviving population. Another RAC paper[1] includes an application of the model to a particular nuclear attack.

The basic problem can be subdivided according to a number of principles of classification. One possible subdivision is by time period dealt with. Other subdivisions can be physical problems when physical resources are used in optimal fashion or management problems (monetary and fiscal policy, price controls, material controls, etc) for optimizing the use of resources. The model described here deals with physical capabilities (with management assumed perfect) of resources that exist after a period of clearing rubble, decontamination, and completion of repairs that do not cause significant drain on productive resources. The model is used to determine whether the fixed plant and equipment plus land and labor resources are then sufficient, without further augmentation by investment or by imports in excess of normal, to provide for minimum levels of governmental activity and indefinite support of the population in good health.

The model goes into great detail on food production and supporting activities as central to survival. The detail is in the form of highly disaggregated food-production activities and provision of flexibility in mixes of food-production activities to meet survival requirements. A distinguishing feature of the model is concentration of detail in the sectors considered most important for the principal model application. More detail in other sectors would be needed for useful application to other kinds of problems.

GENERAL CHARACTERISTICS OF THE MODEL

The model is an application of linear-programming mathematics. The problem is to find a combination of levels of available types of activities that maximizes a linear function of those activities subject to a set of linear inequalities in which the activity levels are the variables.*

Mathematically the problem may be stated as

maximize

$$Z = \sum^{j} C_j X_j$$

subject to

$$\sum^{j} a_{ij} X_j \begin{pmatrix} \geq \\ = \\ \leq \end{pmatrix} b_i \, ,$$

where X_j is a variable level of the jth activity rate C_j , the given contribution to the objective Z per unit of the jth activity rate; a_{ij} , the amount of the ith item used or made available per unit of the jth activity. The model has 149 activity rates (annual) into which all resource-using activity for survival has been divided, and there are 82 constraining rows.

The a_{ij} are, by convention, positive for inputs to activities and negative for outputs. The expression $\sum^{j} a_{ij} X_j$ for an i representing goods and services currently produced may be considered an excess of current input requirements over current output. When this sum equals zero, requirements equal supply, and the usual row constrains the sum to be less than or equal to a b_i of zero. Occasionally there is a row with a constraint that the sum be greater than or equal to a b_i of zero. Such a row occurs, for example, in certain nutrition cases (to be discussed later) where a constraint is needed to make sure that what can healthfully be consumed be at least as much as is supplied to the diet.

For an i representing fixed capacities, the expression $\sum^{j} a_{ij} X_j$ consists entirely of requirements, and this sum is constrained to be less than or equal to a b_i that represents postattack capacity. Finally, in a few cases, b_i is preceded by

*A theorem in linear programming states that if there is more than one combination that meets the requirement there are infinitely many.

an equality sign to represent a stipulated level of one activity or a stipulated level of use of a fixed capacity.

Appendix A has the entire matrix of a_{ij} . Table 1 classifies the matrix elements by column (activity), row (constraint), and sign (noted earlier as indicating outputs if negative and inputs if positive). The following comments describe the matrix in terms of both activities and constraints.

ACTIVITIES

Persons Supported

Persons supported is a class consisting of only one activity, the number of millions of people supported each year. It is the only variable with a nonzero c_j. This is convenient because the absence of other nonzero terms of the objective function implies that the selection of activities that maximize the objective is identical for any positive magnitude that may be assigned to the value of human life.

Each million persons supported requires minimum quantities of calories and particular nutrients. There is also a maximum number of calories that is compatible with health and a maximum weight of food that can be eaten. The plus entries in the box for human nutrients represent a_{ij} describing amounts of these minima and maxima per million persons supported.

The industrial capacities indicated per million persons in the "persons supported" column are capacities that are required directly and indirectly to support delivery of nonfood commodities that the average person is considered to need for his support. For example, footwear requirements imply need for footwear-production capacity directly plus leather tanning and finishing, electric power, fuel, and many other kinds of industrial capacity indirectly. Each row of the group "industrial capacities" has the sum of all direct and indirect demands on that capacity for all nonfood requirements of one million people.

Pursuing the footwear illustration further, it may be noted that an indirect input to footwear production is hides and skins. The production process that produces hides and skins happens to be defined in terms of the amount of meat produced, and any capacity constraints appear in the model as constraints on meat production. Regardless of how production processes and constraints are defined, however—it would be just as correct to call hides and skins the principal product and meat the byproduct—the requirement for hides and skins per million persons must be provided for.

The byproducts covered by the model are the hides and skins just mentioned and cotton fiber. The latter is a byproduct of cottonseed (a food and animal-feed product) production. Here the byproduct is, at least in peacetime, more valuable than the principal product. It illustrates the principle that the determination of which of joint products is the byproduct is arbitrary. Applications of the present model are not affected by which of the joint products are defined as the byproducts.

Labor requirements are similar in concept to industrial capacities and byproducts. The production processes that directly or indirectly produce the nonfood requirements per million persons all use labor. The entry in a "labor" row is the sum of all these labor requirements.

TABLE 1

General Form of the Model

Types of balance	Activities: Persons supported	Production: Crops	Production: Livestock products	Production: Industrial inputs to agriculture	Government operations		Constant terms[a]
Human nutrie							
Lower limits	+	–	–			≤	0
Upper limits	+	–	–			≥	0
Livestock nutrients							
Lower limits		–	+			≤	0
Upper limits		–	+			≥	0
Land classes							
Upper limits		+				≤	Postattack availability[b]
Stipulations		+				≥	Postattack availability[b]
Industrial inputs to agriculture		+		–		≥	0
Special constraints							
Soybean-grain mix		+ –				≤	0
Level of government					+	=	Stipulated level of government activity
Industrial capacities	+	+	+	+	+	≤	Postattack availability[c]
Byproducts	+	+ –	+ –	+	+	≤	0
Livestock capacities			+			≤	Postattack availability[c]
Labor	+	+	+	+	+	≤	Postattack availability[c]

[a]When preceded by ≤, ≥, or =, the element of the column is an upper bound, lower bound, or both, respectively, on the cumulative product. (See "Constant Terms" subsection of the section "Derivation of Model Inputs" of this paper for further interpretation of the constant-terms elements.)

[b]Same as preattack.

[c]Output of damage assessment.

The foregoing listing of items in the "persons supported" column has both direct and indirect inputs to nonfood requirements but only direct inputs to food requirements. This reflects the fact that the indirect inputs to nonfood requirements per million people are the same for all model applications, whereas the indirect inputs to food requirements depend on the solution mix of foods and ways of producing them. The model does, of course, account for indirect inputs to nutrition but does so as inputs to separate activities for each way of producing each food.

Production

Maximizing the number of persons that can be supported involves decisions about three classes of production variables: crops, livestock products, and industrial inputs to agriculture. The decisions for the last group are really implied by those of the first two groups and could have been omitted from the list of decision variables. The way they were retained, however, avoids any overdetermination of the model and has some conveniences in analysis of solutions.

The crop-production activities produce both food and animal-feed crops. The negative entries in the human-nutrient and livestock-nutrient rows refer to amounts of nutrients yielded in later processing (including byproduct production) per billion pounds of each crop after any crop deductions for seed.

The plus entries in the next two classes of rows represent amounts of types of land and industrial inputs to agriculture required per billion pounds of each crop.

A single row for soybean-grain mix has soybean-meal equivalents for bread baking per billion pounds of soybeans and of breadgrains. The sign is plus for the soybean crop and minus for the breadgrains. The reason for this row is discussed in the section "Balance Constraints," subsection "Special Constraints."

The industrial-capacity rows are industrial capacities required directly as inputs to agriculture (fertilizer, pesticides, and petroleum products) and required both directly and indirectly as inputs to the processing and distribution of agricultural products. The indirect inputs to agriculture are accounted for in the columns for industrial inputs to agriculture. As suggested earlier, it would have been possible to consolidate the columns for industrial inputs to agriculture with the columns for the agricultural activities.

The negative entry in the byproducts section is production (negative requirement) of cotton fiber per billion pounds of cottonseed. The remaining entries in the crops columns are self-explanatory.

The labor entries are for labor employed in agriculture per billion pounds of each crop plus labor required directly or indirectly to process and distribute each billion pounds of crop.

The columns for livestock products (beef, milk, pork, lamb, poultry meat, and eggs) can be explained in much the same way as the columns for crops. The negative requirement in the byproduct section is hides and skins yielded by beef production.

The industrial inputs to agriculture are columns each of which refers to a row of the group with the same class name. Each column has a negative entry in the corresponding row giving the amount of the industrial output (negative requirement) in units used for the row per unit used to measure the level of the column production activity.

The entries for industrial capacity and labor rows are amounts of each industrial capacity or unit of labor that is required directly or indirectly for each unit of delivery to agriculture. In the case of a capacity required directly (e.g., petroleum-refining capacity per unit of petroleum-product deliveries to agriculture), the entry is unity for the direct requirement plus any feedback of additional capacity of the same type required indirectly (e.g., additional petroleum-refining capacity required indirectly to support output of the industries that supply inputs to petroleum refining). The government-operations class of activity has only one column in the present model although a breakdown by type of operation would be possible. The industrial capacity and byproduct entries are direct and indirect requirements to support sales of goods and services to Federal, state, and local governments. The labor row consolidates the labor for purchased goods and services with labor employed directly.

The entry in the row for level of government is a factor to convert units of the column activity to units of the row constraint. The model happens to define both units identically; hence the scaling factor is unity.

BALANCE CONSTRAINTS

The matrix elements whose signs appear in Table 1 have already been stated to be coefficients of variables in a linear inequality or equation. The types of constraining inequalities and equations are discussed in the following paragraphs.

Human Nutrients

A human-nutrient row for a lower bound per million persons states that the requirements of the nutrient to support surviving persons, minus the nutrients produced by crops, minus the nutrients produced by livestock, must be less than or equal to zero.

A row for an upper bound states that the maximum consumption for all survivors must be no less than the quantities yielded by crops and livestock, i.e., production must not exceed what can healthfully be eaten. There are upper bounds for calories, fats, and weight of ration.

This second kind of balance constraint would not be necessary if food weight, calories, and nutrients were not yielded in fixed proportions by crops and livestock products. An optimal production program would not produce more of any item than could healthfully be consumed. Constraints may be needed, however, to prevent the satisfaction of requirements of some nutrients by types of food with such small percentages of those nutrients and such large percentages of calories, fats, or weight as to make the intake of food excessive in one or more of calories, fats, and weight.*

Livestock Nutrients

In the cases of lower bounds, a typical livestock-nutrient balance constraint states that what is required to produce the solution quantities of live-

*At present it appears that a typical situation is one in which diets that maximize the number of persons supported are well below maximum per capita levels of calories, fats, and weight. The constraints on maximum production have therefore not been needed yet.

stock products minus what is yielded by crops (including pasture and byproducts of human-food crops) must be less than or equal to zero. That is, requirements must be less than or equal to supply. A row for upper bounds (on weight of ration) states that the maximum consumption of nutrients in production of the solution quantities of livestock products must be no less than the quantities yielded by the crops.

Land Classes

The typical land constraint deals with the maximum acreage that can be devoted to a crop or class of crops. Thus there are maximum acreages for each crop, for grains as a class, for all crops other than pasture, and for all crops including pasture. Each such constraint for a class of land states that the combined requirements for all crops must be less than or equal to the amount of the class of land available. Convertibility of land to alternative uses is allowed for by the rough device of having the sum of subclass maxima of a class exceed the class maximum. For example, the sum of maximum acreages for each grain exceeds the grainland maximum, which implies that maximum use of grainland for some grains is not consistent with maximum use of grainland for other grains.*

In addition to the maximum acreages, there are three minima. The amount of land devoted to fruits and vegetables must be at least as great as in recent peacetime years. The principal reason is that the model omits specific accounting for vitamin C and other nutrients for which fruits and vegetables might be important. In addition the small amount of land involved would not add much to the output of crops higher in calorie and protein yields, and in the case of fruits the conversion to other production would mean loss of trees well beyond the end of the food emergency. The third minimum acreage constraint relates to wheat. At least one-half the land suitable for wheat must be devoted to wheat. At least that much wheatland is considered not usable for other crops with normal inputs and yields.

Industrial Inputs to Agriculture

The model accounts for three industrial inputs to agriculture: fertilizers, pesticides, and petroleum products. A row for each states that the aggregate requirements for crop production minus the amount produced by industry must be no greater than zero.

Special Constraints

The constraint with respect to mix of soybeans and grains is designed to limit the proportion of soybean meal in bread flours and as a meat extender. Soybean meal is far superior to wheat flour, rye flour, and cornmeal as a source of protein and is also superior to meat, but there are limits to the percentage of soybean meal that can be included in bread acceptable to consumers or that can be used to "adulterate" meat. The existence of any such limits under emergency conditions is perhaps debatable, but the model provides for such limits well above what is accepted now.

* The correct way in principle to handle land convertibility is to classify land by productivity in alternative use and to have a separate alternative way of producing each crop for each class of land that may be used. This may be attempted in a later version of the model.

The way the constraint works is as follows. Soybean production has three kinds of food columns: one in which the soybean meal byproduct of oil production is fed to livestock; one in which the meal is used for human food, primarily as a substitute for breadgrains; and one in which the meal is used as a meat extender. The second and third types of soybean production have positive coefficients in the special-constraint row. These positive coefficients are equal to the quantities of meal yielded per billion pounds of soybean production. Each of the breadgrain columns has a negative coefficient equal to that yield multiplied by the maximum ratio of soybean meal for flour to total flour. Each of the meat columns has a negative coefficient equal to the product of the soybean-meal yield of soybean production and the maximum ratio of proportion of extender in total meat. The constraining inequality states that the total amount of soybean meal produced minus the maximum used in bread flours and meat must not exceed zero.*

The constraint with respect to level of government activity states how many units of the 1958 mix of direct and indirect requirements generated by government operations are stipulated for the problem. The a_{ij} here is unity, and the stipulation is a percentage of the 1958 level multiplied by 0.001 to convert millions of dollars of the activity vector to billions of dollars for the activity variable. The scaling by 0.001 could also have been in the a_{ij} rather than in the stipulation constraint.†

Industrial Capacities, Livestock Capacities, and Labor

Each industrial-capacity, livestock-capacity, or labor row states that total requirements by solution activities must not exceed the postattack capacity available. In each case the postattack capacity available is an output of a damage assessment. The industrial and livestock capacities are defined in units of the outputs they support. The labor capacity unit is millions of workers.

Byproducts

Each of the two byproduct rows (hides and skins; cotton fiber) states that total requirements by using activities minus total supply provided by producing activities must be no greater than zero. This is in effect a stipulation of no stockpile depletion. For a situation in which there is considered to be a large stockpile of a byproduct (e.g., survival of a large peacetime stock of cotton or salvage of large quantities of hides and skins from livestock dying or slaughtered soon after the attack), the constant term may be any maximum inventory-depletion rate that is considered proper.

*This is a palatability constraint for which the justification in emergency is questionable. However, if the concessions to palatability are accepted, it ought to be with a separate constraining inequality for each use rather than with only a single aggregate constraint. The procedure used so far overstates capabilities slightly by permitting the computer to use the meat-extender activity (which requires no ultimate baking inputs) for production of soybean meal both as a meat extender and as a bread-flour substitute.

†Use of an activity vector with requirements measured in millions instead of billions of 1958 dollars is a vestige of early-stage computations with direct requirements in which use of billions of dollars would have required too many decimal places for the computer program.

DERIVATION OF MODEL INPUTS

Evaluation of a model may use one or both of two kinds of criteria: (a) the plausibility of answers yielded by the model and (b) the apparent soundness of the estimates of inputs to the model. The purpose of this section is to provide bases for judgments on the second kind of criterion.

Full achievement of this purpose here would involve providing work sheets for complete derivation of every number in the model. However, that would make the paper impractically long and would add little to achieving the objective beyond what may be yielded by more aggregated descriptions of the derivations of most numbers. The latter level of detail of the derivation of estimates is used here.

The discussion is in terms of the following major categories: (a) an overview of data-requirements sources, (b) the food-production submodel, (c) the remaining industry submodel, (d) industrial capacities, (e) land capacities, (f) per capita consumption requirements, and (g) government-operation requirements.

All the final estimates, except those for capacities, appear in App A. The land capacities are in a text table, and the industrial capacities cannot be presented because they vary with the problem.

OVERVIEW OF DATA REQUIREMENTS

The sectoral classification system of the model and the selection of sources are tailored largely to the intended use of the model in analysis of the capability of the economy to provide minimum subsistence to survivors of weapons effects. Since physiological standards for nutrition are much less compressible than customary standards of other kinds of household consumption, the main emphasis of the model is on resources and decisions needed for nutrition, a key physiological requirement. (Survival standards are discussed in more detail in the subsection "Nutrient Requirements.") The emphasis on nutrition takes two forms. One is the use of considerably more detail for the agricultural sectors than appears in any published model of the US economy. The other is the use of alternative input-output combinations for each agricultural crop and infinitely many alternative human diets, with the mathematical procedure selecting the combinations that make the most effective use of available resources. Outside the food-production area the model is rather highly aggregated, and there are no process alternatives. The model could probably be improved by disaggregation and provision for alternative processes outside the food area, but it is felt that there is a reasonable balance at the margin between efforts at accuracy in food and nonfood areas.

FOOD-PRODUCTION SUBMODEL

The food-production submodel consists of the columns for food-production activities and rows for nutrients, land and industrial inputs to agriculture, the soybean-grain-mix constraint, and part of each labor input to food production.

The food-production activities cover production and subsequent processing of the following crops and livestock products: wheat, corn, oats, rice, rye, peanuts, cottonseed, soybeans, edible dry beans, fruits, potatoes, sweet potatoes, beet sugar, cane sugar, other vegetables, grain sorghum, barley, hay, pasture, beef, pork and lard, lamb, poultry, eggs, and milk. Omitted are a number of minor food and feed crops, fish, and exotic foods. The fish are omitted because of difficulty of measurement of a postattack fishing and fish-preservation capacity that would probably be too small to affect the diet significantly.*

Each of the crops has at least four different activity columns. The four columns correspond to production with normal fertilizer and pesticide inputs, without fertilizer, without pesticides, and with neither fertilizer nor pesticides. In addition there are further columns in some cases for alternative ways of processing crops. For example, corn may provide nutrients exclusively for livestock or mainly for humans with byproducts for livestock. When corn is intended for livestock, a distinction is made between the activities of producing for poultry and for other livestock because the digestible-nutrient contents are not the same for the two classes. Appendix A has a complete list of activities.

Human Nutrients

The human-nutrient rows deal with minima for calories, proteins, fats, iron, and calcium, and they deal with maxima for calories, fats, and weight of ration. The rationale for this list is discussed below in the discussion of per capita requirements.

All the food-processing activities are measured in billions of pounds of crop or livestock products. The human-nutrient yield is estimated through two factors, the weight of edible food per unit of the activity and the amount of each nutrient per unit of food (with calories considered as a nutrient). Factors for converting crop weights to food weights are readily available from an introductory table of Agricultural Statistics[2] and from such food engineering texts as Parker, Harvey, and Statler.[3] The nutrient contents of foods are from Watt and Merrill.[4] A third factor that might be considered is the percentage of nutritive value of each crop or livestock product that is lost before reaching a human stomach. In the absence of data with respect to individual crops, the model, as noted elsewhere, applies a uniform 15 percent margin on per capita nutrient requirements.

*In 1965 fish accounted for only 7 percent of the total US consumption (at retail weight) of meat, poultry, and fish,[2] and destruction of ports and fishing vessels should reduce the capacity.

It may be noted that the nutrient value of wheat is based on conversion to whole-grain flour. There is now a substantial use of wheat in this way to make whole wheat bread; but by far the bulk of wheat is now used to produce a more highly refined bread flour and a rather high-protein byproduct for animal feed. On the assumption that protein for human food would be scarcer than protein for livestock feeds in the postattack situation, only the processing to whole wheat flour was provided for in the model despite the general consumer preference for bread made with more highly refined flours. It is not clear, however, that the assumption of greater shortage of human-food protein is correct for all damage patterns: it may therefore be worthwhile to add an activity for the peacetime flour-extraction rate as an alternative to manufacture of whole-grain flour.

The model similarly increases the nutritive value of rice for humans at the expense of animal-feed byproducts by omitting processing stages that normally convert parts of the grain with high-protein values to animal feeds.

Livestock Nutrients

The livestock nutrient rows are classified by type of livestock and by type of nutrient. The classification by type of livestock serves to assist in distinguishing among the nutritive values of identical feeds for different livestock classes. The classification by nutrient helps constrain the livestock.

For any one of the two kinds of livestock nutrients, there are four rows in which entries for nutrient outputs of a crop may appear: total, excluding poultry; cattle and sheep; hogs; and poultry. A crop intended to be fed to livestock other than poultry has an entry for one or both of cattle and sheep and/or hogs. There is an identical entry for both if the feed is suitable for both classes of livestock (e.g., corn is suitable for both, but hay is suitable only for cattle and sheep). Having a unit of activity recorded as supplying a unit of output to each of two classes of animals leaves open the possibility, even though only one unit of nutrient is produced, of a total animal feeding that exceeds production. However, the first row, for total excluding poultry, balances the total nutrient input requirements of all livestock products other than poultry against the once-counted production by all crop activities. This adds an upper bound on total nutrient availability to the overlapping (and therefore double-counted) availabilities for individual classes of livestock. Outputs of a poultry nutrient have not only a separate row (the fourth), but also separate crop-production activities. In the case of a type of feed that can actually be fed either to poultry or to other livestock (e.g., corn), the model defines two distinct producing activities even though the products are identical in appearance and input requirements. The reason for the separate treatment of poultry-feed-producing activities is that the amount of digestible nutrient per unit of some feeds when fed to poultry is too different from the amount of digestible nutrient of the same feeds when fed to other livestock. It would not be possible to have an unambiguous nutritive value of a feed without specification as to whether the feed would be fed to poultry or to other livestock.

The model has two classes of livestock nutrient. The first class is a US Department of Agriculture measure of nutrient quantity called "feed units." A feed unit is the weight of feed that is equivalent in nutritive value to a standard quantity of corn grain when fed to a particular class of livestock for marginal changes in a balanced ration. The unit is not based on any chemical analysis of the content of the feed but rather on experimental substitutions; hence nothing rigorous can be said about the content of a feed unit in proteins, fats, etc. The definition in terms of marginal changes in a balanced diet, however, suggests that the feed-unit value of a pound of feed is primarily a matter of the energy value of the digestible nutrients, which may be measured gross or, sometimes, net of energy consumed in eating and digesting the feed.

Since the model is concerned with formulation of complete rations for livestock, not just with marginal changes in a balanced ration, it is necessary to consider requirements other than for food units. The model assumes, however, that accounting for only the single most important of such other requirements, proteins, is necessary for reasonable assurance of approximate balance when common types of feed are used. Of course, to the extent that the assumption is wrong, the model tends to overstate the amount of flexibility in the ration.

The feed-unit and protein values per unit of feed weight for the model come generally from a Department of Agriculture publication by Hodges.[5] In a few cases, the ratios are weighted (by production) averages of more detailed data in the source (e.g., the model average for hay instead of the source's data on individual types of hay). There was also some supplementing of the Hodges data with data from appendix tables and text of Morrison.[6]

The weights of byproduct feeds produced in processing of human-food crops come from the same types of food engineering texts used to estimate the food portion.

Minimum requirements of feed units per unit of livestock produced are average ratios for 1960–1965 in which the numerators are feed units consumed as reported by the Department of Agriculture in "Statistical Bulletin 337,"[7] and denominators are livestock products produced as reported in Agricultural Statistics.[2]

Minimum requirements of protein are based on feed input and product output experience for 1959 only. The denominator of livestock product output is from the same source as the denominator for feed-unit requirements; but the numerator is calculated from the Hodges[5] data cited in connection with digestible-protein values of feed classes and from data of the same source on the quantities of each kind of feed estimated to have been consumed by each class of livestock in 1959. The cumulative product of percentage of protein and amount of each kind of feed represented an aggregate protein consumption.

Inadequate data on green pasture presented special difficulties both for estimating nutritive value per unit of weight consumed and for calculating the pasture portions of the estimates of nutrient inputs per unit of livestock product. The Hodges data do not include feed-unit values or protein values per unit of pasture, but they do include a table (Table 22) that compares the total digestible-nutrient percentages of individual grasses and hays. The model uses an average of these ratios (0.30) to convert feed-unit and protein values of hay to corresponding values for grass. The weight of grass consumed in 1959 by each class of livestock is derived from the estimate of feed-unit value per weight unit of pasture grass and estimates in the previously cited "Statistical Bulletin 337" of the number of feed units each class of livestock must have obtained from pasture in addition to the directly measured feeds to produce the livestock products listed. The feed units from pasture were estimated by the Department of Agriculture as a residual because there is no direct way of measuring what an animal consumes in grazing. The final estimates of the model are subject to errors in the Department of Agriculture procedure for estimating pasture feed units as a difference between two roughly estimated quantities and to sampling errors in arriving at the ratio between nutritive values of hay and pasture. Actual pastures may include grasses and weeds that are inferior to the grasses used in the sample.

Land Inputs to Agriculture

Land requirements per unit of output in the real world vary continuously as a function of quantities of fertilizers and pesticides of various kinds, the quality of seed, the quality of land, the quality of management, and the amount of effort expended in preparation of the land and care of the crop. The model's approximation to reality uses average quantities and qualities of all these inputs for one possibility with respect to each crop, and then adds three other discrete possibilities: normal inputs of all kinds except for complete absence of fertilizers, normal inputs of all kinds except for complete absence of pesticides, and normal inputs of all kinds except for complete absence of both fertilizers and pesticides. Absence of one or both of fertilizers and pesticides implies an increased requirement of land per unit of output.

Although the activities of the model are restricted to those with full or zero availability of one or both of fertilizers and pesticides, the solution to any problem using the model can approximate the effects of partial availability by having an appropriate mix of activities with both zero and full availability of fertilizer and pesticides. For example, availability of sufficient fertilizer for a 20-percent-of-normal application to the land for a crop is treated as full availability on an activity using 20 percent of the land and zero availability on the activity using the other 80 percent of the land devoted to a crop. This approximation to reality is wrong to the extent that the true relation between land productivity and inputs of fertilizers and pesticides departs from linearity. There are also errors in the assumption that there is no need to distinguish among different kinds of fertilizers and different kinds of pesticides.

The land requirements per unit of average current application of fertilizer and pesticides come from 1963 experience as reported in appropriate tables of Agricultural Statistics. The requirements in the absence of fertilizer come almost entirely from a Department of Agriculture publication by Ibach and Linberg.[8] They studied differences in yield per acre for farms using and not using fertilizers. Their data on the farms not using fertilizers in 1954 are assumed for the present model to be applicable to current farming where there are normal inputs of all other kinds.

This undoubtedly overestimates the effectiveness of fertilizers in increasing yields per acre. It is quite likely that the 1954 farmers who used no fertilizer were also less-than-average users of pesticides and in general less progressive in their farming techniques. In addition, some of the increase in yields between 1954 and 1963 is attributable to factors other than increased application of fertilizers. Furthermore, it would take more than 1 year of absence of normal fertilizer use to get the full loss of productivity; although, in the other direction, it would take more than 1 year of normal fertilizer use to restore any productivity lost in a prolonged period of absence of normal applications of fertilizer. There are other, more random errors in addition to these biases in favor of overestimating the importance of fertilizer, and further research on the influence of fertilizers would be worthwhile in any further work on the model.

The data on effects of dispensing with pesticides are even more sketchy. A Stanford Research Institute study by Moll, Cline, and Marr[9] has some lightly documented estimates of effects of pesticide absence in the first year after an attack for wheat, potatoes, sugar beets, corn, and alfalfa. Presumably the effects could grow after the first year. For the present model, therefore, the Stanford Research Institute estimates of crop yields without pesticides are reduced slightly. The wheat and corn estimates are also applied to other grains, and a yield of 85 percent is used. Sweet-potato yields are made the same as yields of potatoes, with an estimate of 70 percent, and sugarcane is combined with sugar beets for a yield of 85 percent. On the basis of scattered qualitative information, it was judged that fruits and vegetables depend on pesticides much more than the foregoing crops, and a yield of 60 percent was arbitrarily assigned. In the absence of any information about peanuts, cottonseed, and soybeans, they were assigned intermediate yields at 75 percent of normal.

Following the precedent of the Stanford Research Institute study, the case of absence of both fertilizers and pesticides is assigned a percentage-of-normal yield that is the product of the percentages for fertilizer and pesticide absences separately. This is based on the plausible but unproved assumption that insects, rodents, and weeds take the same percentage of a crop regardless of the amount of fertilizer used. Another plausible assumption might be that they take the same absolute amount, in which case the aggregate loss from absence of both fertilizers and pesticides would be greater than indicated by the product of the two separate absence packages.

Yields per acre for any given crop depend not only on how much fertilizer and pesticides are applied but also on which land is used. The model classifies agricultural acreage of the US by the types of crops for which the acreages are well suited, and all requirements of land per unit of crop output are requirements of well-suited land.

Some lands are well suited for more than one crop or class of crops, so that the total amount of land of all types is less than the sum of potential well-suited lands for each crop. The model makes sure that total computed use of land in any class or aggregate of classes does not exceed the amount of land available by requiring balance of requirements and supply at every level of aggregation. For example, a given wheat production places an equal requirement on each of wheatland, grainland, cropland, and agricultural land. This prevents land with alternative uses from being calculated as being used more than once.

The classification system for land and the estimates of amounts of land in each class are taken almost unchanged from informal estimates of the Department of Agriculture.[10] Of two alternative estimates from the Department, one with relatively large and the other with relatively small flexibility of land use, the one with lesser flexibility was taken, and additional restrictions were inserted on the amounts of land normally used for wheat, fruits, and vegetables that could be diverted to other uses.

Industrial Inputs to Agriculture

The model accounts for three kinds of industrial inputs to agriculture: the fertilizers and pesticides just referred to in the discussion of land requirements and petroleum products. The units of measurement used by the model are as follows: for fertilizers the unit is aggregate weight of nitrogen, phosphoric acid, and potash; for pesticides and petroleum products the units are values, respectively, for Industries 29 and 31 of "The 1958 Interindustry Relations Study"[11] of the Office of Business Economics (OBE) of the US Department of Commerce. (The study is discussed later.)

The fertilizer inputs are 1963 totals distributed among 1963 crop acreages in proportion to 1959 use per acre as reported in a Department of Agriculture publication by Ibach, Adams, and Fox.[12] The pesticides and petroleum inputs per acre are those of 1958, based on distributions according to a slightly more aggregated classification of crops in an unpublished Department of Agriculture study[13] in support of the 1958 interindustry model of the OBE of the Department of Commerce. That study distributed 1958 use of the inputs among crops. Data from Agricultural Statistics[2] permitted substitution of quantities of land for crop values; then inputs of pesticides and petroleum products per unit of land were multiplied by 1963-experience land requirements per unit of agricultural product to yield inputs of pesticides and petroleum product per unit of agricultural product. It was not practical to blow up the 1958 inputs to exhaust a 1963 total consumption; hence, unlike the case for fertilizers, the coefficients here have a probable downward bias for reflection of 1963 technology.

For activities in which either fertilizers or pesticides or both are absent, the model has the other industrial requirements per unit of output rise in proportion to the requirement for land. This probably overstates input requirements a little. For example, the complete loss of a harvest in one area because of an insect invasion made possible by absence of pesticides should eliminate the petroleum-product requirements associated with harvesting.

The cumulative product of each row of negative input coefficients and crop-production-activity levels provides total requirements for the industrial input concerned. A negative coefficient in the column for the industrial activity that produces the product generates a balancing output of the product in the model. The industrial activities are all OBE industry levels measured in dollar value. In the cases of pesticides and petroleum products, the units of measurement for row and column are identical; hence the coefficient is unity. In the case of fertilizers, the row is weight of nutrient and the column is value; hence the coefficient is a factor for converting column units to row units.

Capacity-constraint rows for production of fertilizer and pesticides, respectively, have coefficients of unity in corresponding industrial-activity columns. In the final solution the product of unity and the activity level (i.e., the activity level) must not exceed the stipulated capacity. Petroleum-product capacity, which has uses other than for agriculture, is dealt with in a row to be discussed later.

It may be noted that the OBE industry for pesticides also includes fertilizers. The model here, however, has separate rows and columns to permit use of data on separate capacities.*

*Aggregation errors of the OBE classification are preserved despite the provision for separate output capacities in that there is no provision for differences between fertilizer and pesticides in the mixes of flow inputs and indirect capacity requirements.

Livestock Capacities

Levels of livestock-product production need to be constrained by the amount of livestock available. The livestock-production activities are measured in terms of weight of output per year, and for convenience the livestock-capacity constraints are measured in the same units. Using the same units makes it possible to make the coefficients all equal to 1. With row units of numbers of animals or their liveweight, the coefficients would have been the conversion factors that are now used to convert livestock numbers to product capacity. The cumulative product of a row of coefficients and solution levels of livestock product is the aggregate amount of the row capacity needed for the solution activity levels.

INDUSTRIAL-TECHNOLOGY SUBMODEL

All rows other than those already considered and the special constraint rows belong to the industrial-technology submodel. Each coefficient describes an amount of a row industrial capacity needed directly or indirectly to support a unit of a column activity.

Industrial-Capacity Requirements

The industrial capacities considered by the model are capacities for each of fertilizers and pesticides and capacities for certain OBE industries and an aggregation of OBE industries. The fertilizer and pesticide rows have entries of 1 in the corresponding fertilizer and pesticide activity columns. The coefficients for other rows are scaled elements of data from the OBE interindustry model.

The basic OBE model has the economy divided into 83 producing sectors and has a table of direct and indirect requirements for each of 82 sectors (the scrap sector being excluded) per unit of final demand (delivery for purposes other than as input to current production). In addition, data are available for producing such a table with more detailed breakdowns of the interindustry sectors. OBE has described its project in a number of published articles of the Survey of Current Business[14–17] and in mimeographed material that it will supply on request.[11,18]

The RAC model uses as inputs a direct- and indirect-requirements table computed with data published by OBE[17] for disaggregating three of the sectors: Industry 14 (food and kindred products), Industry 38 (nonferrous metals), and Industry 65 (electricity, gas, and water and sanitary services).

The general procedure for calculating a table of direct and indirect requirements from a table of interindustry flows in a base year is as follows. Let X_{ij} be the base-year flow from Industry i to Industry j; and let X_j be the total output of Industry i (including both interindustry flows and deliveries to final demand). The first step is to calculate the matrix A, consisting of elements a_{ij}, each of which is calculated as

$$a_{ij} = X_{ij}/X_j$$

The table of direct and indirect requirements is $(I - A)^{-1}$, where I is an identity matrix of proper dimensions.

Both OBE and the RAC model use this general procedure; but there is a difference in definition of an industry output. The OBE procedure defines an industry output as including the value of scrap and byproducts. The RAC procedure treats these as negative inputs instead of output.

This difference in definition leads to a more fundamental difference than merely a lower nominal value of X_i and a higher value of each a_{ij} in the RAC approach. In order to prevent a requirement for output of the jth industry from generating a requirement for a normal mix of outputs of the ith industry by way of the formula

$$X_i = a_{ij} X_j$$

when the base year X_{ij} has a flow largely of byproducts of the principal production of the ith industry, OBE transfers any part of X_{ij} that represents byproducts from X_{ij} to X_{ii} before it uses X_{ij} in calculation of a_{ij}. OBE considers it improper, for example, for a model to generate a dollar's worth of meat-industry output of standard mix in an attempt to supply the leather-tanning industry with a dollar's worth of hide and skin byproduct. They prefer to have meat-industry output of standard mix determined entirely by the requirements for food, with a side calculation determining whether this implies sufficient hides and skins output to supply needs of the leather-tanning and -finishing industry.

The RAC procedure has byproduct requirements calculated as part of the main model rather than as a side calculation but takes care of the mix problem by having different rows for the principal products and the byproducts of an industry. If a byproduct is a principal product of some other industry of the OBE model, the RAC procedure estimates all requirements on the row for the industry producing it as a principal product. If there is no industry producing the item as a principal product, as in the case of hides and skins, the distribution row is a brand new one for a new industry defined as inventory depletion of the item. All industries that use the item have positive coefficients for that row, and any industry or industries producing it as a byproduct have negative coefficients. A solution level of the inventory-depletion activity is the excess of requirements for the byproduct over supply. For a problem in which the inventory-depletion rate is to be constrained (perhaps even to zero), there may be no feasible solution unless the model permits production in excess of requirements for the principal product of an industry producing the byproduct. The RAC model has this kind of flexibility. The activity level for any industry producing products in fixed proportions is generated by requirements for the product that needs the highest level, and surpluses of the other products are produced. In the RAC model it is immaterial which of joint products unique to an industry is designated as the principal product.

The RAC version of the OBE A matrix has seven byproduct rows (identifications of byproduct element of X_{ij} supplied by OBE on magnetic tape) with no industries producing them as (defined) principal products. Two of these appear in the final RAC model as byproducts, the supply of which must be accounted for and shown sufficient in any feasible solution. The two byproducts are hides and skins and cotton fiber. Hides and skins output is a byproduct of the activity that produces beef. Cotton fiber is a byproduct of the activity that produces cottonseed. It may be noted that in peacetime the demand for cotton fiber has much more effect on production of cotton and cottonseed than the demand for cottonseed. As has been noted, however, the choice of which of two joint products should be defined the byproduct in the RAC model does not affect the results.

In addition to defining industry outputs in the special way just described, the preparation of the OBE data for use in the RAC model also involved a number of changes in the base year X_{ij} before calculation of the a_{ij}. All rows for distribution of products of OBE's two agricultural industries were reduced to zero since the RAC food submodel was replacing them. Those elements that referred to textile-fiber requirements, however, were transferred to the row for cotton byproduct of cottonseed production. The OBE food-processing industries were assigned both additions to and subtractions from their inputs. The additions were values of transportation and warehousing plus wholesale and retail margins needed to move outputs of the food-processing industries to consumers. The data for this came from OBE work-sheet records of margins between producer prices and purchaser prices of foods. The subtractions were flows of food among food-processing industries and some of the packaging and printing inputs. The reductions of packaging and printing were as emergency austerity measures. The elimination of the interindustry flows of foods was consistent with the treatment of food-processing activities as minimum amounts of activity outside agriculture needed to release the nutrients in agricultural production. For example, release of the nutrients in oilseeds requires plants that extract the oil from the seeds and make shortenings; release of nutrients in grain requires milling and baking. However, the use of shortening in baking is not required to release the nutrients in either oilseeds or grain, therefore the RAC model suppresses the OBE requirement of oilseed-mill output per unit of bakery output.

Once all X_{ij} had been adjusted as needed according to the above rules, the a_{ij} and $(I - A)^{-1}$ were calculated in the standard way. This provided a table of direct and indirect requirements for each row industry per unit of final demand for the principal product (as defined) of the column industry. The amount of each kind of food processing required per unit of each of the RAC model's food-production activities per unit of agricultural food product may then be considered a scaling factor to apply against the corresponding food-processing industry's direct and indirect requirements per unit of its final deliveries. "Final" here refers to requirements generated from outside the sectors defined in the $(I - A)^{-1}$ table, not to the more commonly denoted demand categories of household consumption, exports, investment, and government purchases of goods and services.

The RAC model preparation used such a scaling to obtain the direct and indirect inputs to food processing and distribution associated with each agricultural food product but first eliminated some rows of $(I - A)^{-1}$ and aggregated some others. The eliminations were of rows for service and other industries having very flexible capacities or which were considered to be too unimportant under emergency conditions to be permitted to affect estimates of viability of the economy. For an example of the latter it was felt that any shortage of household-furniture capacity could be made good either by doing without the normal output of that capacity or by production of the needed items outside the household-furniture industry. The row aggregations covered all the metalworking industries. All metalworking industries were combined into a single industry providing parts for repair and maintenance of production machinery and transportation and communication equipment. Of course the aggregation would be improper for production of major pieces of equipment. A locomotive cannot be built in a textile-machinery plant, but it is quite likely that a textile-machinery plant could use some of its tools to make certain locomotive parts. The eliminations and aggregations left only 13 capacities of modified OBE industries (including inventory-depletion industries) that are accounted for in the RAC model.

The 13 industries with their OBE and RAC codes are listed in the accompanying tabulation.

OBE code	RAC code	Industry
16	BE16	Broad and narrow fabrics; yarn and thread mills
24	BE24	Paper and allied products except containers
27	BE27	Chemicals and selected chemical products
29	BE29	Drugs; cleaning and toilet preparations
31	BE31	Petroleum refining and related industries
37	BE37	Primary iron and steel manufacturing
39	BE39	Metal containers
40–63	BEMET	Metalworking industries
65	BE65	Transportation and warehousing
38.1	BE93	Copper manufacturing
38.2	BE94	Aluminum manufacturing
68.1	BE96	Electric utilities
14.3	BE86	Canning and preserving of fruits, vegetables, and seafoods

It may be noted that no separate railroad-transportation industry, either total or by any geographic classification, appears specifically in the model. The flow inputs to all transportation are accounted for in use of the matrix $(I - A)^{-1}$ in full detail for calculating direct and indirect requirements for the listed class of capacities, but there is no provision for a possible shortage of any particular class of transportation capacity.

This is a major weakness of the model should it ever be applied to a problem requiring heavy-traffic movements. It is considered of no great importance, though, for a minimum-survival model. It is not easy to destroy a large enough percentage of rolling stock and miles of route to make the aggregate capacity for train or truck movements insufficient to handle a bare-survival volume of traffic. Nuclear bombing can create bottlenecks by destroying classification yards and traffic centers such as Chicago and St. Louis, but it should be possible to break the resulting bottlenecks sufficiently for light traffic to move through or around them. Military-type bridges, transshipment of cargos, and laying of new track for short distances are the kinds of expedients that are adequate for light traffic. Our experience in interdiction of North Vietnamese supply routes is an indication of how quickly emergency repairs can be made.

Each row of the submodel for these industrial-capacity requirements gives an amount of the corresponding industrial commodity that is required directly and indirectly per unit of each activity of the model, including the activities for nonfood support of population and governments and the provision of industrial inputs to agriculture as well as the activities that are defined as food producing. The cumulative product of the coefficients along a row and the associated activity levels of a solution is a total (net of any negative terms for byproduct output) requirement for capacity to produce the product (or supply it from inventories in the case of a byproduct).

Labor Requirements

The model has a single row of labor requirements that has one or two or three components for each column activity. One component consists of agricultural labor in food and feed production. The second consists of labor employed in the industrial sectors of the economy. It is the only component for the persons-supported activity and for the three activities supplying direct industrial inputs to agriculture, and it is added to agricultural labor for agricultural outputs that require industrial processing. The third component consists of labor employed directly by the government sector. The government-operations activity has this component plus an industrial-sector component for government purchases from industry. The first two components are discussed in the following paragraphs. The third is dealt with in the section, "Government Requirements."

The agricultural-labor component with normal inputs of fertilizer and pesticides consists of 1965 ratios between inputs of labor and outputs of agricultural products. The labor inputs are based on man-hours statistics as reported by the Department of Agriculture for individual crops and livestock products.[19] Man-hours are converted to employment on the rather arbitrary assumption of 2000 man-hours/year for an agricultural worker. The seasonal nature of agricultural-labor requirements implies probably a lower number of man-hours per year for workers employed entirely in agriculture, but it is assumed that, under conditions of labor shortage, useful nonfarm work could be found for some agricultural workers. Outputs of agricultural products for the denominator of each ratio of labor inputs to product output come from Agricultural Statistics.[2]

The industrial component is calculated as

$$L = N(I - A)^{-1} ,$$

where L is a row vector of direct and indirect requirements for labor per unit of final demand for output of each industry, N is a corresponding vector of direct requirements, and I and A have the meanings previously assigned. In effect, this procedure estimates the direct and indirect labor requirement per unit of a particular industry's final demand as a cumulative product of the direct and indirect requirement for each industry's output per unit of this final demand and the amount of labor required directly per unit of each industry output. The ratios N would be 1965 experience for OBE industries as estimated by Faucett[20] if the labor row were needed for a current problem in which a labor shortage was possible. Since the only problem worked on with a potential labor shortage is a problem for 1975, the ratios N have been projected to 1975 before the processing described here. The source of productivity changes is a study by the Engineer Strategic Studies Group[21] of productivity changes in industry. The model has no provision for increases of labor production in agriculture.

The labor row before the projection of productivity changes to 1975 has a number of biases. A general downward bias is associated with loss of labor productivity to be expected when both farmers and industrial entrepreneurs undertake unfamiliar kinds of production with facilities and equipment that are optimized for other kinds of production. On the other hand, hours of work could be increased over peacetime levels. Sociological and psychological factors in labor-productivity changes have potential importance and direction of effect that have not been investigated.

PER CAPITA REQUIREMENTS

Basic Concepts

Any estimate of per capita requirements for survival is likely to suffer from two classes of ambiguities. The first is the representativeness of the calculated average. The second is the standard of austerity used.

The representativeness problem arises from the fact that people differ in their survival requirements. For example, a person with diabetes may need a steady supply of insulin to survive. But estimating a per capita requirement for insulin as total insulin requirements divided by total population, both diabetic and nondiabetic, implies in a mathematical model that the percentage of the population that can survive is no greater than the insulin capacity as a percentage of total requirements.

The correct way in principle for dealing with differences among people in their survival needs is to classify the population into groups that are homogeneous with respect to their requirements. This was not practical for the RAC model. To avoid major errors of assigning to the entire population survival requirements that are significant only to small segments of the population, the RAC model attempts to deal only with the types of things that are widely needed. These are food, clothing, and shelter for protection against the environment, and the medical and sanitary supplies and services that may be needed to prevent the spread of epidemic disease.

The austerity problem is more complicated than the representativeness problem. Factors that affect the desired degree of average austerity include (a) the length of time the austerity is to last, (b) factors other than living standards affecting the psychological state of the population during the period of austerity, (c) the consequences for health and productivity of marginal changes in any tentatively proposed average level of living, and (d) the value system for trading off increments in these consequences against increments in any costs of changing the living standards. In general, authors do not try to explain their survival lists in such terms, and no one who tried would ever be able to communicate with complete success all four classes of factors in his decision.

Nevertheless a brief attempt will be made along these lines for the survival-requirements vector of the present model. The length of time involved is 1 to 2 years. The model is organized as a steady-state model, but there could be some slight improvement in standards during the period. It is assumed that the population is psychologically prepared to assume heavy burdens for years in the hope of building toward a better life. Morale and productivity of labor are assumed to require no higher levels of living than are needed to maintain physical health for both productive and nonproductive members of the population. Peacetime poverty standards are of no use as a guide here because the aspirations of the poor in peacetime are assumed to be conditioned in large part by living levels achieved by the more successful elements of the population. With uniform levels of living for the entire population, the standard need not be much more than physical health. The value system of the present author is not communicable fully, but it is of a type that would permit virtually no increment in living levels for survivors that would significantly reduce the number who could survive. If the trade-off in survivor living standards should be against postattack foreign aid, against peacetime costs of providing for higher levels of postattack living, or against other conceivable costs, somewhat higher levels of living might well appear to be more proper standards.

The model distinguishes between food and all other survival requirements. Comparatively little compression of food standards is compatible with health over a period exceeding a year when the standards are measured in terms of requirements for specific nutritive elements of food. One may eliminate steak from a diet but not the requirements for proteins, iron, and other nutrients that are supplied by steak. On the other hand, use of many items of clothing and toilet articles can be reduced or eliminated without significant loss of health. The food-nutrient requirements of the model are therefore approximately equal to peacetime standards, but other requirements are slashed heavily.

Nutrient Requirements

The model has minimum per capita requirements for calories, proteins, fats, iron, and calcium. There are of course many other nutrients and vitamins that are necessary for health. It was judged in preparation of the model, however, that a diet of natural foods that was clearly adequate with respect to the items listed was unlikely to be seriously inadequate with respect to others. For example, it would be practically impossible to meet requirements for the listed items without heavy use of grain, potatoes, and sugar that would provide all the carbohydrates required. Meeting calcium requirements, together with a model restriction on use of fruit lands for purposes other than fruit production, probably takes care of any vitamin C requirements. The rather generous allowance of proteins, plus the impossibility of optimizing without use of livestock-product capacity, virtually eliminates any prospect that the protein supply would not be properly balanced with respect to particular essential amino acids. Nevertheless, some shortages of particular nutrients or vitamins are conceivable, and the model could easily be modified to add a row for any new nutrient that may be considered worthy.

The minimum per capita nutrient requirements for food actually eaten are mostly recommendations (with an unknown safety margin for items other than calories) of the National Research Council[22] for age and sex classes weighted by Bureau of the Census population statistics.[23] There are two exceptions. Although the National Research Council has no standard for fat, it recognizes that some unknown amount is important. A RAND Corporation document by Pogrund[24] recommends that fat provide at least 40 percent of all calories, and this requirement was built into early versions of the model. The present version uses 30 percent of minimum calories, which is closer to an official Army recommendation[25] that 25 to 30 percent of actual calories is clearly sufficient. The other change is a reduction of the National Research Council recommendation of 849 mg/day of calcium to 744 mg.

The reason for the reduction is as follows. The Army source just cited concurs in the National Research Council view that 800 mg/day is desirable for an adult male but states that 700 mg is sufficient and cites an Army regulation that requires only 700 mg for a soldier even though diets actually served at Army messes appear to include about 900 mg. The same Army source suggests that 400 mg/day is sufficient for an indefinite period under emergency conditions. The decision to reduce the model's initial requirement by one-eighth came after trial runs in which the calcium requirement was of major importance in determining the size of population that could be supported. It was then decided that the average requirement would be reduced in proportion to the difference between National Research Council recommendations and Army regulations for an adult male.

The maximum intakes per capita presented greater problems. The model has three kinds of upper limits on calories, fats, and total weight of food that can be eaten.

The third upper limit is not a limitation that can be used very accurately, because there are no experimental data and because the weight depends on the composition of the food. The consumption is ordinarily about 3.9 lb of retail weight per capita. The model temporarily has an arbitrarily high limit designed to provide no effective constraint in any run.

With respect to calories, informal advice from the Department of Agriculture suggested that the maximum should not be more than 15 percent above the minimum. The model, however, has a maximum about 10 percent above what now appears to be eaten, which is itself well above 15 percent in excess of the minimum. It was felt that in an emergency people could overeat at least as much as they do now. In addition, the present national average represents many who eat considerably less than the average as well as many who eat considerably more.

The Army source cited earlier for minimum requirements[illegible] recommends that not more than 50 percent of calories be supplied by fat and reports that Army Field Ration A has 40 to 45 percent fat calories. The average civilian diet for 1965 as reported by the Department of Agriculture[illegible] has a number of grams of retail weight of fat that may be calculated as equal to about 41 percent of the total calories in retail purchases;* many people probably consume considerably larger percentages than the average. The model has a maximum amount of fat that would be 60 percent of minimum calories and 47 percent of maximum calories. For cases where maximum fat may be associated with minimum calories, the upper limit on fat is probably too high. Computer outputs should always be inspected for desirability of recomputation with a lower limit.

The average daily requirements used in the model are summarized in the accompanying tabulation.

Item	Daily requirement	
	Minimum	Maximum
Calories	2175	[illegible]
Proteins, g	59.6	—
Fats, g	34.65	69.30
Iron, g	0.0125	—
Calcium, g	0.744	—
Weight total,[a] lb		

[a]Arbitrarily high.

*There are no data on the percentage of the calories actually consumed that may be accounted for by the fat in purchased food.

The model scales these amounts upward to an annual basis and for an average wastage of 15 percent of the nutrient content of all foods. Wastage in peacetime can occur in distribution to consumers, in kitchens, and in failure to eat all that is prepared. The 15 percent for the model assumes negligible wastage at the table, a kitchen loss at the low end of a normal 4 to 21 percent range found in experiment in Army kitchens,[25] and the remainder lost to rodent damage and other food spoilage in the distribution process. No data were found on peacetime average losses in distribution before purchase at retail of about 3150 cal per capita. Some of these losses would undoubtedly result from shortages of proper transportation and warehousing capacity, but others could probably be reduced by application of more than customary care.

Nonfood Requirements

The direct nonfood requirements are based on personal judgment of what might be dispensed with in recorded 1958 personal-consumption expenditures. The judgments were applied to details of those expenditures as published by the Department of Commerce in the October 1965 issue of the Survey of Current Business.[16] The classification there is not only by producing industry of the 1958 interindustry study, which is not very informative for some highly aggregated industries, but also by type of household purpose. For example, Industry 72 is "hotels and lodging places and personal and repair services except auto." But a further classification of one expenditure states that it is for "shoe cleaning and repair." The judgment then is on how much of Industry 72 output is needed for shoe repair.*

After judgments were made on each combination of consumer purpose and industry number, the expenditures for each industry number were aggregated to yield a total consumption expenditure for each industry. Division of these totals by 1958 population yielded a per capita estimate.

Table 2 has the published Department of Commerce estimates for 1958 with major classification by consumption purpose and minor classification by industry. The table is shortened as compared with the published one in that the industry detail is omitted for functional categories that were judged not to be worthy of inclusion on the final list. The judgments added to the table appear in a column of percentages for the expenditure items that were judged worthy of retention in whole or in part.

There is no point in trying to prove here any necessity for the particular percentages noted in the last column. A few notes on the assumptions may, however, add to the plausibility of the stated percentages.

All food items are omitted because, as has been noted, food requirements are considered on the basis of nutrients rather than dollars.

Nearly all clothing is omitted on the assumption that, although displaced persons may provide a one-time burden on the economy, the absence of style changes, the possibility of great reductions in most wardrobes without damage to health, and the sharing of wardrobes would permit the economy to go for several years without much need for new clothing.

*Quite another problem, of course, is the suitability of the Department of Commerce input pattern for Industry 72 as an indicator of what it takes to repair shoes.

TABLE 2

1958 Expenditure Items and Factors for Conversion to Postattack Conditions

Expenditure class[a]	1958 amount, millions of dollars		Percent of emergency expenditures allowed
	Producer prices	Purchaser prices	
Food purchased for off-premises consumption	41,426	58,406	—[b]
Purchased meals and beverages	7,813	15,321	—[b]
Food furnished government (including military) and commercial employees	881	1,224	—[b]
Food consumed and produced on farms	1,410	1,410	—[b]
Tobacco products	4,254	5,982	0
Shoes and other footwear, total	2,337	4,075	
32, rubber and miscellaneous plastic products	227	442	10
34, footwear and other leather products	2,066	3,571	[illegible]
80, imports	44	91	0
Shoe cleaning and repair, total	219	219	
72, hotels and lodging places, personal and repair services except auto	219	219	200
Laundering in establishments, total	977	977	
72, hotels and lodging places, personal and repair services except auto	949	949	80
77, medical and educational service and nonprofit establishments	28	28	28
Food produced and consumed on farms	1,410	1,410	—[b]
Women's and children's clothing and accessories except footwear, total	7,912	13,356	
16, broad and narrow fabrics, yarn and thread mills	306	[illegible]	0
17, miscellaneous textile goods and floor coverings	14	30	0
18, apparel	7,049	11,596	20
19, miscellaneous fabricated textile products	41	78	0
24, paper and allied products except containers	32	70	0
32, rubber and miscellaneous plastic products	9	17	0
34, footwear and other leather products	301	559	0
64, miscellaneous manufacturing	66	101	0
80, gross imports of goods and services	129	260	0
83, scrap, used, and secondhand goods	-36	-36	0
Men's and boys' clothing and accessories, total	4,305	7,164	
16, broad and narrow fabrics, yarn and thread mills	4	8	0
18, apparel	4,085	6,715	20
19, miscellaneous fabricated textile products	3	6	0
32, rubber and miscellaneous plastic products	1	1	0
34, footwear and other leather products	162	298	0
80, gross imports of goods and services	48	118	0
83, scrap, used, and secondhand goods	4	17	0
Standard clothing issued to military personnel	57	[illegible]	0
Cleaning, dyeing, pressing, alteration, storage, and repair of garments, including furs (in shops)	1,797	1,797	0
Jewelry and watches	924	1,850	0
Other clothing, accessories, and jewelry	372	372	0
Toilet articles and preparations	1,393	2,590	0
Barbershops, beauty parlors, and baths	2,014	2,014	0
Owner-occupied nonfarm dwellings, space-rental value, total	26,809	26,809	
71, real estate and rental	26,809	26,809	40
Tenant-occupied nonfarm dwellings and other housing, total	12,457	12,457	
71, real estate and rental	12,232	12,232	40

TABLE 2 (continued)

Expenditure class[a]	1958 amount, millions of dollars		Percent of emergency expenditures allowed
	Producer prices	Purchaser prices	
72, hotels and lodging places, personal and repair services, except auto	143	143	40
77, medical and educational service and nonprofit establishments	82	82	40
Rental value of farmhouses, total	1,861	1,861	
71, real estate and rental	1,861	1,861	40
Furniture, including mattresses and bedsprings	2,441	4,346	0
Kitchen and other household appliances	2,712	2,712	0
China, glassware, tableware, and utensils	914	1,697	0
Other durable house furnishings	1,958	3,728	0
Semidurable house furnishings	1,341	2,521	0
Cleaning and polishing preparations and miscellaneous household supplies and paper products, total	2,085	3,008	
9, stone and clay mining and quarrying	12	21	0
24, paper and allied products, excluding containers and boxes	570	858	60
25, paperboard containers and boxes	38	44	0
26, printing and publishing	2	3	0
27, chemicals and selected chemical products	104	145	60
29, drugs, cleaning and toilet preparations	1,076	1,574	60
30, paints and allied products	18	36	40
36, stone and clay products	27	50	40
42, other fabricated metal products	48	84	40
53, electrical industrial equipment and apparatus	5	7	40
55, electric lighting and wiring equipment	114	161	40
58, miscellaneous electrical equipment, machinery, and supplies	29	39	40
64, miscellaneous manufacturing	44	74	40
80, imports	1	1	40
Stationery and writing supplies	506	938	0
Electricity, total	4,381	4,381	
96, electricity	4,381	4,381	30
Gas, total	2,685	2,685	
97, gas	2,685	2,685	50
Water and other sanitary services, total	1,048	1,048	
98, water	980	980	100
79, state and local government enterprises	68	68	100
Other fuel and ice, total	2,351	4,153	
7, coal mining	261	4,153	40
20, lumber and wood products, excluding containers	48	576	40
27, chemicals and selected chemical products	10	76	40
31, petroleum refining and related products	2,008	3,462	40
37, primary iron and steel manufacturing	10	11	0
68, electricity, gas, water, and other sanitary services	14	14	0
Telephone and telegraph	3,892	3,892	0
Domestic service	3,503	3,503	0
Other household operation, total	1,768	1,769	
65, transportation and warehousing	286	286	
70, finance and insurance	117	117	

TABLE 2 (continued)

Expenditure class[a]	1958 amount, millions of dollars		Percent of emergency expenditures allowed
	Producer prices	Purchaser prices	
72, hotels and lodging places, personal and repair services, except auto	733	733	40
73, business services	62	62	60
78, Federal government enterprises	570	570	60
Drug preparations and sundries, total	1,692	3,195	
24, paper and allied products, except containers	116	253	50
27, chemical and selected chemical products		1	0
29, drugs, cleaning and toilet preparations	1,442	2,687	20
32, rubber and miscellaneous plastic products	47	90	0
54, household appliances	6	11	0
55, electric lighting and wiring equipment	3	4	0
62, scientific and controlling instruments	77	149	0
Ophthalmic products and orthopedic appliances	193	663	60
Physicians	4,574	4,574	60
Dentists	1,876	1,876	60
Other professional services	832	832	60
Privately controlled hospitals and sanatoria	4,202	4,202	100
Health insurance	1,130	1,130	0
Brokerage charges and investment counseling	884	884	0
Bank service charges, trust services, and deposit-box rental	810	810	0
Services furnished without payment by financial intermediaries except insurance companies	4,074	4,074	0
Expense of handling life insurance	3,210	3,210	0
Legal services	1,531	1,531	0
Funeral and burial expenses, total	1,308	1,328	
9, stone and clay mining and quarrying	5	12	0
36, stone and clay products	48	60	0
71, real estate and rental	242	242	50
72, hotels and lodging places, personal and repair services, except auto	1,013	1,013	20
Other personal business, total	931	931	
66, communications, excluding radio and television broadcasting	17	17	20
73, business services	117	117	0
76, amusements	6	6	0
77, medical and educational service and nonprofit establishments	729	729	50
78, Federal government enterprises	62	62	0
New cars and purchase of used cars	9,508	13,258	0
Automotive (tires, tubes, accessories, parts, repair, greasing, washing, parking, storage, and rental), total	5,581	6,507	
19, miscellaneous fabricated textile products	43	75	5
27, chemicals and selected chemical products	52	76	5
29, drugs, cleaning and toilet preparations	22	38	5
32, rubber and miscellaneous plastic products	801	1,372	5
42, other fabricated metal products	12	20	5
52, service industry machines	16	35	5
55, electric lighting and wiring equipment	15	30	5
56, radio, television, and communication equipment	32	55	5
58, miscellaneous electrical machinery, equipment, and supplies	163	248	5
59, motor vehicles and equipment	81	145	5
75, automobile repair and service	4,387	4,387	5
83, scrap, used and secondhand goods	-43	26	5

TABLE 2 (continued)

Expenditure class[a]	1958 amount, millions of dollars		Percent of emergency expenditures allowed
	Producer prices	Purchaser prices	
Gasoline and oil, total	5,251	5,251	
31, petroleum refining and related products	5,251	5,251	5
Bridge, tunnel, ferry, and road tolls	250	250	0
Automobile insurance premiums less claims paid	1,606	1,606	0
Street and electric railway and local bus, total	1,219	1,219	
65, transportation and warehousing	1,219	1,219	100
Taxicabs	574	574	0
Railway (commutation)	124	124	0
Railway (excluding commutation) and sleeping and parlor car	338	338	0
Intercity bus	296	296	0
Airline	479	479	0
Other intercity transportation	32	32	0
Books and maps	632	1,022	0
Magazines, newspapers, and sheet music, total	1,439	2,061	
26, printing and publishing	1,468	2,090	5
83, scrap, used and secondhand goods	-29	-29	5
Nondurable toys and sport supplies	1,188	2,115	0
Wheel goods, durable toys, sport equipment, boats, and pleasure aircraft	1,080	1,845	0
Radio and television receivers, records, and musical instruments	1,644	2,836	0
Radio and television repair, total	681	681	
72, hotels and lodging places, personal and repair services, except auto	681	681	5
Flowers, seeds, and potted plants	338	544	0
Admissions to motion-picture theaters	992	992	0
Admissions to legitimate theaters, opera, and entertainments of nonprofit institutions (except athletics)	297	297	0
Admissions to spectator sports	249	249	0
Clubs and fraternal organizations except insurance	692	692	0
Commercial participant amusements	848	848	0
Pari-mutuel net receipts	454	454	0
Other recreation	1,174	1,181	0
Private higher education	1,282	1,282	0
Private elementary and secondary schools	1,006	1,006	0
Other private education and research	852	852	0
Religious and welfare activities, total	4,178	4,178	
77, medical and educational service and nonprofit establishments	4,178	4,178	100
Foreign travel by US residents	1,900	1,900	0
Expenditures abroad by US government personnel (military and civilian)	892	1,077	0
Expenditures in the US by foreigners	-1,046	-1,046	0
Personal remittances in kind to foreigners	- 107	- 107	0
Total personal consumption expenditures	224,032	290,069	
Durable commodities	23,262	37,881	
Nondurable commodities	88,765	140,152	
Services	112,005	112,036	

[a]The major classes are standard personal consumption expenditure classes of the National Income Division of the Office of Business Economics. The classes with numerical codes are sectors of the 1958 input-output table of the National Economic Division, Office of Business Economics.

[b]Considered elsewhere under another classification system.

Some production of footwear is permitted to replace that which can no longer be repaired and may be needed for essential travel to and from work. It is assumed that the number of workers who walk to work instead of riding will greatly increase. With the sharp reduction in new-shoe purchases, a doubling of shoe repairs is allowed.

For most inputs to household operation that are accepted at all, the factor is about 40 percent per capita. This reflects both an expected increase in housing density and such austerity as reduction in the use of electricity for appliances and lighting.

The automotive-expenditure judgments are based on the assumption that nobody will drive a personal car. A small allowance for automotive expenditures is intended to represent some incremental input to public automotive transportation, where the requirements for gasoline, tires, batteries, etc, per capita are lower than for personal autos. Those who do not use public transportation will be expected to walk or stay at home in the hypothesized circumstances of a large labor supply in relation to capital resources. Dormitory accommodations near places of work are conceivable for workers who would otherwise have to commute by auto.

Such an approach yields levels of living that are probably well above levels ordinarily achieved in large areas of the world right now but well below what is considered extreme poverty in the US. However, as noted earlier, poverty is a relative matter. What is properly considered an intolerable level of living for a person in the present environment may be quite bearable under conditions of austerity for all after a nuclear attack.

Table 3 has the results of applying the factors and aggregating to the levels of "1958 Interindustry Study" industries.*

The direct and indirect requirements for nonfood items that appear in the PERCA column of the model are calculated starting with the matrix-vector multiplication

$$(I - A)^{-1}C$$

for the nonlabor elements and LC for the labor elements, where C is the vector of direct requirements from Table 3 and A and L have the meanings previously assigned. After these matrix-vector multiplications, there are deletions and metalworking industry aggregations to conform to the industry classification of the industrial submodel.

GOVERNMENT REQUIREMENTS

The nature of governmental activity at Federal, state, and local levels is bound to change drastically after a heavy nuclear attack. How it may change depends on such things as whether military action continues, whether there are resources in excess of what is needed for survival, and what those faced with operation after a nuclear attack consider important. Some kinds of governmental

*An example of a particularly regrettable aggregation is the inclusion of shoe-repair expenditures by households in Industry 72 (hotels and lodging places, personal and repair services, except auto).

activity can also depend on the size of the surviving population. A large population needs more of many kinds of government services than a small population.*

In general, however, except for construction and military activities of governments, it is probably accurate enough to consider that all governmental

TABLE 3

Nonfood Consumption Expenditures by Industry

(1958 population and producer prices)

Code	Industry	Expenditures	
		Total, millions of dollars	Per capita, dollars
7	Coal mining	104.40	0.597
18	Apparel	2,226.80	12.733
20	Lumber and wood products, except containers	19.20	0.110
24	Paper and allied products, except containers and boxes	468.50	2.679
26	Printing and publishing	73.40	0.420
27	Chemicals and selected chemical products	69.00	0.395
29	Drugs, cleaning and toilet preparations	935.10	5.347
31	Petroleum refining	764.55	4.372
32	Rubber and miscellaneous plastic products	62.75	0.359
34	Footwear and other leather products	413.20	2.363
42	Other fabricated metal products	17.40	0.099
52	Service industry machines	0.80	0.005
53	Electrical industrial equipment and apparatus	2.00	0.011
55	Electric lighting and wiring equipment	12.35	0.071
56	Radio, television, and communication equipment	3.60	0.021
58	Miscellaneous electrical equipment and supplies	19.75	0.113
59	Motor vehicles and equipment	4.65	...
64	Miscellaneous manufacturing	25.60	0.146
65	Transportation and warehousing	1,219.00	6.970
71	Real estate and rental	7,360.80	42.090
72	Hotels and lodging places, personal and repair services, except auto	1,784.25	10.202
73	Business services	37.20	0.213
75	Automobile repair and services	219.35	1.254
77	Medical and educational service and nonprofit establishments	13,134.50	75.105
78	Federal government enterprises	342.00	1.956
79	State and local government enterprises	68.00	0.389
83	Scrap	0.45	0.002
96	Electricity	1,314.30	7.515
97	Gas	1,342.50	7.677
98	Water and sanitary services	980.00	5.604

activities have labor as their principal direct inputs, with other direct inputs consisting primarily of supplies and maintenance of office buildings. New construction has no place in a steady-state survival model, and the model makes no provision for military requirements. It is therefore assumed for the current model that the 1958 mix of direct and indirect requirements, excluding requirements generated by new construction and military expenditures, is satisfactory. The level can be tailored to the size of the surviving population.

*The PARM project of the National Planning Association, under Office of Emergency Planning (OEP) contract, has developed a model that generates requirements for various classes of governmental services as functions of population.

The mix of direct requirements consists of state and local expenditures other than for construction in 1958 plus an estimate of the nonmilitary expenditures other than for construction by Federal government. The state and local data are as published by OBE in the Survey of Current Business.[15] The nonmilitary expenditures of the Federal government are from unpublished work sheets made available by OBE.*

The model can, of course, use other levels and mixes of government requirements. However, if mixes are used that require substantial amounts of output from the ordnance industry or other particular metalworking industries, it will become necessary to disaggregate the present aggregation of all metalworking industries.

CONSTANT TERMS

The column of constant terms changes with each problem to which the problem is applied. Depending on whether it is preceded by ≤, ≥, or =, each element of the column is an upper bound, a lower bound, or both on the cumulative product of a row of coefficients and corresponding solution magnitudes. In the cases of the nutrient rows, the constant terms are necessarily zero for all problems since neither humans nor livestock can live for very long on nutrients stored in their bodies. The other zeros of the constant-terms column of Table 1 could be rates of desired inventory depletion for any problem in which that should appear to be a useful concept. A zero implies that requirements may not exceed supply from current production. The remaining constant terms preceded by inequality signs are fixed capacities of kinds that are not used up in current production. In the case of land, the postattack capacity is the same as preattack. For industrial capacities and labor supply the percentage of preattack capacity is an output of assessment of physical damage from the attack. The stipulated level of government activity tells how much is desired of the government-operations activity when measured in the units fixed for level of government.

The most difficult data problems are associated with the determination of preattack capacities. A practical definition of capacity is an amount of output that would not be exceeded under any reasonably possible circumstances of input that did not include more fixed plant and equipment. If it is further assumed that industry capacities never declined in peacetime, the highest output actually achieved in recent years is a lower bound on existing capacity. The amount of understatement depends on the percentage of capacity that was idle at the time of this historical peak, on the possibility of increasing output by use of extra shifts or more workers per shift, and on any new investment or technological change that might increase production potential.

Despite the foregoing elements of understatement, lack of research time and a desire to err if at all on the side of understatement of economic capacity of the country has led to use of historical production peaks for most kinds of capacity. Faucett[20] is the source of data on OBE industry outputs in 1958 prices, the prices of the OBE model. The only adjustment of Faucett data needed for the present model was a technical one of adding what OBE calls secondary

*The work-sheet data have not been released by OBE for general use; hence it is not possible to give the table here. The RAC model processes the data in a way that prevents its accurate reconstruction from information appearing in this paper.

transfers to the output of each industry.* For some more detailed capacities to process agricultural crops, the historical experience came from Agricultural Statistics[2] data on the amounts of crops so processed in recent years.

An exception for industrial capacities is the use of current data[26] on percentage of capacity of wheat grain mills being used. Together with Agricultural Statistics data on amount of wheat being processed this yields a capacity measured in amount of wheat processed. The Bureau of the Census data are based on operation of a maximum number of shifts 5 days/week. Informal advice from the industry is that operation 7 days/week would be practical for extended periods of time. Negligible amounts of downtime are needed for maintenance. Accordingly the calculated capacities for operation 5 days/week are increased by 40 percent before being used in the model.

Data on livestock-product production peaks are from Agricultural Statistics[2] and on the labor force from current issues of the Survey of Current Business.[27]

The livestock capacities involve a certain amount of ambiguity for a steady-state model that purports to describe rates that may last for more than a year. Capacities of some livestock can be increased at little investment cost and in a relatively short time compared with the length of the period studied. This is particularly true of poultry flocks in the production of poultry meat and eggs. A hen reaches peak egg production in about 7 months and will lay hundreds of eggs within a year. A minor diversion of eggs from breakfast tables to hatcheries, plus a diversion of female chicks from butcher shops to egg laying a few months later, has a biological potential of greatly increasing poultry-flock capacities in a short time. There are technological problems of differences in plant and equipment of poultry producers providing eggs, meat, and breeding flocks, but it is reasonable to assume that a great deal of these kinds of plant and equipment could be improvised. The potential for increasing poultry flocks during the period under consideration is enormous. The model now contains no provision for the reduction in livestock output per unit of input that would inevitably be associated with use of improvised facilities and hence overstates the capability of the economy. However, the model uses what is considered a very conservative steady-state equivalent of 1.33 and 3.00 times the flock capacity for meat and eggs respectively that exist immediately after the losses from nuclear-weapon effects.† There are no such adjustments for other classes of livestock, although an argument might well be made for a small adjustment to be applied to swine herds, which also have rapid reproduction cycles.

Projections of preattack capacity are based on the previously cited Engineer Strategic Study Group report,[21] which, in turn, is based on a National Planning Association study.[26] Minor adjustments using other data were needed to convert the source's estimates of percentage change between 1960 and 1975 to a percentage change between 1965 and 1975.

*Each industry produces the products that define the scope of the industry plus some products of kinds that define the scopes of other industries. These are called primary and secondary products, respectively. The OBE definition of an industry's output, which is also the RAC definition, includes all the primary and secondary production of that industry plus the production in all other industries of products that are primary to that one. The Faucett data did not include this additional production, and the RAC adjustment of Faucett data added such production in the proportion added by OBE for 1958.

†These nearly arbitrary numbers can be of great importance in some problems because of the low input requirements and the excellent balance of human nutrients in eggs. When dairy products are scarce, eggs can be a principal source of calcium.

USES OF THE MODEL

The model is designed primarily to indicate whether a postattack economy is physically viable without substantial investment in reconstruction. It does this by estimating a maximum number of weapons-effects survivors that can be supported for 1 to 2 years without depletion of inventories that would lead to subsequent collapse. A large margin between the number that could be supported and the number that needs to be supported suggests a requirement of no more than a relatively low standard of management efficiency and a likelihood of potentially rapid economic recovery as resources not needed for survival are diverted to reconstruction.

A narrow margin or a deficit of economic capability suggests a need for efficient management, of course, to use surviving resources as effectively as possible. The model also suggests some of the kinds of things management, both preattack and postattack, might consider to increase the number of people supportable. Standard output of the model includes not only the number of people who can be supported under the conditions postulated but also shadow prices of the constant terms of the model. A "shadow price" is an amount of increase in the objective (millions of persons supported) per unit of change in the constant term (capacity, allowable depletion rate, or stipulated level of government operations). Additional options in most linear-programming routines (including the one used by RAC) allow testing of the sensitivity of various aspects of the answers to stipulations and parameters of the model. It can be used to measure the worth of preattack preparations such as provisions of stockpiles and of postattack measures for conservation of resources and for highest priority reconstruction after an attack. In the case of reconstruction measures, the model tells where marginal changes in capacity are most needed, but it does not say anything about what it takes in time and sacrifices of other uses of the inputs to achieve any given change in capacity. This would require a more dynamic model.

POTENTIAL IMPROVEMENTS IN THE MODEL

Potential improvements in the model may be classified as (a) increased accuracy in the estimate of particular matrix coefficients and preattack capacities, (b) provision of greater detail for greater realism of the model structure in applications to the steady-state problems for which the model is designed, and (c) introduction of capability to handle problems with dynamic elements (circumstances that change during the time horizon of the model).

Potential improvements of the first kind have in many cases been indicated and are in other cases inferable from earlier discussion. Earlier discussion has also suggested directly or indirectly points at which the model structure might be made more suitable for practical problems. Included among the possibilities are (a) additional rows for human and livestock nutrients, (b) additional activities for producing human and livestock nutrients, and (c) more detail in the industrial sectors of the economy that support food processing and inputs to agriculture (primarily chemical industries). Potential modification to include dynamic elements is discussed in the following paragraphs.

A fully dynamic model, such as PARM[28] or IRAM,[29] has each input to a production activity identified with respect to lead time before output as well as with respect to type of input, and it has investment activities with similarly time-phased input requirements. Such a model has vastly expanded data and computation requirements and would be impractical for a linear-programming model with the optional food-production and supporting-industry activity detail considered necessary here.

A possible compromise would be to consider the model as covering two steady-state periods. The second period would be a submodel similar to the present model, having no investment activities. The first period would be long enough to satisfy the following conditions as well as possible: (a) reconstruction activities can be completed or nearly completed during the period, but the resulting capacity increases are not available to any significant extent until the next period and (b) the depletion of goods in process and working inventories (as distinguished from deliberately prepared stockpiles) cannot be a major source of inputs to production. The structure of the submodel for the first period would differ from that of the second period in that the optional activities would include investment activities of kinds that previous exercise of the static model might show to be potentially useful. The kind of problem to be run on the model would be a maximization of the number of survivors in both periods, taking account of the possibilities of depleting certain stockpiles in the first period provided that investments in new capacity make further depletions in the second period unnecessary.

Appendix A

TECHNOLOGY MATRIX FOR LINEAR-PROGRAMMING COMPUTATIONS

Tables

Tables A1 and A2 present definitions of the constraints and activities of the linear-programming model with the constraints and activities classified as rows and columns, respectively. Table A3 contains a tabulation of the technology matrix.

TABLE A1

Definitions for Constraining Rows of the Technology Matrix

Row name[a]	Type of constraint	Unit
+CALMI	Food calories (minimum)	Billions
+HPRO	Food protein	Millions of kg
+FAT	Food fat (minimum)	Millions of kg
+IRON	Food iron	Millions of kg
+CALC	Food calcium	Millions of kg
+NUTX	Unused	—
+NUTY	Unused	—
-HWT	Food weight	Billions of lb
-FATMA	Food fat (maximum)	Millions of kg
-CALMA	Food calories (maximum)	Millions
+FUTOT	Feed units for all livestock	Billions of lb
+FURUM	Feed units for cattle and sheep	
+FUHOG	Feed units for hogs	
+FUPO	Feed units for poultry	
+PROTO	Feed protein for all livestock	
+PRORU	Feed protein for cattle and sheep	
+PROHO	Feed protein for hogs	
+PROPO	Feed protein for poultry	
-LWT	Feed weight	Billions of lb
+LAWHE	Land for wheat (maximum)	Millions of acres
-WLMIN	Land for wheat (minimum)	
+LACOR	Land for corn	
+LAOAT	Land for oats	
+LARIC	Land for rice	
+LARYE	Land for rye	
+LAPEA	Land for peanuts	
+LACOT	Land for cotton	
+LASOY	Land for soybeans	
+LABEA	Land for edible beans	
0LAFRU	Land for fruits	
+LAPOT	Land for potatoes	
+LASWE	Land for sweet potatoes	
+LABEE	Land for sugar beets	
+LACAN	Land for sugarcane	
+LAVEG	Land for vegetables	
+LASOR	Land for sorghum grain	
+LABAR	Land for barley	Millions of acres

TABLE A1 (continued)

Row name[a]	Type of constraint	Unit
- LAHAY	Land for hay	Millions of acres
- LAPAS	Land for pasture	
- LAGRA	Total grainland	
- LATCR	Total cropland	
- LATLA	Total agricultural land	Millions of acres
- FERT	Fertilizer (nutrients, oxide basis)	Billions of lb
- PEST	Pesticide	Billions of 1958 dollars
- PETRO	Petroleum products	Billions of 1958 dollars
- CAFER	Capacity for fertilizer	Billions of lb
- CAPES	Capacity for pesticides	Billions of 1958 dollars
- SPGRA	Capacity for grain milling (input measure)	Billions of lb
- SPCER	Capacity for cereal preparations (input measure)	
- SPRIC	Capacity for rice milling (input measure)	
- SPOIL	Capacity for oilseed processing (input measure)	
- SPBT	Capacity for sugar-beet milling (input measure)	
- SPCN	Capacity for sugarcane milling (input measure)	
- SPSOY	Food soybean meal	Billions of lb
- BE16	Capacity for fabric yarn and thread	Billions of 1958 dollars
- BE24	Capacity for paper and allied products except containers	
- BE27	Capacity for chemicals and selected chemical products	
- BE29	Capacity for drugs, cleaning and toilet preparations	
- BE31	Capacity for petroleum refining and related products	
- BE37	Capacity for primary iron and steel	
- BE39	Capacity for metal containers	
- BEMET	Capacity for metalworking	
- BE65	Capacity for transportation and warehousing	
- BE86	Capacity for canning and preserving fruits and vegetables	
- BE93	Capacity for copper manufacturing	
- BE94	Capacity for aluminum manufacturing	
+ BE95	Capacity for other nonferrous-metals manufacturing	
+ BE96	Capacity for electric power	
+ BE97	Capacity for gas-utility service	
+ BE98	Capacity for water and sanitary service	
+ BE103	Hides and skins	
- BE107	Cotton	Billions of 1958 dollars
+ LABOR	Labor	Millions of workers
+ CMILK	Capacity for milk production (livestock)	Billions of lb
+ MAPOR	Capacity for pork production (livestock)	
+ MABEE	Capacity for beef production (livestock)	
+ MAEGG	Capacity for egg production (livestock)	
+ MAPOU	Capacity for poultry-meat production (livestock)	
+ MALAM	Capacity for lamb production (livestock)	
+ FRVEG	Fresh vegetables (maximum)	
+ FRFRU	Fresh fruit (maximum)	Billions of lb
0GOVT	Level of government activity (1958 package)	1000 units

[a]Preceding a row name, +, 0, or − tells whether the cumulative product of a row's elements and corresponding column-activity levels is constrained to be ≥, =, or ≤, respectively, a constant term.

TABLE A2

Definitions for Column Activities of the Technology Matrix

Column name	Type of activity[a]	Unit
PERCA	Population survival	Millions of people
HWH1	Food wheat	Billions of lb
HCO1	Food corn with byproduct feed for livestock other than poultry	
HCO2	Food corn with byproduct feed for poultry	
HOA1	Food oatmeal	
HRI1	Food rice with byproduct feed for livestock other than poultry	
HRI2	Food rice with byproduct feed for poultry	
HRY1	Food rye with byproduct feed for livestock other than poultry	
HRY2	Food rye with byproduct feed for poultry	
HPE1	Food peanuts	
HCS1	Food cottonseed oil	
HSY1	Food soybean oil and food meal for use in bread	
HSY2	Food soybean oil and feed for livestock other than poultry	
HSY3	Food soybean oil and feed meal for poultry	
HSY4	Food soybean meal for use in bread[b]	
HSY5	Food soybean oil and food meal for use as meat extender	
HSY6	Food meal for use as meat extender	
HBN1	Food edible beans	
HFR1	Food fresh fruit	
HFR2	Food processed fruit	
HPT1	Food potatoes	
HSW1	Food sweet potatoes	
HBT1	Food sugar beets	
HCA1	Food sugarcane	
HVE1	Food fresh vegetables	
HVE2	Food processed vegetables	
LCO1	Feed corn fed to livestock other than poultry	
LCO2	Feed corn fed to poultry	
LSG1	Sorghum grain fed to livestock other than poultry	
LSG2	Sorghum grain fed to poultry	
LOA1	Feed oats fed to livestock other than poultry	
LOA2	Feed oats fed to poultry	
LBA1	Feed barley fed to livestock other than poultry	
LBA2	Feed barley fed to poultry	
LHA1	Feed hay	
LPA1	Feed grass	
HWH1F	Food wheat	
HCO1F	Food corn with byproduct feed for livestock other than poultry	
HCO2F	Food corn with byproduct feed for poultry	
HOA1F	Food oatmeal	
HRI1F	Food rice with byproduct feed for livestock other than poultry	
HRI2F	Food rice with byproduct feed for poultry	Billions of lb

TABLE A2 (continued)

Column name	Type of activity[a]	Unit
HRY1F	Food rye with byproduct feed for livestock other than poultry	Billions of lb
HRY2F	Food rye with byproduct feed for poultry	
HPE1F	Food peanuts	
HCS1F	Food cottonseed oil	
HSY1F	Food soybean oil and food meal for use in bread	
HSY2F	Food soybean oil and feed for livestock other than poultry	
HSY3F	Food soybean oil and feed meal for poultry	
HSY4F	Food soybean meal for use in bread[b]	
HSY5F	ood soybean oil and food meal for use as meat extender	
HSY6F	Food meal for use as meat extender	
HBN1F	Food edible beans	
HFR1F	Food fresh fruit	
HFR2F	Food processed fruit	
HPT1F	Food potatoes	
HSW1F	Food sweet potatoes	
HBT1F	Food sugar beets	
HCN1F	Food sugarcane	
HVE1F	Food fresh vegetables	
HVE2F	Food processed vegetables	
LCO1F	Feed corn fed to livestock other than poultry	
LCO2F	Feed corn fed to poultry	
LSG1F	Sorghum grain fed to livestock other than poultry	
LSG2F	Sorghum grain fed to poultry	
LOA1F	Feed oats fed to livestock other than poultry	
LOA2F	Feed oats fed to poultry	
LBA1F	Feed barley fed to livestock other than poultry	
LBA2F	Feed barley fed to poultry	
LHA1F	Feed hay	
HWH1P	Food wheat	
HCO1P	Food corn with byproduct feed for livestock other than poultry	
HCO2P	Food corn with byproduct feed for poultry	
HOA1P	Food oatmeal	
HRI1P	Food rice with byproduct feed for livestock other than poultry	
HRI2P	Food rice with byproduct feed for poultry	
HRY1P	Food rye with byproduct feed for livestock other than poultry	
HRY2P	Food rye with byproduct feed for poultry	
HPN1P	Food peanuts	
HCS1P	Food cottonseed oil	
HSY1P	Food soybean oil and food meal for use in bread	
HSY2P	Food soybean oil and feed for livestock other than poultry	
HSY3P	Food soybean oil and feed meal for poultry	
HSY4P	Food soybean meal for use in bread[b]	
HSY5P	Food soybean oil and food meal for use as meat extender	Billions of lb

TABLE A2 (continued)

Column name	Type of activity[a]	Unit
HSY6P	Food meal for use as meat extender	Billions of lb
HBN1P	Food edible beans	
HFR1P	Food fresh fruit	
HFR2P	Food processed fruit	
HPT1P	Food potatoes	
HSW1P	Food sweet potatoes	
HBT1P	Food sugar beets	
HCN1P	Food sugarcane	
HVE1P	Food fresh vegetables	
HVE2P	Food processed vegetables	
LCO1P	Feed corn fed to livestock other than poultry	
LCO2P	Feed corn fed to poultry	
LSG1P	Sorghum grain fed to livestock other than poultry	
LSG2P	Sorghum grain fed to poultry	
LOA1P	Feed oats fed to livestock other than poultry	
LOA2P	Feed oats fed to poultry	
LBA1P	Feed barley fed to livestock other than poultry	
LBA2P	Feed barley fed to poultry	
LHA1P	Feed hay	
HW[illegible]N	Food wheat	
HCO1N	Food corn with byproduct feed for livestock other than poultry	
HCO2N	Food corn with byproduct feed for poultry	
HOA1N	Food oatmeal	
HRI1N	Food rice with byproduct feed for livestock other than poultry	
HRI2N	Food rice with byproduct feed for poultry	
HRY1N	Food rye with byproduct feed for livestock other than poultry	
HRY2N	Food rye with byproduct feed for poultry	
HPN1N	Food peanuts	
HCS1N	Food cottonseed oil	
HSY1N	Food soybean oil and food meal for use in bread	
HSY2N	Food soybean oil and feed for livestock other than poultry	
HSY3N	Food soybean oil and feed meal for poultry	
HSY4N	Food soybean meal for use in bread[b]	
HSY5N	Food soybean oil and food meal for use as meat extender	
HSY6N	Food meal for use as meat extender	
HBN1N	Food edible beans	
HFR1N	Food fresh fruit	
HFR2N	Food processed fruit	
HPT1N	Food potatoes	
HSW1N	Food sweet potatoes	
HBT1N	Food sugar beets	
HCN1N	Food sugarcane	
HVE1N	Food fresh vegetables	
HVE2N	Food processed vegetables	
LCO1N	Feed corn fed to livestock other than poultry	
LCO2N	Feed corn fed to poultry	Billions of lb

TABLE A2 (continued)

Column name	Type of activity[a]	Unit
LSG1N	Sorghum grain fed to livestock other than poultry	Billions of lb
LSG2N	Sorghum grain fed to poultry	
LOA1N	Feed oats fed to livestock other than poultry	
LOA2N	Feed oats fed to poultry	
LBA1N	Feed barley fed to livestock other than poultry	
LBA2N	Feed barley fed to poultry	
LHA1N	Feed hay	
BEEF	Food beef (dressed)	
EGGS	Food eggs	
POUL	Food poultry meat (dressed)	
PORK	Food pork (dressed) and lard	
JPORK	Food pork[b] (dressed)	
LAMB	Food lamb (dressed)	
MILK	Food milk	Billions of lb
BC27F	Fertilizers	Billions of 1958 dollars
BC27P	Pesticides	Billions of 1958 dollars
BC31	Petroleum products	Billions of 1958 dollars
STGOV	Government operations (1958 package)	One unit

[a]F, P, or N at the end of a crop name denotes a process without the normal inputs of fertilizer, pesticides, or both, respectively.

[b]To reduce intake of fats and/or calories, the oil or fat is not used for food.

TABLE A3

Technology Matrix

			1	2	3	4	5	6	7	8
			PERCA	HWH1	HC01	HC02	HOA1	HRI1	HRI2	HRY1
1	+	CALMI	913.000000	-1158.000000	-1252.000000	-1252.000000	-684.000000	-1174.000000	-1176.000000	-1186.000000
2	+	HPRU	25.100000	-6.300000	-32.400000	-32.400000	-24.900000	-24.300000	-24.300000	-36.400000
3	+	FAT	25.450000	-7.000000	-13.800000	-13.800000	-13.000000	-5.500000	-5.500000	-4.400000
4	+	TRUN	0.005240	-0.011500	-0.009400	-0.009400	-0.007330	-0.006500	-0.006500	-0.006000
5	+	CALC	0.320400	-0.143000	-0.035000	-0.035000	-0.093000	-0.126000	-0.126000	-0.096000
6	+	NUTX								
7	+	NUTY								
8	-	HWT	9000.000000	-0.900000	-0.860000	-0.860000	-0.390000	-0.720000	-0.720000	-0.750000
9	-	FATMA	50.900000	-7.000000	-13.800000	-13.800000	-13.000000	5.500000	-5.500000	-4.400000
10	-	CALMA	1160.000000	-1158.000000	-1252.000000	-1252.000000	-684.000000	-1174.000000	-1176.000000	-1186.000000
11	+	FUTOT			-0.090000		-0.170000	-0.053000		-0.160000
12	+	FURUM			-0.090000		-0.170000	-0.053000		-0.160000
13	+	FUHOG			-0.090000		-0.170000	-0.053000		-0.160000
14	+	FUPU				-0.090000			-0.053000	
15	+	PROTO			0.008200		0.015000	-0.007700		-0.022000
16	+	PRORU			0.008200		-0.015000	-0.007700		-0.022000
17	+	PROHO			0.004200		-0.015000	-0.007700		-0.022000
18	+	PROPO				0.010000			-0.007700	
19	-	LWT			-0.110000	-0.110000	-0.560000	-0.060000	-0.060000	-0.190000
20	+	LAWHE		0.726000						
21	-	WLMIN		0.726000						
22	+	LACOR			0.268000	0.268000				
23	+	LAOAT					0.692000			
24	+	LARIC						0.252000	0.252000	
25	+	LARYE								0.747000
26	+	LAPEA								
27	+	LACOT								
28	+	LASUY								
29	+	LABEA								
30		LAFRU								
31	+	LAPOT								
32	+	LASWE								
33	+	LABEE								
34	+	LACAN								
35	+	LAVEG								
36	+	LASOR								
37	+	LABAR								
38	+	LAHAY								
39	+	LAPAS								
40	+	LAGRA		0.726000	0.268000	0.268000	0.692000			0.747000
41	+	LATCR		0.726000	0.268000	0.268000	0.692000	0.252000	0.252000	0.747000
42	+	LATLA		0.726000	0.268000	0.268000	0.692000	0.252000	0.252000	0.747000
43	+	FERT		0.034600	0.035100	0.035100	0.028800	0.036000	0.036000	[illegible]
44	+	PEST		2.550000	0.200000	0.200000	0.370000	0.890000	0.390000	0.760000
45	+	PETRO		1.250000	0.520000	0.520000	2.920000	0.440000	0.440000	1.360000
46	+	CAFER								
47	+	CAPES								
48	+	SPGRA		1.000000	1.000000	1.000000				1.000000
49	+	SPCER					1.000000			
50	+	SPRIC						1.000000	1.000000	
51	+	SPOIL								
52	+	SPMT								
53	+	SPCN								
54	+	SPSUY		-0.235000	-0.140000	-0.140000				0.190000
55	+	BE16	0.007310	0.001143	0.002612	[illegible]	0.001539	0.001751	0.001751	0.000450
56	+	BE24	0.036076	0.018754	0.005137	0.005137	0.001323	0.001347	0.001347	0.007131
57	+	BE27	0.004157	0.002774	0.001627	0.001627	0.001488	0.000665	0.000665	[illegible]
58	+	BE29	0.038096	0.001667	0.003978	0.003978	0.001038	0.001367	0.001367	0.001358
59	+	BE31	0.007458	0.006076	0.003566	0.003566	0.002681	[illegible]	[illegible]	0.004950
60	+	BE37	0.021623	0.006361	0.001961	0.001961	0.000575	0.001074	[illegible]	[illegible]
61	+	BE39	0.000416	0.001268	0.001918	0.001914	0.000662	0.000437	[illegible]	[illegible]
62	+	BEMET	0.007583	0.004796	0.005161	0.005161	0.001169	[illegible]	0.001566	[illegible]
63	+	BE55	0.013262	0.027960	0.016397	0.016397	0.008605	0.011669	0.011669	0.002762
64	+	BE86								
65	+	BE33	0.000272	0.000116	0.000197	0.000197	0.000137	[illegible]	[illegible]	[illegible]
66	+	BE46	0.000299	0.000337	0.000767	0.000767	0.000066	[illegible]	[illegible]	0.001265
67	+	BE95	0.000567	0.000865	0.000496	0.000496	0.000085	0.000116	[illegible]	[illegible]
68	+	BE96	[illegible]	0.004243	0.007493	0.007490	0.000584	[illegible]	[illegible]	[illegible]
69	+	BE97	[illegible]	0.002362	0.001386	0.001386	0.003216	0.003232	[illegible]	[illegible]
70	+	BE98	0.005488	0.000578	0.000339	0.000339	0.000045	[illegible]	[illegible]	[illegible]
71	+	BE103	0.000159	0.000064	0.000002	0.000002	0.000031	[illegible]	[illegible]	[illegible]
72	+	BE107	0.000885	0.000136	0.000083	0.000080	0.000267	[illegible]	[illegible]	[illegible]
73	+	LABOR	0.018273	0.031765	0.019096	0.019096	0.035205	0.006017	[illegible]	0.028415
74	+	CHICK								
75	+	MAPOR								
76	+	MABEE								
77	+	MALGO								
78	+	MAPOU								
79	+	MALAM								
80	+	FRVEG								
81	+	FNFRO								
82		GOVT								

TABLE A3 (continued)

			9	10	11	12	13	14	15	16
			HRY2	HPE1	HCS1	HSY1	HSY2	HSY3	HSY4	HSY5
1	+	CALMI	-1186.000000	-1710.000000	-618.000000	-1474.000000	-696.000000	-696.000000	-778.000000	-1474.000000
2	+	HPRO	-36.400000	-82.300000		-152.600000			-152.600000	-152.600000
3	+	FAT	-4.400000	-135.100000	-69.900000	-82.500000	-78.800000	-78.800000	-3.800000	-82.500000
4	+	IRON	-0.006000	-0.005800		-0.044400			-0.044400	-0.044400
5	+	CALC	-0.096000	-0.226000		-0.904000			-0.904000	-0.904000
6	+	NUTX								
7	+	NUTY								
8	-	HWT	-0.750000	-0.670000	-0.150000	-0.930000	-0.173000	-0.173000	-0.930000	-0.930000
9	-	FATMA	-4.400000	-135.100000	-69.900000	-82.500000	-78.800000	-78.800000	-3.700000	-82.500000
10	-	CALMA	-1186.000000	-1710.000000	-0.618000	-1474.000000	-696.000000	-696.000000	-776.000000	-1474.000000
11	+	FUTOT			-0.470000		-1.280000			
12	+	FURUM			-0.470000		-1.280000			
13	+	FUHOG					-1.280000			
14		FUPO	-0.160000					-0.750000		
15	+	PRPTO			-0.160000		-0.253000			
16	+	PRRU			-0.160000		-0.253000			
17	+	PRHO			-0.160000		-0.253000			
18	+	PROPO	-0.022000					-0.652000		
19	-	CWT	-0.190000		0.470000		-0.590000	-0.590000		
20	+	LAWHE								
21	-	WLMIN								
22	+	LACOR								
23	+	LAOAT								
24	+	LARIC								
25	+	LARYE	0.787000							
26	+	LAPEA		0.697000						
27	+	LACOT			1.199000					
28	+	LASOY				0.680000	0.680000	0.680000	0.680000	0.680000
29	+	LABEA								
30		LAFRU								
31	+	LAPOT								
32	+	LASWE								
33	+	LABEE								
34	+	LACAN								
35	+	LAVEG								
36	+	LASOR								
37	+	LAHAR								
38	+	LAHAY								
39	+	SPAS								
40	+	LAGRA	0.787000							
41	+	LATCR	0.787000	0.697000	1.199000	0.680000	0.680000	0.680000	0.680000	0.680000
42	+	LATLA	0.787000	0.697000	1.199000	0.680000	0.680000	0.680000	0.680000	0.680000
43	+	FERT	0.020000	0.080700	0.157000	0.016600	0.016600	0.016600	0.016600	0.016600
44	+	PEST	2.760000	0.070000	6.160000	0.070000	0.070000	0.070000	0.070000	0.070000
45	+	PETRO	1.360000	1.810000	5.250000	1.760000	1.760000	1.760000	1.760000	1.760000
46	+	CAFER								
47	+	CAPES								
48	+	SPGRA	1.000000							
49	+	SPCER								
50	+	SPRIC								
51	+	SPOIL			1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
52	+	SPBT								
53	+	SPCN								
54	+	[illegible]	-0.130000			0.788000			0.788000	0.788000
55	+	BE1	0.000850		0.000070	0.000856	0.000309	0.000309	0.000856	
56	+	BE26	0.007131		0.000435	0.008733	0.002405	0.002405	0.008733	
57	+	BE27	0.002259		0.000617	0.005333	0.003411	0.003411	0.005333	
58	+	BE29	0.021359		0.000084	0.001105	0.000458	0.000458	0.001105	
59	+	BE31	0.004950		0.001020	0.010053	0.005664	0.005664	0.010053	
60	+	BE37	0.012722		0.000528	0.005208	0.002919	0.002919	0.005208	
61	+	BE39	0.002662		0.000636	0.005686	0.003516	0.003516	0.005686	
62	+	BEMET	0.007164		0.000900	0.011235	0.004975	0.004975	0.011235	
63	+	BE65	0.022762		0.002808	0.032057	0.015523	0.015523	0.032057	
64	+	BE86								
65	+	BE93	0.000173		0.000031	0.000426	0.000141	0.000141	0.000426	0.000141
66	+	BE94	0.001065		0.000046	0.001270	0.000252	0.000252	0.001270	0.000252
67	+	BE95	0.000689		0.000076	0.001939	0.000418	0.000418	0.001939	0.000418
68	+	BE96	0.003457		0.000193	0.005108	0.002101	0.002101	0.005108	0.002101
69	+	BE97	0.001924		0.000176	0.002225	0.000976	0.000976	0.002225	0.000976
70	+	BE98	0.000471		0.000067	0.000806	0.000373	0.000373	0.000806	0.000373
71	+	BE103	0.000003		0.000001	0.000007	0.000005	0.000005	0.000007	0.000005
72	+	BE107	0.000111		-0.242600	0.000116	0.000052	0.000052	0.000116	0.000052
73	-	LABOR	0.028815	0.008054	0.029815	0.035278	0.012670	0.012670	0.035278	0.012670
74	+	CMILK								
75	+	MAPOR								
76	+	MABEE								
77	+	MAEGG								
78	+	MAPOU								
79	+	MALAM								
80	+	FRVEG								
81	+	FRFRU								
82		GOVT								

TABLE A3 (continued)

			17	18	19	20	21	22	23	24
			HSY6	HBN1	HFR1	HFR2	HPT1	HSW1	[illegible]	HCA1
1	+	CALM1	-778.000000	-549.000000	-295.000000	-295.000000	-294.000000	-455.000000	-218.000000	-154.000000
2	+	HPRO	-152.600000	-100.400000	-2.900000	-2.900000	-7.000000	-6.600000		
3	+	FAT	-3.800000	-6.400000	-1.600000	-1.600000	-2.500000	-2.600000		
4	+	IRON	-0.044400	-0.028200	-0.002600	-0.002600	-0.002500	-0.002600	-0.000230	[illegible]
5	+	CALC	-0.934000	-0.631000	-0.042000	-0.042000	-0.039000	-0.111000	-0.004500	[illegible]
6	+	NUTX								
7	+	NUTY								
8	-	HWT	-0.930000	-0.960000	-0.800000	-0.900000	-0.800000	-0.610000	-0.130000	0.090000
9	-	FATMA	-3.700000	-6.400000	-1.600000	-1.600000	-2.500000	-2.600000		
10	-	CALMA	-778.000000	-549.000000	-295.000000	-295.000000	-294.000000	-455.000000	18.000000	[illegible]
11	+	FUTOT							-0.110000	-0.030000
12	+	FURUM							-0.110000	-0.030000
13	+	FUHOG							-0.110000	-0.030000
14	+	FUPO								
15	+	PROTO							-0.015000	
16	+	PROXU							[illegible]	
17	+	PROHU							[illegible]	
18	+	PRUPO								
19	-	LNT							-0.130000	[illegible]
20	+	LAWHE								
21	-	WLMIN								
22	+	LACOR								
23	+	LAOAT								
24	+	LARIC								
25	+	LARYE								
26	+	LAPEA								
27	+	LACOT								
28	+	LASOY	0.683000							
29	+	LABEA		0.687000						
30		LAFRU			0.075000	0.075000				
31	+	LAPOT					0.050000			
32	+	LASWE						0.124000		
33	+	LABEE							0.028000	
34	+	LACAN								0.011000
35	+	LAVEG								
36	+	LASOR								
37	+	LABAR								
38	+	LAHAY								
39	+	LAPAS								
40	+	LAGRA								
41	+	LATCR	0.680000	0.687000	0.075000	0.075000	0.050000	0.126000	0.028000	0.011000
42	+	LATLA	0.680000	0.687000	0.075000	0.075000	0.050000	0.126000	0.028000	0.011000
43	+	FERT	0.016600	0.058500	0.018700	0.018700	0.039300	[illegible]	0.008500	[illegible]
44	+	PEST	0.070000	3.260000	1.960000	1.960000	0.260000	0.600000	0.110000	[illegible]
45	+	PETRO	1.760000	4.080000			0.300000	0.740000	0.170000	[illegible]
46	+	CAFER								
47	+	CAPES								
48	+	SPGRA								
49	+	SPCER								
50	+	SPRIC								
51	+	SPOIL	1.000000						1.000000	
52	+	SPBT								[illegible]
53	+	SPCM								
54	+	SPSOY	0.788000							
55	+	BE16				0.000359			[illegible]	[illegible]
56	+	BE24				0.004681			[illegible]	[illegible]
57	+	BE27				0.002185			[illegible]	[illegible]
58	+	BE29				0.001012			[illegible]	[illegible]
59	+	BE31				0.002732			[illegible]	[illegible]
60	+	BE37				0.010862			[illegible]	[illegible]
61	+	BE39				0.017057			[illegible]	[illegible]
62	+	BEME1				0.007084			[illegible]	[illegible]
63	+	BE65				0.021564			[illegible]	[illegible]
64	+	BE86				0.159359				
65	+	BE93				0.000273			[illegible]	[illegible]
66	+	BE94				0.000365			[illegible]	[illegible]
67	+	BE95				0.000669			[illegible]	[illegible]
68	+	BE96				0.002359			[illegible]	[illegible]
69	+	BE97				0.001357			[illegible]	[illegible]
70	+	BE98				0.000236			[illegible]	[illegible]
71	+	BE103				0.000105				
72	+	BE107				0.000068			[illegible]	[illegible]
73	+	LABOR	0.012470	0.041677	0.007462	0.091169	0.001269	[illegible]	[illegible]	[illegible]
74	+	CHILA								
75	+	WAPOR								
76	+	WABEE								
77	+	WAEGG								
78	+	WAPOU								
79	+	WALAM								
80	+	PRVEG								
81	+	FRFRU			1.000000					
82		GOVT								

TAB[illegible] A3 (continued)

			25	26	27	28	29	30	31	32
			HVE1	HVE2	LC01	LC02	LS01	LS02	LTA1	LTA2
1	+	CALMI	-160.000000	-160.000000						
2	+	HPRO	-6.600000	-6.600000						
3	+	FAT	-1.100000	-1.100000						
4	+	IRON	-0.003900	-0.003900						
5	+	CALC	-0.112000	-0.112000						
6	+	NUTX								
7	+	NUTY								
8	-	HWT	-0.700000	-0.700000						
9	-	FATMA	-1.100000	-1.100000						
10	-	CALMA	-160.000000	-160.000000						
11	+	FOTOT			-1.020000		-0.930000		[illegible]	
12	+	FURUM			-1.020000		-0.930000		-0.91[illegible]	
13	+	FUMIG			-1.020000		-0.930000		[illegible]	
14	+	FUPI				-0.970000		-0.870[illegible]		-0.850000
15	+	PROTO			-0.061000		-0.091000		-0.044[illegible]	
16	+	PRORU			-0.061000		-0.091000		-0.044	
17	+	PROMO			-0.063000		-0.091000		[illegible]	
18	+	PROPO				-0.780000		0.1010		-0.061[illegible]
19	-	LWT			-0.970000	-0.970000	-0.970000	-0.970[illegible]	-0.94	-0.96[illegible]
20	+	LAWME								
21	-	WLMIN								
22	+	LACOM			0.268000	0.268000				
23	+	LAOAT								
24	+	LARIC							.69[illegible]	0.692000
25	+	LARYE								
26	+	LAPEA								
27	+	LACOT								
28	+	LASOY								
29	+	LABEA								
30		LAFRU								
31	+	LAPOT								
32	+	LASWE								
33	+	LABEE								
34	+	LACAN								
35	+	LAVEG	0.0[illegible]6000	0.096000						
36	+	LASOR					0.412000	.412[illegible]		
37	+	LABAR								
38	+	LAHAY								
39	+	LAPAS								
40	+	LAGRA			0.268000	0.268000	.412000	0.412[illegible]	0.44[illegible]	.692[illegible]
41	+	LATCR	0.096000	0.096000	0.268000	0.268000	0.412000	0.412[illegible]	0.44[illegible]	0.692[illegible]
42	+	LATLA	0.096000	0.096000	0.268000	0.268000	0.412000	0.41[illegible]	.44[illegible]	.692[illegible]
43	+	FERT	0.332000	0.332000	0.235100	0.235100	0.012100	0.0121	[illegible]	0.02[illegible]
44	+	PEST	0.670000	0.670000	0.200000	0.200000	.4[illegible]	.4[illegible]	.3[illegible]	.37[illegible]
45	+	PETRO	0.570000	0.570000	0.520000	0.520000	1.1[illegible]	1.010[illegible]	.3[illegible]	.39[illegible]
46	+	LAFER								
47	+	LAPES								
48	+	SPGRA								
49	+	SPCEA								
50	+	SPREC								
51	+	SPOIL								
52	+	SPAT								
53	+	SPCN								
54	+	SPS[illegible]Y								
55	+	HE16		0.100157						
56	+	HE24		0.104481						
57	+	HE27		[illegible]2185						
58	+	HE28		[illegible]1012						
59	+	HE31		[illegible]2712						
60	+	HE37		0.010862						
61	+	HE39		0.317057						
62	+	HEMET		0.097086						
63	+	HE65		0.021566						
64	+	HE66		0.159157						
65	+	[illegible]		[illegible]226						
66	+	[illegible]		[illegible]365						
67	+	[illegible]		[illegible]669						
68	+	[illegible]		[illegible]159						
69	+	[illegible]		[illegible]157						
70	+	[illegible]		[illegible]216						
71	+	[illegible]		[illegible]335						
72	+	[illegible]		[illegible]368						
73	+	LAMIN	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
74	+	MILK								
75	+	[illegible]								
76	+	[illegible]								
77	+	[illegible]								
78	+	[illegible]								
79	+	[illegible]								
80	+	[illegible]	[illegible]							
[illegible]	+	[illegible]								
[illegible]		[illegible]								

TABLE A3 (continued)

			33	34	35	36	37	38	39	40
			LHA1	LAA2	LHA1	LPA1	[illegible]	[illegible]	[illegible]	[illegible]
1	+	CALRI					[illegible]	[illegible]	[illegible]	[illegible]
2	+	HPRO					[illegible]	[illegible]	[illegible]	[illegible]
3	+	FAT					[illegible]	[illegible]	[illegible]	[illegible]
4	+	IRON					[illegible]	[illegible]	[illegible]	[illegible]
5	+	CALC					[illegible]	[illegible]	[illegible]	[illegible]
6	+	NUTR								
7	+	NUTY								
8	-	HHT					[illegible]	[illegible]	[illegible]	[illegible]
9	-	FATHA					[illegible]	[illegible]	[illegible]	[illegible]
10	-	CALHA					[illegible]	[illegible]	[illegible]	[illegible]
11	+	FUTIT	-0.470000		[illegible]	[illegible]		[illegible]		[illegible]
12	+	FUMUN	-0.470000		[illegible]	[illegible]		[illegible]		[illegible]
13	+	FUMUG	-0.470000					[illegible]		[illegible]
14	+	FUPO		-0.460000					[illegible]	
15	+	PROP1	-0.096000		[illegible]	[illegible]		[illegible]		[illegible]
16	+	PROP1	-0.096000		[illegible]	[illegible]		[illegible]		[illegible]
17	+	PROP3	-0.096000					[illegible]		[illegible]
18	+	PROP3		.092000					[illegible]	
19		LHT	-0.960000	-0.960000	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
20	+	LAMHE					[illegible]			
21	-	WLMEN					[illegible]			
22	+	LAC 4						[illegible]	[illegible]	
23	+	LAOAT								
24	+	LARE								[illegible]
25	+	LARYC								
26	+	LAPEA								
27	+	LACOT								
28	+	LASOY								
29	+	LABEA								
30		LAPHJ								
31	+	LAPOT								
32	+	LASWE								
33	+	LAHEE								
34	+	LACEN								
35	+	LAVEG								
36	+	LASIH								
37	+	LASAX	[illegible]	[illegible]						
38	+	LAHAY			[illegible]					
39	+	LAPAS				[illegible]				
40	+	LAWEA	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]
41	+	LAT 4	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
42	+	LATCA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
43	+	FEAT	[illegible]	[illegible]	[illegible]					
44	+	PEST	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]
45	+	PETC1	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
46	+	CAPER								
47	+	APES								
48	+	SPWHA					[illegible]	[illegible]	[illegible]	
49	+	SPCEA								[illegible]
50	+	SPAIC								
51	+	SP.11								
52	+	SPBT								
53	+	SPCN								
54	+	SPSIV					[illegible]	[illegible]	[illegible]	
55	+	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]
56	+	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]
57	+	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]
58	+	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]
59	+	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]
60	+	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]
61	+	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]
62	+	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]
63	+	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]
64	+	[illegible]								
65	+	[illegible]					[illegible]		[illegible]	[illegible]
66	+	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]
67	+	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]
68	+	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]
69	+	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]
70	+	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]
71	+	[illegible]					[illegible]			
72	+	[illegible]					[illegible]	[illegible]		[illegible]
73	+	LASHW	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]
74	+	[illegible]								
75	+	[illegible]								
76	+	[illegible]								
77	+	[illegible]								
78	+	[illegible]								
79	+	[illegible]								
80	+	[illegible]								
81	+	[illegible]								
82		[illegible]								

TABLE A3 (continued)

		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	CALRI	-1176.[illegible]	-1176.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	-26.[illegible]	-26.[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	
3	FAT	-5.500000	-5.500000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	IRON	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	
5	CALC	-0.126000	-0.126000	[illegible]	[illegible]	[illegible]		[illegible]	
6	[illegible]								
7	[illegible]								
8	HWT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	FATMA	-5.500000	-5.500000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	CALMA	-1176.[illegible]	1176.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]		[illegible]			[illegible]		[illegible]
12	[illegible]	[illegible]		[illegible]			[illegible]		[illegible]
13	[illegible]	[illegible]		[illegible]					[illegible]
14	[illegible]		[illegible]		[illegible]				
15	[illegible]	[illegible]		[illegible]			[illegible]		[illegible]
16	[illegible]	[illegible]		[illegible]			[illegible]		[illegible]
17	[illegible]	[illegible]		[illegible]			[illegible]		[illegible]
18	[illegible]		[illegible]		[illegible]				
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]
20	[illegible]								
21	[illegible]								
22	[illegible]								
23	[illegible]								
24	[illegible]	[illegible]	[illegible]						
25	[illegible]			[illegible]	[illegible]				
26	[illegible]					[illegible]			
27	[illegible]						[illegible]		
28	[illegible]							[illegible]	[illegible]
29	[illegible]								
30	[illegible]								
31	[illegible]								
32	[illegible]								
33	[illegible]								
34	[illegible]								
35	[illegible]								
36	[illegible]								
37	[illegible]								
38	[illegible]								
39	[illegible]								
40	[illegible]			[illegible]	[illegible]				
41	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
42	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
43	[illegible]								
44	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
46	[illegible]								
47	[illegible]								
48	[illegible]			[illegible]	[illegible]				
49	[illegible]								
50	[illegible]	[illegible]	[illegible]						
51	[illegible]								
52	[illegible]						[illegible]	[illegible]	[illegible]
53	[illegible]								
54	[illegible]			[illegible]	[illegible]				
55	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
56	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
57	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
58	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
59	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
61	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
62	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
63	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
64	[illegible]								
65	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
66	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
67	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
68	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
69	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
71	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
72	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
73	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
74	[illegible]								
75	[illegible]								
76	[illegible]								
77	[illegible]								
78	[illegible]								
79	[illegible]								
80	[illegible]								
81	[illegible]								
82	[illegible]								

TABLE A3 (continued)

			49	50	51	52	53	54	55	56
			HSY3F	HSY4F	HSY5F	HSY6F	HRN1F	HFR1F	HFR2F	HPT1F
1	+	CALMI	-696.000000	-778.000000	-1474.000000	-778.000000	-549.000000	-295.000000	-295.000000	-294.000000
2	+	HPRO		-152.600000	-152.600000	-152.600000	-120.400000	-2.900000	-2.400000	-7.000000
3	+	FAT	-78.800000	-3.800000	-82.500000	-3.800000	-6.400000	-1.600000	-1.600000	-2.500000
4	+	IRON		-0.044400	-0.044400	-0.044400	-0.028200	-0.002600	-0.002600	-0.002400
5	+	CALC		-0.904000	-0.904000	-0.904000	-0.631000	-0.042000	-0.042000	-0.039000
6	+	NUTX								
7	+	NUTY								
8	-	HWT	-0.173000	-0.930000	-0.930000	-0.930000	-0.960000	-0.800000	-0.800000	-0.800000
9	-	FATMA	-78.800000	-3.700000	-82.500000	-3.700000	-6.400000	-1.600000	-1.600000	-2.500000
10	-	CALMA	-696.000000	-778.000000	-1474.000000	-778.000000	-549.000000	-295.000000	-295.000000	-294.000000
11	+	FUTOT								
12	+	FURUM								
13	+	FUHOG								
14	+	FUPO	-0.750000							
15	+	PROTO								
16	+	PRORU								
17	+	PRUHO								
18	+	PROPO	-0.650000							
19	-	LWT	-0.590000							
20	+	LAWHE								
21	-	WLMIN								
22	+	LACOR								
23	+	LAOAT								
24	+	LARIC								
25	+	LARYE								
26	+	LAPEA								
27	+	LACOT								
28	+	LASOY	1.010000	1.010000	1.010000	1.010000				
29	+	LABEA					1.300000			
30		LAFRU						0.278000	0.278000	
31	+	LAPOT								0.164000
32	+	LASWE								
33	+	LABEE								
34	+	LACAN								
35	+	LAVEG								
36	+	LASOR								
37	+	LABAR								
38	+	LAHAY								
39	+	LAPAS								
40	+	LAGRA								
41	+	LATCR	1.010000	1.010000	1.010000	1.010000	1.300000	0.278000	0.278000	0.164000
42	+	LATLA	1.010000	1.010000	1.010000	1.010000	1.300000	0.278000	0.278000	0.164000
43	+	FERT								
44	+	PEST	0.110000	0.110000	0.110000	0.110000	6.180000	7.280000	7.280000	0.800000
45	+	PETRO	2.620000	2.620000	2.620000	2.620000	7.740000			[illegible]
46	+	CAFER								
47	+	CAPES								
48	+	SPGRA								
49	+	SPCER								
50	+	SPRIC								
51	+	SPOIL	1.000000	1.000000	1.000000	1.000000				
52	+	SPBT								
53	+	SPCN								
54	+	SPSOY		0.788000	0.788000	0.788000				
55	+	BE16	0.000389	0.000856	0.000389	0.000389			0.000359	
56	+	BE24	0.002405	0.008733	0.002405	0.002405			0.004641	
57	+	BE27	0.003411	0.005303	0.003411	0.003411			0.002385	
58	+	BE29	0.000458	0.001109	0.000459	0.000458			0.001012	
59	+	BE31	0.005640	0.010053	0.005640	0.005640			0.002742	
60	+	BE37	0.0029[illegible]	0.005208	0.002919	0.002919			0.011862	
61	+	BE39	0.0035[illegible]	0.007586	0.003516	0.003516			0.017257	
62	+	BEMET	0.004975	0.011235	0.004975	0.004975			0.007096	
63	+	BE65	0.015523	0.032057	0.015523	0.015523			0.021566	
64	+	BE86							0.159359	
65	+	BE93	0.000181	0.000426	0.000181	0.000181			0.000273	
66	+	BE94	0.000252	0.001270	0.000252	0.000252			0.000365	
67	+	BE95	0.000418	0.001039	0.000418	0.000418			0.000569	
68	+	BE96	0.002101	0.005108	0.002101	0.002101			0.002359	
69	+	BE97	0.000976	0.002725	0.000976	0.000976			0.001357	
70	+	BE98	0.000373	0.000806	0.000373	0.000373			0.000234	
71	+	BE103	0.000005	0.000007	0.000005	0.000005			0.000005	
72	+	BE107	0.000052	0.000116	0.000052	0.000052			0.000048	
73	+	LABOR	0.012826	0.035278	0.012670	0.012670	0.076790	0.027661	0.293155	0.004197
74	+	CHILK								
75	+	MAPOR								
76	+	MABEE								
77	+	MAEGG								
78	+	MAPOU								
79	+	MALAM								
80	+	FRVEG								
81	+	FRFRU						1.000000		
82		GOVT								

TABLE A3 (continued)

			57	58	59	60	61	62	63	64
			HSWIF	HBTIF	HCNIF	HVE1F	HVE2F	LCOIF	[illegible]	LSGIF
1	+	CALMT	-455.000000	-208.000000	-152.000000	-160.700000	-160.700000			
2	+	HPRO	-6.600000			-6.600000	-6.600000			
3	+	FAT	-2.600000			-1.100000	-1.100000			
4	+	IRON	-0.002600	-0.000220	-0.000160	-0.003900	-0.003900			
5	+	CALC	-0.111000	-0.004300	-0.003100	-0.112000	-0.112000			
6	+	NUTX								
7	+	NUTY								
8	-	HWT	-0.810000			-0.700000	-0.700000			
9	-	FATMA	-2.600000			-1.100000	-1.200000			
10	-	CALMA	-455.000000	-208.000000	-152.000000	-160.[illegible]	-160.[illegible]			
11	+	FUTOT		-0.110000	-0.040000			-1.320000		-0.930000
12	+	FURUM		-0.110000	-0.040000			-1.320000		-0.930000
13	+	FUHOG		-0.110000	-0.040000			-1.320000		-0.930000
14	+	FUPO							-0.970000	
15	+	PROTO		-0.015000				-0.053000		-0.091000
16	+	PRORU		-0.015000				-0.063000		-0.091000
17	+	PROHO		-0.015000				-0.053000		-0.091000
18	+	PROPO							-0.780000	
19	-	EWT		-0.130000	-0.040000			-0.970000	-0.970000	-0.970000
20	+	LAWHE								
21	-	REMIN								
22	+	LACOR						0.727000	0.727000	
23	+	LAOAT								
24	+	LARIC								
25	+	LARYE								
26	+	LAPEA								
27	+	LACOT								
28	+	LASOY								
29	+	LABEA								
30		LAFRU								
31	+	LAPOT								
32	+	LASWE	0.475000							
33	+	LABEE		0.050000						
34	+	LACAN			0.059000					
35	+	LAVEG				0.357000	0.357000			
36	+	LASOR								1.070000
37	+	LABAR								
38	+	LAHAY								
39	+	LAPAS								
40	+	LAGRA						0.727000	0.727000	1.070000
41	+	LATCR	0.475000	0.050000	0.059000	0.357000	0.357000	0.727000	0.727000	1.070000
42	+	LATLA	0.475000	0.050000	0.059000	0.357000	0.357000	0.727000	0.727000	1.070000
43	+	FERT								
44	+	PEST	2.300000	0.210000	0.270000	1.750000	1.750000	0.530000	0.530000	1.040000
45	+	PETRO	2.840000	0.376000	0.410000	2.120000	2.120000	1.370000	1.370000	2.620000
46	+	CAFER								
47	+	CAPES								
48	+	SPGRA								
49	+	SPCER								
50	+	SPRIC								
51	+	SPOIL								
52	+	SPBT		1.000000						
53	+	SPCN			1.000000					
54	+	SPSOY								
55	+	BE16		0.000074	0.000103		0.000359			
56	+	BE24		0.000079	0.000110		0.004581			
57	+	BE27		0.000043	0.000060		0.002365			
58	+	BE29		0.000009	0.000013		0.001012			
59	+	BE31		0.000126	0.000176		0.002732			
60	+	BE37		0.000074	0.000103		0.010862			
61	+	BE39		0.000047	0.000065		0.017057			
62	+	BEMET		0.000217	0.000303		0.007086			
63	+	BE65		0.001425	0.001990		0.221564			
64	+	BE86					0.159359			
65	+	BE93		0.000006	0.000009		0.000273			
66	+	BE94		0.000008	0.000011		0.000365			
67	+	BE95		0.000014	0.000020		0.000669			
68	+	BE96		0.000075	0.000104		0.002359			
69	+	BE97		0.000172	0.000240		0.001357			
70	+	BE98		0.000016	0.000022		0.000234			
71	+	BE103					0.000005			
72	+	BE107		0.000009	0.000013		0.000044			
73	+	LABOR	0.021759	0.001567	0.003110	0.020851	0.037396	0.002328	0.002328	0.002424
74	+	CMILK								
75	+	MAPOR								
76	+	MABEE								
77	+	MAEGG								
78	+	MAPOU								
79	+	MALAM								
80	+	FRVEG				1.000000				
81	+	FRFRU								
82		GOVT								

TABLE A3 (continued)

			65	66	67	68	69	70	71	72
			LSG2F	LOA1F	LOA2F	LBA1F	LBA2F	LHA1F	HWHIP	HCUIP
1	+	CALMI							-1158.000000	-1252.000000
2	+	HPRO							-46.700000	-32.400000
3	+	FAT							-7.000000	-13.800000
4	+	IRON							-0.01500	-0.009400
5	+	CALC							-0.143000	-0.035000
6	+	NUTX								
7	+	NUTY								
8	-	HWT							-0.940000	-2.860000
9	-	FATMA							-7.000000	-13.800000
10	-	CALMA							-1158.000000	-1252.000000
11	+	FUTOT		-0.910000		-0.870000		-0.410000		-0.090000
12	+	FURUM		-0.910000		-0.870000		-0.410000		-0.090000
13	+	FUHOG		-0.910000		-0.870000				-0.090000
14	+	FUPO	-0.870000		-0.850000		-0.860000			
15	+	PROTO		-0.088000		-0.096000		-0.382000		0.008200
16	+	PRORU		-0.088000		-0.096000		-0.382000		0.008200
17	+	PROHO		-0.088000		-0.096000				0.008200
18	+	PROPO	-0.101000		-0.063000		-0.092000			
19	-	LWT	-0.970000	-0.940000	-0.940000	-0.960000	-0.960000	-1.000000		-0.110000
20	+	LAWHE							0.464000	
21	-	WLMIN							0.855000	
22	+	LACOR								0.315000
23	+	LAOAT		1.090000	1.090000					
24	+	LARIC								
25	+	LARYE								
26	+	LAPEA								
27	+	LACOT								
28	+	LASOY								
29	+	LABCA								
30		LAPHO								
31	+	LAPOT								
32	+	LASWE								
33	+	LABEE								
34	+	LACAN								
35	+	LAVEG								
36	+	LASOR	1.070000							
37	+	LABAR				0.853000	0.853000			
38	+	LAHAY						0.382000		
39	+	LAPAS								
40	+	LAGRA	1.070000	1.090000	1.090000	0.853000	0.853000		0.854000	0.315000
41	+	LATCR	1.070000	1.090000	1.090000	0.853000	0.853000	0.382000	0.854000	0.315000
42	+	LATLA	1.070000	1.090000	1.090000	0.853000	0.853000	0.382000	0.854000	0.315000
43	+	FERT							0.040700	0.041300
44	+	PEST	1.040000	0.580000	0.580000	0.920000	0.920000	0.390000		
45	+	PETRO	2.620000	1.450000	1.450000	2.090000	2.090000	0.931000	1.470000	0.612000
46	+	CAFER								
47	+	CAPES								
48	+	SPGRA							1.000000	1.000000
49	+	SPCER								
50	+	SPRIC								
51	+	SPOIL								
52	+	SPBT								
53	+	SPCN								
54	+	SPSOY							-0.035000	-0.140000
55	+	BE16							0.001043	0.000612
56	+	BE24							0.008753	0.005137
57	+	BE27							0.002774	0.001627
58	+	BE29							0.001667	0.000978
59	+	BE31							0.006076	0.003566
60	+	BE37							0.003341	0.001961
61	+	BE39							0.003268	0.001918
62	+	BEMET							0.008796	0.005161
63	+	BE65							0.027940	0.016397
64	+	BE86								
65	+	BE93							0.000336	0.000197
66	+	BE94							0.001307	0.000767
67	+	BE95							0.000845	0.000496
68	+	BE96							0.004243	0.002490
69	+	BE97							0.002362	0.001386
70	.	BE78							0.000578	0.000339
71	+	BE103							0.000004	0.000002
72	+	BE107							0.000136	0.000080
73	+	LABOR	0.002425	0.002418	0.002418	0.002673	0.002673	0.000936	0.031918	0.019024
74	+	CMILK								
75	+	MAPOR								
76	+	MABEE								
77	+	MAEGG								
78	+	MAPOU								
79	+	MALAM								
80	+	FRVEG								
81	+	FRFRU								
82		GOVT								

TABLE A3 (continued)

			73	74	75	76	77	78	79	80
			HCJ2P	HOAIP	HRI1P	HRI2P	HRY1P	HRY2P	H[illegible]NIP	HESIP
1	+	CALMT	-1252.000000	-684.000000	-1174.000000	-1174.000000	-1156.000000	-11[illegible]	-171[illegible]	-618.000000
2	+	HPRO	-37.400000	-24.900000	-24.300000	-24.300000	-36.400000	-36.4[illegible]	-83.[illegible]	
3	+	FAT	-13.800000	-13.000000	-5.500000	-5.500000	-4.400000	-4.4[illegible]	-135.1[illegible]	-69.900000
4	+	IRON	-0.009400	-0.0[illegible]900	-0.006500	-0.006500	-0.006000	-0.006[illegible]	-0.0[illegible]58[illegible]	
5	+	CALC	-0.035000	-0.393000	-0.126000	-0.126000	-0.096000	-0.096[illegible]	-0.226[illegible]	
6	+	NUTX								
7	+	NUTY								
8	-	HWT	-0.860000	-0.390000	-0.720000	-0.720000	-0.750000	-0.75[illegible]	-0.67[illegible]	-0.150000
9	-	FATMA	-13.800000	-13.000000	-5.500000	-5.500000	-4.400000	-4.4[illegible]	-135.1[illegible]	-65.900000
10	-	CALMA	-1252.000000	-684.000000	-1174.000000	-1174.000000	-1186.000000	-1186.000[illegible]	-1710.[illegible]	-0.618000
11	+	FUTUT		-0.170000	-0.053000		-0.160000			-0.470000
12	+	FURUM		-0.170000	-0.053000		-0.160000			-0.470000
13	+	FUHUG		-0.170000	-0.053000		-0.160000			
14	+	FUPU	-0.090000			-0.053000		-0.160[illegible]		
15	+	PRUTO		-0.015000	-0.007000		-0.022000			-0.160000
16	+	PRORU		-0.015000	-0.007000		-0.022000			-0.160000
17	+	PRUHO		-0.015000	-0.007000		-0.022000			-0.160000
18	+	PROPO	0.010000			-0.007000		-0.022[illegible]		
19	-	LWT	-0.110000	-0.560000	-0.060000	-0.060000	-0.190000	-0.190[illegible]		-0.470000
20	+	LAWHE								
21	-	WCMIN								
22	+	LACOR	0.315000							
23	+	LAOAT		0.814000						
24	+	LARIC			0.296000	0.296000				
25	+	LARYE					0.926000	0.926[illegible]		
26	+	LAPEA							0.939[illegible]	
27	+	LACOT								1.600000
28	+	LASOY								
29	+	LABEA								
30		LAFRU								
31	+	LAPOT								
32	+	LASWE								
33	+	LABEE								
34	+	LACAN								
35	+	LAVEG								
36	+	LASOR								
37	+	LABAR								
38	+	LAHAY								
39	+	LAPAS								
40	+	LAGRA	0.315000	0.814000			0.926000	0.926[illegible]		
41	+	LATCR	0.315000	0.814000	0.296000	0.296000	0.926000	0.926[illegible]	0.92[illegible]	1.600000
42	+	LATLA	0.315000	0.814000	0.296000	0.296000	0.926000	0.926[illegible]	0.92[illegible]	1.600000
43	+	FERT	0.041300	0.041300	0.047300	0.047300	0.023500	0.0235[illegible]	0.107[illegible]	0.262[illegible]
44	+	PEST								
45	+	PETRO	0.612000	1.080000	0.518000	0.518000	1.6[illegible]	1.6[illegible]	2.41[illegible]	7.[illegible]
46	+	CAFER								
47	+	CAPES								
48	+	SPGRA	1.000000				1.000000	1.000[illegible]		
49	+	SPCER		1.000000						
50	+	SPRIC			1.000000	1.000000				
51	+	SPOIL								1.000000
52	+	SPHT								
53	+	SPCN								
54	+	SPSOY	-0.140000				-0.190000	-0.190[illegible]		
55	+	BE16	0.000612	0.000539	0.000731	0.000731	0.000850	0.000[illegible]		0.000[illegible]
56	+	BE24	0.005137	0.001023	0.001387	0.001387	0.007131	0.007131		0.000435
57	+	BE27	0.001627	0.000488	0.000662	0.000662	0.002259	0.002259		0.000617
58	+	BE29	0.000978	0.001008	0.001367	0.001367	0.001358	0.001358		0.000[illegible]
59	+	BE31	0.003566	0.000681	0.000923	0.000923	0.004957	0.004957		0.001020
60	+	BE37	0.001961	0.000575	0.000780	0.000780	0.002722	0.002722		0.000528
61	+	BE39	0.001918	0.000662	0.000897	0.000897	0.002662	0.002662		0.000636
62	+	BEMET	0.005161	0.001169	0.001586	0.001586	0.007164	0.007164		0.000[illegible]
63	+	BE65	0.016397	0.008605	0.011669	0.011669	0.022762	0.022762		0.002[illegible]
64	+	BE86								
65	+	BE93	0.000197	0.000037	0.000050	0.000050	0.000273	0.000273		0.000[illegible]
66	+	BE94	0.000767	0.000046	0.000063	0.000063	0.001065	0.001065		0.000146
67	+	BE95	0.000496	0.000085	0.000116	0.000116	0.000689	0.000689		0.000076
68	+	BE96	0.002490	0.000584	0.000792	0.000792	0.003457	0.003457		0.000380
69	+	BE97	0.001386	0.000216	0.000292	0.000292	0.001924	0.001924		0.000176
70	+	BE98	0.000339	0.000045	0.000060	0.000060	0.000471	0.000471		0.000067
71	+	BE103	0.000002	0.000001	0.000001	0.000001	0.000003	0.000003		0.000001
72	+	BE107	0.000080	0.000067	0.000091	0.000091	0.000111	0.000111		-0.292400
73	+	LABOR	0.019024	0.004729	0.005813	0.005813	0.056498	0.0564[illegible]	0.010735	0.005393
74	+	CHILK								
75	+	MAPUR								
76	+	MABEE								
77	+	MAEGG								
78	+	MAPOU								
79	+	MALAM								
80	+	FRVEG								
81	+	FRFRU								
82		GOVT								

TABLE A3 (continued)

			A1	A2	A3	A4	A5	A6	A7	A8
			HSY1P	HSY2P	HSY3P	HSY4P	HSY5P	HSY6P	HRN1P	HFR1P
1	+	CALMI	-1474.000000	-696.000000	-696.000000	-778.000000	-1474.000000	-778.000000	-549.000000	-295.000000
2	+	HPRO	-152.600000			-152.600000	-152.600000	-152.600000	[illegible]	-7.900000
3	+	FAT	-82.500000	-78.800000	-78.800000	-3.800000	82.500000	-3.800000	-6.400000	-1.600000
4	+	IRON	-0.044400			-0.044400	-0.044400	-0.044400	[illegible]	-0.002600
5	+	CALC	-0.904000			-0.904000	0.904000	-0.904000	-0.635000	-0.042000
6	+	NUTX								
7	+	NUTY								
8	-	HWT	-0.930000	-0.173000	-0.173000	-0.930000	-0.930000	-0.930000	-0.960000	-0.800000
9	-	FATHA	-82.500000	-78.800000	-78.800000	-3.700000	-82.500000	-3.700000	-6.400000	-1.600000
10	-	CALMA	-1474.000000	-696.000000	-696.000000	-778.000000	-1474.000000	-778.000000	-549.000000	-295.000000
11	+	FUTOT		-1.280000						
12	+	FURUM		-1.280000						
13	+	FUHOG		-1.280000						
14	+	FUPO			0.750000					
15	+	PROTO		-0.253000						
16	+	PRORU		-0.253000						
17	+	PROHO		-0.253000						
18	+	PROPO			0.650000					
19	-	LWT		-0.590000	0.590000					
20	+	LAWHE								
21	-	WLMIN								
22	+	LACOR								
23	+	LAOAT								
24	+	LARIC								
25	+	LARYE								
26	+	LAPEA								
27	+	LACOT								
28	+	LASOY	0.907000	0.907000	0.907000	0.907000	0.907000	0.907000		
29	+	LABEA							1.150000	
30		LAFRU								0.125000
31	+	LAPOT								
32	+	LASWE								
33	+	LABEE								
34	+	LACAN								
35	+	LAVEG								
36	+	LASOR								
37	+	LABAR								
38	+	LAHAY								
39	+	LAPAS								
40	+	LAGRA								
41	+	LATCR	0.907000	0.907000	0.907000	0.907000	0.907000	0.907000	1.150000	0.125000
42	+	LATLA	0.907000	0.907000	0.907000	0.907000	0.907000	0.907000	1.150000	0.125000
43	+	FERT	0.022100	0.022100	0.022100	0.022100	0.022100	0.022100	0.093500	0.031200
44	+	PEST								
45	+	PETRO	2.350000	2.350000	2.350000	2.350000	2.350000	2.350000	6.800000	
46	+	CAFER								
47	+	CAPES								
48	+	SPGRA								
49	+	SPCER								
50	+	SPRIC								
51	+	SPOIL	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000		
52	+	SPCUT								
53	+	SPCN								
54	+	SPSOY	0.788000			0.788000	0.788000	0.788000		
55	+	BE16	0.000856	0.000389	0.000389	0.000856	0.000389	0.000389		
56	+	BE24	0.008733	0.002405	0.002405	0.008733	0.002405	0.002405		
57	+	BE27	0.005303	0.003411	0.003411	0.005303	0.003411	0.003411		
58	+	BE29	0.001105	0.000458	0.000458	0.001105	0.000458	0.000458		
59	+	BE31	0.010053	0.005640	0.005640	0.010053	0.005640	0.005640		
60	+	BE37	0.005208	0.002919	0.002919	0.005208	0.002919	0.002919		
61	+	BE39	0.005686	0.003516	0.003516	0.005686	0.003516	0.003516		
62	+	BEMET	0.011235	0.004975	0.004975	0.011235	0.004975	0.004975		
63	+	BE65	0.032057	0.015523	0.015523	0.032057	0.015523	0.015523		
64	+	BE86								
65	+	BE93	0.000426	0.000181	0.000181	0.000426	0.000181	0.000181		
66	+	BE94	0.001270	0.000252	0.000252	0.001270	0.000252	0.000252		
67	+	BE95	0.001039	0.000418	0.000418	0.001039	0.000418	0.000418		
68	+	BE96	0.005108	0.002101	0.002101	0.005108	0.002101	0.002101		
69	+	BE97	0.002725	0.000976	0.000976	0.002725	0.000976	0.000976		
70	+	BE98	0.000806	0.000373	0.000373	0.000806	0.000373	0.000373		
71	+	BE103	0.000007	0.000005	0.000005	0.000007	0.000005	0.000005		
72	+	BE107	0.000116	0.000052	0.000052	0.000116	0.000052	0.000052		
73	+	LABOR	0.035170	0.012737	0.012737	0.035278	0.012670	0.012670	0.069765	0.012438
74	+	CMILK								
75	+	MAPOR								
76	+	MABEE								
77	+	MAEGG								
78	+	MAPOU								
79	+	MALAM								
80	+	FRVEG								
81	+	FRFRU								1.000000
82		GOVT								

TABLE A3 (continued)

			39	40	41	42	43	44	45	46
			HFR2P	HPTIP	HSWIP	HBTIP	HCNIP	[illegible]	[illegible]	[illegible]
1	+	CALMI	-295.000000	-294.000000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
2	+	HPRO	2.900000	[illegible]	[illegible]			[illegible]	[illegible]	
3	+	FAT	-1.600000	-2.500000	-2.400000			-1.1[illegible]	[illegible]	
4	+	IRON	-0.002600	-0.002500	-0.002600	[illegible]	[illegible]	[illegible]	[illegible]	
5	+	CALC	-0.042000	-0.039000	-0.111000	-0.004300	[illegible]	[illegible]	[illegible]	
6	+	NUTX								
7	+	NUTY								
8	-	HWT	-0.800000	-0.800000	-0.810000			[illegible]	[illegible]	
9	-	FATMA	-1.600000	-2.500000	-2.600000			-1.10[illegible]	-1.1[illegible]	
10	-	CALMA	-295.000000	-294.000000	-475.000000	-209.000000	-152.000000	[illegible]	[illegible]	
11	+	FUTOT				0.110000	-0.030000			-1.020000
12	+	FUROM				-0.110000	-0.030000			-1.020000
13	+	FUHOG				-0.110000	-0.030000			-1.020000
14	+	FUPO								
15	+	PROTO				-0.015000				-0.063000
16	+	PRORU				-0.015000				-0.063000
17	+	PROHO				-0.015000				-0.063000
18	+	PRUPO								
19	-	LWT				-0.130000	-0.040000			-0.970000
20	+	LAWHE								
21	-	WLMIN								
22	+	LACOR								0.315000
23	+	LADAT								
24	+	LARIC								
25	+	LAPYE								
26	+	LAPEA								
27	+	LACOT								
28	+	LASOY								
29	+	LABEA								
30		LAFRU	0.125000							
31	+	LAPOT		0.083000						
32	+	LASWE			0.207000					
33	+	LABEE				0.033000				
34	+	LACAN					0.013000			
35	+	LAVEG						0.160[illegible]	[illegible]	
36	+	LASOR								
37	+	LABAR								
38	+	LAHAY								
39	+	LAPAS								
40	+	LAGRA								0.315000
41	+	LATCR	0.125000	0.083000	0.207000	0.033000	0.013000	0.160000	[illegible]	0.315000
42	+	LATLA	0.125000	0.083000	0.207000	0.033000	0.013000	0.160000	[illegible]	0.315000
43	+	FERT	0.031200	0.065500	0.062200	0.010000	0.004800	0.0538[illegible]	0.0538[illegible]	0.041300
44	+	PEST								
45	+	PETRO		0.500000	1.230000	0.200000	0.091000	0.950000	[illegible]	0.612[illegible]
46	+	CAFER								
47	+	CAPES								
48	+	SPGRA								
49	+	SPCER								
50	+	SPRIC								
51	+	SPOIL								
52	+	SPBT				1.000000				
53	+	SPCN					[illegible]000			
54	+	SPSOY								
55	+	BE16	0.000359			[illegible]	0.000133		[illegible]	
56	+	BE24	0.004681			0.000039	0.000110		0.004681	
57	+	BE27	0.002385			0.000043	0.000060		0.002385	
58	+	BE29	0.001012			0.000009	0.000013		0.001012	
59	+	BE31	0.002732			0.000126	0.000176		0.002732	
60	+	BE37	0.010862			0.000174	0.000103		0.010862	
61	+	BE39	0.017057			0.000047	0.000065		0.017057	
62	+	BEMET	0.007084			0.000217	0.000303		0.007084	
63	+	BE65	0.021564			0.001425	0.001990		0.021564	
64	+	BE86	0.159359						0.159359	
65	+	BE93	0.000273			0.000006	0.000009		0.000273	
66	+	BE94	0.000365			0.000008	0.000011		0.000365	
67	+	BE95	0.000669			0.000014	0.000020		0.000669	
68	+	BE96	0.002359			0.000075	0.000104		0.002359	
69	+	BE97	0.001357			0.000172	0.000240		0.001357	
70	+	BE98	0.000334			0.000016	0.000022		0.000334	
71	+	BE103	0.000305						0.000305	
72	+	BE107	0.000048			0.000009	0.000013		0.000048	
73	+	LABOR	0.160921	0.002124	0.009481	0.001253	0.001386	0.009365	0.025890	0.001109
74	+	CHICK								
75	+	HAPOK								
76	+	HABLE								
77	+	HAEGG								
78	+	HAPOU								
79	+	HALAM								
80	+	FAVEG						1.000000		
81	+	FAFRU								
82		GOVT								

TABLE A3 continued

			97	98	99	100	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	+	CALMI								
2	+	HPRO								
3	+	FAT								
4	+	IRON								
5	+	CALC								
6	+	NUTK								
7	+	NUTY								
8	-	HWT								
9	-	FATMA								
10	-	CALMA								
11	-	FUTUT		-0.930000		-0.910000		-0.47[illegible]		-0.41[illegible]
12	+	FURUR		-0.930000		-0.910000		-0.47[illegible]		-0.41[illegible]
13	+	FUMOG		-0.930000		-0.910000		-0.47[illegible]	-0.46[illegible]	
14	+	FUPO	-0.970000		-0.870000		-0.850000			
15	+	PROTO		-0.091000		-0.088000		[illegible]		[illegible]
16	+	PROKU		-0.091000		-0.088000		[illegible]		[illegible]
17	+	PROMO		-0.091000		-0.088000		-0.096[illegible]		
18	+	PROPO	-0.750000		-0.101000		-0.063000		[illegible]	
19	-	LWT	-0.970000	-0.970000	-0.970000	-0.940000	-0.940000	-0.960[illegible]	-0.96[illegible]	-1.00[illegible]
20	+	LAWHE								
21	-	WLMIN								
22	+	LACOR	0.315000							
23	+	LADAT								
24	+	LARIC				0.814000	0.814000			
25	+	LARYE								
26	+	LAPEA								
27	+	LACOT								
28	+	LASOY								
29	+	LABEA								
30		LAFRU								
31	+	LAPOT								
32	+	LASWE								
33	+	LABEE								
34	+	LACAN								
35	+	LAVEG								
36	+	LASOR		0.485000	0.485000					
37	+	LABAR						.698[illegible]	0.698[illegible]	
38	+	LAHAY								0.324[illegible]
39	+	LAPAS								
40	+	LAGRA	0.315000	0.485000	0.485000	[illegible]814000	0.814000	0.698[illegible]	0.698[illegible]	
41	+	LATCR	0.315000	0.485000	0.485000	0.814000	0.814000	0.698[illegible]	0.698[illegible]	0.324[illegible]
42	+	LATLA	0.315000	0.485000	0.485000	0.814000	0.814000	0.698[illegible]	0.698[illegible]	0.324[illegible]
43	+	FERT	0.041300	0.014200	0.014200	0.033900	0.033900	0.0276[illegible]	0.0276[illegible]	0.007[illegible]
44	+	PEST								
45	+	PE[illegible]	0.612000	1.190000	1.190000	1.080000	1.080000	1.71[illegible]	1.71[illegible]	0.79[illegible]
46	+	CAFER								
47	+	CAPES								
48	+	SPGRA								
49	+	SPCFR								
50	+	SPRIC								
51	+	SPOIL								
52	+	SPBT								
53	+	SPCN								
54	+	SPSOY								
55	+	BE16								
56	+	BE24								
57	+	BE27								
58	+	BE29								
59	-	BE31								
60	+	BE37								
61	+	BE39								
62	+	BEMET								
63	+	BE65								
64	+	BE86								
65	+	BE93								
66	+	BE94								
67	+	BE95								
68	+	BE96								
69	+	BE97								
70	+	BE98								
71	+	BE103								
72	+	BE107								
73	+	LABOR	0.001109	0.001100	0.001100	0.001807	0.001807	0.0021[illegible]	[illegible]	[illegible]
74	+	CMILK								
75	+	MAPUR								
76	+	MABEF								
77	+	MAEGG								
78	+	MAPOU								
79	+	MALAM								
80	+	FR[illegible]LG								
81	+	FRFRU								
82		GOVT								

TABLE A3 continued

1	+	CALMT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	+	HPRT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	+	FAT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	+	IRON	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	+	AL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	+	NUTA		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	+	NUTY					[illegible]	[illegible]	[illegible]	[illegible]
8	-	HWT	0.940000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	-	FATMA	-7.000000	-13.800000	[illegible]	[illegible]				
10	-	CALMA	-1158.000000	-1252.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	+	FUOJT				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	+	FUOJM		-0.090000		[illegible]	[illegible]			
13	+	FUMOG		-0.090000		[illegible]	[illegible]		[illegible]	
14	+	FUPJ		-0.090000		[illegible]	[illegible]		[illegible]	
15	+	PROTO			-0.090000				[illegible]	
16	+	PRORU		0.008200		[illegible]	[illegible]	[illegible]		[illegible]
17	+	PROMO		0.008200		[illegible]	[illegible]		[illegible]	
18	+	PROPU		0.008200		[illegible]	[illegible]		[illegible]	
19	-	LWT			0.01[illegible]			[illegible]	[illegible]	
20	+	LAWHE	1.698000	-0.110000	-0.110000	-0.560[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	-	WLMIN	1.698000							
22	+	LACOR								
23	+	LAUAT		0.832000	0.832000					
24	+	LARIC				1.2[illegible]				
25	+	LARYE					[illegible]	[illegible]		
26	+	LAPEA								
27	+	LACOT							[illegible]	[illegible]
28	+	LASOY								
29	+	LAREA								
30		LAFRU								
31	+	LAPOT								
32	+	LASWE								
33	+	LABEE								
34	+	LALAN								
35	+	LAVEG								
36	+	LASUR								
37	+	LABAN								
38	+	LAHAY								
39	+	LAPAS								
40	+	LAGRA	1.698000	0.832000	0.832000	1.24[illegible]				
41	+	LATCH	1.698000	0.832000	0.832000	[illegible]			[illegible]	[illegible]
42	+	LATLA	1.698000	0.832000	0.832000	[illegible]	[illegible]	[illegible]		
43	+	FERT					[illegible]	[illegible]	[illegible]	[illegible]
44	+	PEST							[illegible]	[illegible]
45	+	PETHU	2.910000	1.610000	1.610000					
46	+	CAFER				1.[illegible]	[illegible]	[illegible]		
47	+	CAPES							[illegible]	[illegible]
48	+	SPGRA	1.000000	1.000000	1.000000					
49	+	SPCER							[illegible]	[illegible]
50	+	SPRIC				1.00[illegible]				
51	+	SPOIL					[illegible]	[illegible]		
52	+	SPBT								
53	+	SPCN								
54	+	SPSJY	-0.235000	-0.140000	[illegible]					
55	+	REIA	0.031043	0.000612	[illegible]				[illegible]	[illegible]
56	+	RE2A	0.024755	0.035137	0.035137	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
57	+	RE27	0.012773	0.031627	0.031627	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
58	+	RE29	0.031667	0.000978	0.000978	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
59	+	RE31	[illegible]	0.301566	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
60	+	RE33	0.003361	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
61	+	RE39	0.003268	0.001961	0.001961	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
62	+	REMET	0.008796	0.001918	0.001918	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
63	+	RE84	0.027963	0.005[illegible]	0.035161	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
64	+	RE85		0.016157	0.016157	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
65	+	RE91	0.000336	0.000197	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
66	+	RE94	0.031107	0.000767	0.000767	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
67	+	RE95	0.000845	0.000446	0.000498	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
68	+	RE96	0.004241	0.002490	0.002490	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
69	+	RE97	0.03216[illegible]	0.001185	0.001185	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
70	+	RE98	0.000578	0.000336	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
71	+	RE101	0.000006	0.000002	0.000002	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
72	+	RE10[illegible]	0.000136	0.000080	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
73	+	LABOR	0.011200	0.020726	0.020726	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
74	+	CHICA								
75	+	NAPUA								
76	+	MAREE								
77	+	MAEGG								
78	+	MAPJU								
79	+	MALAN								
80	+	FRVEG								
81	+	FRPRU								
82		GOVT								

TABLE A3 (continued)

			113	114	115	116	117	118	119	120
			HPNIN	HCSIN	HSYIN	HSY2N	HSY3N	HSYAN	[illegible]	HSYAN
1	+	CALRI	-1710.000000	-618.000000	-1474.000000	696.000000	-696.000000	-778.[illegible]	-1474.[illegible]	-778.300000
2	+	HPHO	-82.100000		-152.600000			-152.60[illegible]	-152.60[illegible]	-152.600[illegible]
3	+	FAT	-135.[illegible]	-69.[illegible]	-82.500000	-78.800000	-78.800000	-1.400	[illegible]	1.400[illegible]
4	+	IRON	-0.015800		-0.044400			-0.0444[illegible]	[illegible]	-0.0444[illegible]
5	+	CALC	-0.271000		-0.904000			-0.904[illegible]	[illegible]	-0.904000
6	+	NUTI								
7	+	NUTY								
8	-	NUT	-3.670000	-0.150000	-0.930000	-0.174000	0.174000	-0.93[illegible]	[illegible]	-0.93[illegible]
9	-	FATMA	-135.100000	-69.400000	-82.500000	-78.800000	-78.800000	-1.40[illegible]	[illegible]	-1.40[illegible]
10	-	CALMA	-1710.000000	-0.618000	-1474.000000	-696.000000	-696.000000	-778.[illegible]	-1474.[illegible]	-778.[illegible]
11	+	FUTOT		-0.470000		-1.280000				
12	+	FURJM		-0.470000		-1.280000				
13	+	FJMOG				1.280000				
14	+	FUPO					-0.750000			
15	+	PROTO		-0.160000		-0.253000				
16	+	PRORU		-0.160000		-0.253000				
17	+	PROMU		-0.160000		-0.253000				
18	+	PROPO					-0.650000			
19	-	LWT		-0.470000		-0.590000	-0.590000			
20	+	LAWHE								
21	-	MLMIN								
22	+	LACOR								
23	+	LADAT								
24	+	LARIC								
25	+	LARYE								
26	+	LAPEA	1.960000							
27	+	LACOT		3.490000						
28	+	LASOY			1.350000	1.350000	1.350000	1.35[illegible]	1.[illegible]	1.35[illegible]
29	+	LAREA								
30		LAFRU								
31	+	LAPOT								
32	+	LASWE								
33	+	LABEE								
34	+	LACAN								
35	+	LAVEG								
36	+	LASOR								
37	+	LABAR								
38	+	LAHAY								
39	+	LAPAS								
40	+	LAGRA								
41	+	LATCR	1.960000	3.490000	1.350000	1.350000	1.350000	1.35[illegible]	1.35[illegible]	1.35[illegible]
42	+	LATLA	1.960000	3.480000	1.350000	1.350000	1.350000	1.35[illegible]	1.35[illegible]	1.35[illegible]
43	+	FERT								
44	+	PEST								
45	+	PETRO	5.040000	15.220000	3.690000	3.690000	3.690000	3.69[illegible]	3.69[illegible]	3.69[illegible]
46	+	CAFER								
47	+	CAPES								
48	+	SPGRA								
49	+	SPCER								
50	+	SPRIC								
51	+	SPOIL		1.000000	1.000000	1.000000	1.000000	1.[illegible]	1.[illegible]	1.[illegible]
52	+	SPOT								
53	+	SPCN								
54	+	SPSOY			0.789000			0.789[illegible]	0.789[illegible]	0.789[illegible]
55	+	BE14		0.000070	0.003850	0.000189	0.000184	[illegible]	[illegible]	[illegible]
56	+	BE24		0.000455	0.038755	0.002405	0.002405	[illegible]	[illegible]	[illegible]
57	+	BE27		0.000617	0.025101	0.011411	0.011411	[illegible]	[illegible]	[illegible]
58	+	BE29		0.000083	0.001135	0.000458	0.000458	[illegible]	[illegible]	[illegible]
59	+	BE31		0.001020	0.013055	0.029660	0.029660	[illegible]	[illegible]	[illegible]
60	+	BE32		0.003528	0.035274	0.002919	0.002919	[illegible]	[illegible]	[illegible]
61	+	BE39		0.003656	0.035686	0.003516	0.003516	[illegible]	[illegible]	[illegible]
62	+	BEMEI		0.000900	0.011235	0.006475	0.006475	[illegible]	[illegible]	[illegible]
63	+	BE63		0.002804	0.032057	0.015521	0.015521	[illegible]	[illegible]	[illegible]
64	+	BE84								
65	+	BE91		0.000011	0.001426	0.000181	0.000181	[illegible]	[illegible]	[illegible]
66	+	BE94		0.000066	0.001279	0.000292	0.000292	[illegible]	[illegible]	[illegible]
67	+	BE95		0.030076	0.051539	0.000418	0.000418	[illegible]	[illegible]	[illegible]
68	+	BE96		0.000180	0.035130	0.002101	0.002101	[illegible]	[illegible]	[illegible]
69	+	BE97		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
70	+	BE98		0.000067	0.000806	0.000175	0.000175	[illegible]	[illegible]	[illegible]
71	+	BE101		0.000001	0.000007	0.000005	0.000005	[illegible]	[illegible]	[illegible]
72	+	BE107		-0.292400	0.035116	0.000092	0.000092	[illegible]	[illegible]	[illegible]
73	+	LABOR	0.022264	0.004109	0.016106	0.003512	0.003512	[illegible]	[illegible]	[illegible]
74	+	CHILD								
75	+	MAPOR								
76	+	MADEE								
77	+	MAEGG								
78	+	MAPOU								
79	+	MALAR								
80	+	FOWEG								
81	+	FAFAU								
82		GOVT								

TABLE A3 (continued)

			121	122	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			HANIN	HEHIN	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	+	CALMI	-549.000000	-295.000000	-295.[illegible]	246.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	+	HPRJ	-100.600000	-2.900000	[illegible]	[illegible]	[illegible]			[illegible]
3	+	FAT	-6.400000	-1.600000	-1.6[illegible]	[illegible]	[illegible]			[illegible]
4	+	IRON	-0.724200	-0.072600	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	+	CALC	-0.631000	-0.042000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	+	NUTX								
7	+	NUTY								
8	-	HWT	-0.960000	0.800000	[illegible]	[illegible]	[illegible]			[illegible]
9	-	FATMA	-6.400000	-1.630000	1.6[illegible]	[illegible]	[illegible]			[illegible]
10	-	CALMA	-549.000000	295.000000	[illegible]	[illegible]	[illegible]	-228.[illegible]	-187.000000	[illegible]
11	+	FUTOT						[illegible]	[illegible]	
12	+	FURUM						[illegible]	[illegible]	
13	+	FUHOG						[illegible]	[illegible]	
14	+	[illegible]								
15	+	PROT[illegible]						[illegible]		
16	+	PRORU						[illegible]		
17	+	[illegible]						[illegible]		
18	+	[illegible]								
19	-	LWT						[illegible]	[illegible]	
20	+	LAWHE								
21	-	WLMIN								
22	+	LACOR								
23	+	LAOAT								
24	+	LARIC								
25	+	LARYE								
26	+	[illegible]								
27	+	LACOT								
28	+	LASOY								
29	+	[illegible]	2.170000							
30		LAFRU		[illegible]	[illegible]					
31	+	LAPOT				[illegible]				
32	+	LASWE					[illegible]			
33	+	[illegible]						[illegible]		
34	+	[illegible]								
35	+	LAVEG								[illegible]
36	+	LASOR								
37	+	[illegible]								
38	+	LAHAY								
39	+	LAPAS								
40	+	[illegible]								
41	+	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
42	+	[illegible]	2.170000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
43	+	FERT								
44	+	PEST								
45	+	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
46	+	[illegible]								
47	+	[illegible]								
48	+	[illegible]								
49	+	[illegible]								
50	+	[illegible]								
51	+	[illegible]								
52	+	[illegible]								
53	+	[illegible]								
54	+	[illegible]								
55	+	[illegible]			[illegible]			[illegible]		
56	+	[illegible]			[illegible]			[illegible]		
57	+	[illegible]			[illegible]			[illegible]		
58	+	[illegible]			[illegible]			[illegible]		
59	+	[illegible]			[illegible]			[illegible]		
60	+	[illegible]			[illegible]			[illegible]		
61	+	[illegible]			[illegible]			[illegible]	[illegible]	
62	+	[illegible]			[illegible]			[illegible]	[illegible]	
63	+	[illegible]			[illegible]			[illegible]		
64	+	[illegible]			[illegible]					
65	+	[illegible]			[illegible]					
66	+	[illegible]			[illegible]			[illegible]		
67	+	[illegible]			[illegible]			[illegible]		
68	+	[illegible]			[illegible]			[illegible]	[illegible]	
69	+	[illegible]			[illegible]			[illegible]	[illegible]	
70	+	[illegible]			[illegible]			[illegible]		
71		[illegible]			[illegible]					
72	+	[illegible]			[illegible]			[illegible]		
73	+	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
74	+	[illegible]								
75	+	[illegible]								
76	+	[illegible]								
77	+	[illegible]								
78	+	[illegible]								
79	+	[illegible]								
80	+	[illegible]								[illegible]
81	+	[illegible]		[illegible]						
82		[illegible]								

TABLE A3 (continued)

			129	13[illegible]	131	132	13[illegible]	134	13[illegible]	13[illegible]
			HVE2N	LCO1N	LCO2N	LSG1N	LSG2N	[illegible]	[illegible]	[illegible]
1	+	CALMI	-160.000000							
2	+	HPRO	-6.600000							
3	+	FAT	-1.100000							
4	+	IRON	-0.003900							
5	+	CALC	-0.112000							
6	+	NUTX								
7	+	NUTY								
8	-	HWT	-0.700000							
9	-	FATNA	-1.130000							
10	-	CALMA	-160.000000							
11	+	FUTOT		-1.020000		-0.940000		-0.910000		[illegible]
12	+	FURUM		-1.020000		-0.930000		-0.91[illegible]		[illegible]
13	+	FUHOG		-1.020000		-0.930000		-0.910[illegible]		[illegible]
14	+	FUPO			-0.970000		-0.870000		[illegible]	
15	+	PROTO		-0.063000		-0.091000		-0.084000		[illegible]
16	+	PRORU		-0.063000		-0.091000		-0.084[illegible]		[illegible]
17	+	PROHO		-0.063000		-0.091000		-0.084[illegible]		[illegible]
18	+	PRUPO			-0.780000		0.101000		[illegible]	
19	-	LWT		-0.970000	-0.970000	-0.970000	-0.9[illegible]	-0.94[illegible]	-0.94[illegible]	[illegible]
20	+	LAWHE								
21	-	WCMIN								
22	+	LACOR		0.832000	0.832000					
23	+	LAOAT						1.24[illegible]	1.24[illegible]	
24	+	LARIC								
25	+	LARYE								
26	+	LAPEA								
27	+	LACOT								
28	+	LASOY								
29	+	LAHEA								
30		LAFRU								
31	+	LAPOT								
32	+	LASHE								
33	+	LABEE								
34	+	LACAN								
35	+	LAVEG	0.832000							
36	+	LASOR				1.260000	1.260000			
37	+	LABAR								1.[illegible]
38	+	LAHAY								
39	+	LAPAS								
40	+	LAGRA		0.832000	0.832000	1.260000	1.260000	1.24[illegible]	1.24[illegible]	1.[illegible]
41	+	LATCH	0.832000	0.832000	0.832000	1.260000	1.260000	1.2[illegible]	1.24[illegible]	[illegible]
42	+	LATLA	0.832000	0.832000	0.832000	1.260000	1.260000	1.2[illegible]	1.24[illegible]	1.[illegible]
43	+	FERT								
44	+	PEST								
45	+	PETRO	1.610000	1.610000	1.610000	3.080000	3.080000	1.7[illegible]	1.7[illegible]	2.45[illegible]
46	+	CAFER								
47	+	CAPES								
48	o	SPGRA								
49	+	SPCER								
50	+	SPRIC								
51	+	SPOIL								
52	+	SPBT								
53	o	SPCN								
54	+	SPSOY								
55	+	BE16	0.000359							
56	+	BE24	0.004681							
57	+	BE27	0.002385							
58	+	BE29	0.001012							
59	+	BF31	0.002732							
60	+	BE37	0.010862							
61	+	BE39	0.017057							
62	+	BEMET	0.007084							
63	+	BE65	0.022564							
64	+	BE86	0.159359							
65	+	BF93	0.000273							
66	+	BE94	0.000565							
67	+	BE95	0.000669							
68	+	BF96	0.002359							
69	+	BF97	0.001357							
70	+	BE98	0.000234							
71	+	BE103	0.000005							
72	+	BE107	0.000046							
73	+	LABOR	0.065138	0.002822	0.002822	0.002855	0.002855	0.001234	0.001234	0.004138
74	+	CMILK								
75	+	MAPOR								
76	+	MABEE								
77	+	MAEGG								
78	+	MAPOU								
79	+	MALAM								
80	+	FRVEG								
81	+	FRFRU								
82		GOVT								

TABLE A3 (continued)

			137 CHAIN	138 CHAIN	[illegible] ALFF	[illegible] FOWL	[illegible]	[illegible]	[illegible]	[illegible]
1	+	CALMT								
2	+	[illegible]			-764.[illegible]	655.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	+	FAT			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	+	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	+	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	+	N[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	+	N[illegible]					[illegible]	[illegible]	[illegible]	[illegible]
8	-	HWT			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	-	FATMA								
10	-	CALMA			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	+	FUTIT			-764.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	+	FUNUM		[illegible]	15.4[illegible]			[illegible]	[illegible]	[illegible]
13	+	FUMIS		[illegible]	15.9[illegible]					[illegible]
14	+	FUM[illegible]	-0.456[illegible]					[illegible]	[illegible]	
15	+	PROTO		[illegible]	2.4[illegible]	[illegible]	[illegible]			
16	+	PRTRO		[illegible]	2.4[illegible]			[illegible]	[illegible]	[illegible]
17	+	PROMO								[illegible]
18	+	PROPO	-0.042[illegible]					[illegible]	[illegible]	
19	-	LWT	-0.95[illegible]	[illegible]		[illegible]	[illegible]			
20	+	LAMHE			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	-	HLMEN								
22	+	LACOR								
23	+	LAQAT								
24	+	LAMIC								
25	+	LARYF								
26	+	LAPEA								
27	+	LALGT								
28	+	LASOY								
29	+	LAREA								
30		LAFRU								
31	+	LAPOT								
32	+	LASWE								
33	+	LABEE								
34	+	LACAN								
35	+	LAVEG								
36	+	LASOR								
37	+	LABAR	1.000000							
38	+	LAHAY		0.449000						
39	+	LAPAS								
40	+	LAGRA	1.000000							
41	+	LATCR	1.000000	0.449000						
42	+	LATLA	1.000000	0.449000						
43	+	FERT								
44	+	PEST								
45	+	PETRO	2.450000	1.000000						
46	+	CAFER								
47	+	CAPES								
48	+	SPGRA								
49	+	SPCER								
50	+	SPRIC								
51	+	SPOIL								
52	+	SPBT								
53	+	SPCN								
54	+	SPSOY								
55	+	BE16			-0.040000			[illegible]	[illegible]	[illegible]
56	+	BE24			0.001601		0.001136	0.001376	0.001326	0.001692
57	+	BE27			0.006642		0.004714	[illegible]	0.005502	[illegible]
58	+	BE29			0.003549		0.002547	[illegible]	0.002973	[illegible]
59	+	BE31			0.001863		0.001323	0.001597	0.001527	0.001947
60	+	BE37			0.003746		0.005277	[illegible]	0.006160	[illegible]
61	+	BE39			0.004683		[illegible]	[illegible]	0.003879	[illegible]
62	+	BEMET			0.003574		0.002539	[illegible]	0.002964	[illegible]
63	+	BE65			0.015886		0.011274	0.013159	0.013159	[illegible]
64	+	BE86			0.073391		0.052304	[illegible]	0.060796	[illegible]
65	+	BE93								
66	+	BE94			0.000447		0.000317	[illegible]	0.000370	0.000472
67	+	BE95			0.000549		0.000390	0.000455	0.000455	[illegible]
68	+	BE96			0.000924		0.000658	[illegible]	[illegible]	[illegible]
69	+	BE97			0.007153		0.005076	[illegible]	0.005925	[illegible]
70	+	BE98			0.002878		0.002042	[illegible]	0.002386	[illegible]
71	+	BE103			0.001008		0.000715	[illegible]	0.000835	[illegible]
72	+	BE107			-0.014700					[illegible]
73	+	LABOR	0.003138	0.001168	0.000203		0.000144	0.000169	0.000168	[illegible]
74	+	CMILK			0.072239	0.019000	0.036232	0.057829	[illegible]	
75	+	MAPOR								[illegible]
76	+	MABEE			1.000000			1.000000	0.84[illegible]	
77	+	MAEGG								
78	+	MAPOU				1.000000				
79	+	MALAM					1.000000			
80	+	FRVEG								1.000000
81	+	FRFRU								
82		GOVT								

TABLE A3 (continued)

			145	146	147	148	149
			MILK	BC27F	BC27P	BC31	STGOV
1	•	CALRI	-309.000000				
2	•	HPRO	-15.900000				
3	•	FAT	-17.700000				
4	•	IRON	-0.000300				
5	•	CALC	-0.536000				
6	•	NUTX					
7	•	NUTY					
8	-	NUT	-1.000000				
9	-	FATMA	-17.700000				
10	-	CALMA	-309.000000				
11	•	FUTOT	1.480000				
12	•	FURUR	1.480000				
13	•	FUHOG					
14	•	FUPO					
15	•	PROTO	0.220000				
16	•	PRORU	0.220000				
17	•	PROHO					
18	•	PROPO					
19	-	LWT	5.170000				
20	•	LAMME					
21	-	MLMIN					
22	•	LACOR					
23	•	LADAT					
24	•	LARIC					
25	•	LARYE					
26	•	LAPEA					
27	•	LACOT					
28	•	LASOY					
29	•	LABEA					
30		LAFRU					
31	•	LAPOT					
32	•	LASWE					
33	•	LABEE					
34	•	LACAN					
35	•	LAVEG					
36	•	LASOR					
37	•	LABAR					
38	•	LAHAY					
39	•	LAPAS					
40	•	LAGRA					
41	•	LATCR					
42	•	LATLA					
43	•	FERT		-34.820000			
44	•	PEST			-1000.000000		
45	•	PETRO				-1000.000000	
46	•	CAFER		34.820000			
47	•	CAPES			1.000000		
48	•	SPGRA					
49	•	SPCER					
50	•	SPRIC					
51	•	SPOIL					
52	•	SPBT					
53	•	SPCN					
54	•	SPSOV					
55	•	BE16	0.000170	0.004929	0.004929	0.001361	177.200000
56	•	BE24	0.001861	0.030946	0.030546	0.013104	332.500000
57	•	BE27	0.000981	1.269032	1.269032	0.048372	607.500000
58	•	BE29	0.000191	0.018504	0.018504	0.004516	755.600000
59	•	BE31	0.001084	0.083768	0.083768	1.087687	695.000000
60	•	BE37	0.001169	0.018923	0.018923	0.014395	461.900002
61	•	BE39	0.001234	0.010872	0.010072	0.008104	33.540000
62	•	BEMET	0.002553	0.099299	0.059299	0.351018	2617.200012
63	•	BE65	0.007775	0.080416	0.080416	0.088528	1458.500000
64	•	BE86					
65	•	BE93	0.000083	0.005367	0.005367	0.001632	76.160000
66	•	BE94	0.000106	0.010216	0.010216	0.001935	81.270000
67	•	BE95	0.000162	0.018045	0.018045	0.003325	146.700001
68	•	BE96	0.001268	0.024161	0.024161	0.012166	445.000000
69	•	BE97	0.000490	0.024583	0.024583	0.018868	211.700001
70	•	BE98	0.000176	0.002535	0.002535	0.002411	140.500000
71	•	BE103	0.000002	0.001373	0.001373	0.000059	1.294000
72	•	BE107	0.000023	0.000641	0.000641	0.000186	16.130000
73	•	LABOR	0.013180	0.051858	0.051858	0.040096	8878.000000
74	•	CHILK	1.000000				
75	•	HAPOR					
76	•	HABEE					
77	•	HAEGG					
78	•	HAPOU					
79	•	HALAM					
80	•	PRVEG					
81	•	FRFRU					1.000000
82		GOVT					

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UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)

Research Analysis Corporation
McLean, Virginia 22101

2a. REPORT SECURITY CLASSIFICATION

UNCLASSIFIED

2b. GROUP

3. REPORT TITLE

A MODEL OF TECHNOLOGICAL CAPACITY TO SUPPORT SURVIVORS OF NUCLEAR ATTACK

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Technical paper

5. AUTHOR(S) (First name, middle initial, last name)

Bernard Sobin

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
September 1968	75	29

8a. CONTRACT OR GRANT NO.

DAHC20-67-C-0137

b. PROJECT NO.

OCD Task 3534B

c.

107.101

d.

9a. ORIGINATOR'S REPORT NUMBER(S)

RAC-TP-313

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

This document has been approved for public release and sale; its distribution is unlimited.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

Office of Civil Defense
Washington, D. C.

13. ABSTRACT

The paper presents a linear programming model of production activities of the US economy after nuclear attack. The model has many alternative combinations of agricultural production for meeting specific nutritive element requirements of the population and one production process for each nonagricultural output. The processes for nonagricultural output are those of the 1958 Interindustry Model of the US Office of Business Economics; the agricultural activities draw on many other sources of data. Rows of the model generally state that the cumulative product of variables and their coefficients must be less than or equal to either zero or some stipulated capacity. In the former case the typical row states that inputs required minus production of the item must not be greater than zero. In the latter case the requirements refer to capacities, which cannot be produced in a static model, and total requirements must not exceed the stipulated capacity remaining after the nuclear attack.

DD FORM 1 NOV 65 1473

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
input-output models for US postattack survival						
interindustry models for US postattack survival						
linear programming for US postattack survival						
postattack capacity of						
US agriculture						
US economy						
US transportation						

UNCLASSIFIED

Security Classification