GEM: AN INTERACTIVE SIMULATION MODEL OF THE GLOBAL ECONOMY

O. Helmer
L. Blencke

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PREFACE

One of the aims of the International Institute for Applied Systems Analysis (IIASA) is to develop methods of systems analysis that lend themselves to applications to policy analysis.

Gaming has proved to be an important methodological planning tool in such areas as military and business affairs, but thus far few applications to socioeconomic planning have been attempted. The game described here is a demonstration model, intended to acquaint the reader with the potentialities of this approach as a preanalytical research tool.

This paper was written by Olaf Helmer. The responsibility for the computer program was Lutz Blencke's, who also made a number of important substantive contributions.

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CONTENTS

INTRODUCTION

The model described here, which is named "GEM" (Global Economic Model), is a six-person interactive simulation model (or game) intended to generate intuitive insights into the economic interactions among six world regions over the next 50 years.

Each player is responsible for manipulating the economy of one of these regions. To do so, he has to make resource allocation decisions (between sector inputs, capital investment, investment in R&D, and supplies to consumers and to government); in addition, he may trade commodities with the other five participants and conclude long-term agreements with them concerning trades, loans, investments, and technology transfer.

The six regions, designated by the letters *S, E, C, O, N,* and *D*, which are intended to resemble very roughly six real-world regions obtained by aggregation from the ten regions of the Mesarovic/Pestel model*, may be abstractly characterized as follows:

- *S* A highly developed, centrally planned economy with substantial energy resources
- *E* A highly developed market economy with greatly limited energy resources
- *C* A developing, centrally planned economy with substantial energy resources

*Mesarovic M., and E. Pestel (1974) Mankind at the Turning Point, Second Report to the Club of Rome. New York, Sutton.

O A small developing market economy with very substantial energy resources
N A highly developed market economy with substantial but inadequate energy resources
D A developing economy with underdeveloped energy resources and a rapidly growing population

The real-world regions that these are intended to resemble somewhat are the following: *S*, the Soviet Union and Eastern Europe; *E*, Western Europe, Australia, and Japan; *C*, China; *O*, the member countries of the Organization of the Petroleum Exporting Countries (OPEC); *N*, North America; and *D*, the developing countries (Latin America, most of Africa, and South and Southeast Asia). The economic structure of each of these regions is highly aggregated and is represented in terms of eight economic sectors.

The GEM game is played over a simulated 50-year period, starting with the present. The 50 years are broken up into ten 5-year scenes; each scene represents one move cycle in the game.

PURPOSE

The purpose of such simulation gaming generally is not so much to solve problems directly as it is to lead to a better intuitive understanding of the problem structure and thereby to help the analyst in the development of models that gradually become more and more appropriate for dealing with the real-world problem situation. Thus a simulation game is preanalytic in nature; it is not intended in itself to be either predictive or decisional. An essential part of the routine of playing a simulation game is a constructive debriefing or review session in which the participants are asked to engage (a) in a self-critique ("What would I do differently if I were to play the game again?") and (b) in a critique of the game ("What numerical inputs or what structural components of the game should be altered in order to achieve greater realism?").

As a result of such inquiries, the game is almost invariably changed in some respects between plays. The gaming activity, therefore, should not be viewed as a series of trial runs of a particular simulation model but as a dynamic process in which a more and more realistic conception of the world gradually evolves. A simulation game must have the built-in capability of such self-correction.

In order to accommodate such self-corrective amendments, it is important that the game be designed flexibly. While it is usually easy to change numerical inputs within wide limits, it should also be feasible to alter structural features of the model without extensive reprogramming. This is true of many aspects of the GEM game, making it possible, in particular, to adjust the degree of detail (e.g., the number of players, the number of economic sectors, and the length of the basic time unit) as well as the move sequence within each game cycle (i.e., the order in which economic activity-level decisions, international trade, and output allocations are handled).

The purpose of GEM is to help acquaint IIASA's staff with the potentialities of simulation gaming as a preanalytical research tool. Thus GEM's primary function is that of a demonstration game. It is for this reason that emphasis has been placed not on obtaining the most precise and up-to-date statistics to serve as input data for the six regions considered in GEM but rather on including in the game model as many important factors descriptive of global economic interactions as are compatible with the requirement of keeping the game simple enough to be played easily. GEM in its present form, therefore, should definitely be thought of as a "Mark 1" version. The absence of precision in the initial choice of numerical inputs – if this is considered a defect – can be easily remedied later by substituting more precise data when these become available. With regard to selecting factors for inclusion in the model, special attention was paid to IIASA's particular reas of interest, such as the world food and energy situations.

MOVE SEQUENCE

The GEM game is played in ten move cycles, called "scenes," each simulating 5 years of real time. The record of a particular play of GEM is a scenario, consisting in scene-by-scene descriptions of decisions made by the players as well as of event occurrences (such as technological breakthroughs or discoveries of new basic-resource reserves) and of notable changes in trend values (such as capital investment or labor unrest). The move structure of each scene is shown in Figure 1.

Before explaining in greater detail the elements contained in Figure 1 and particularly the players' move options, it is necessary to describe the basic structure of the underlying economic model. However, there is one important feature of the game that deserves to be pointed out first. As is evident in Figure 1, the model contains certain stochastic elements. Some of these reflect influences entirely exogenous to the model, such as those controlling the weather and the growth of population. Others, such as

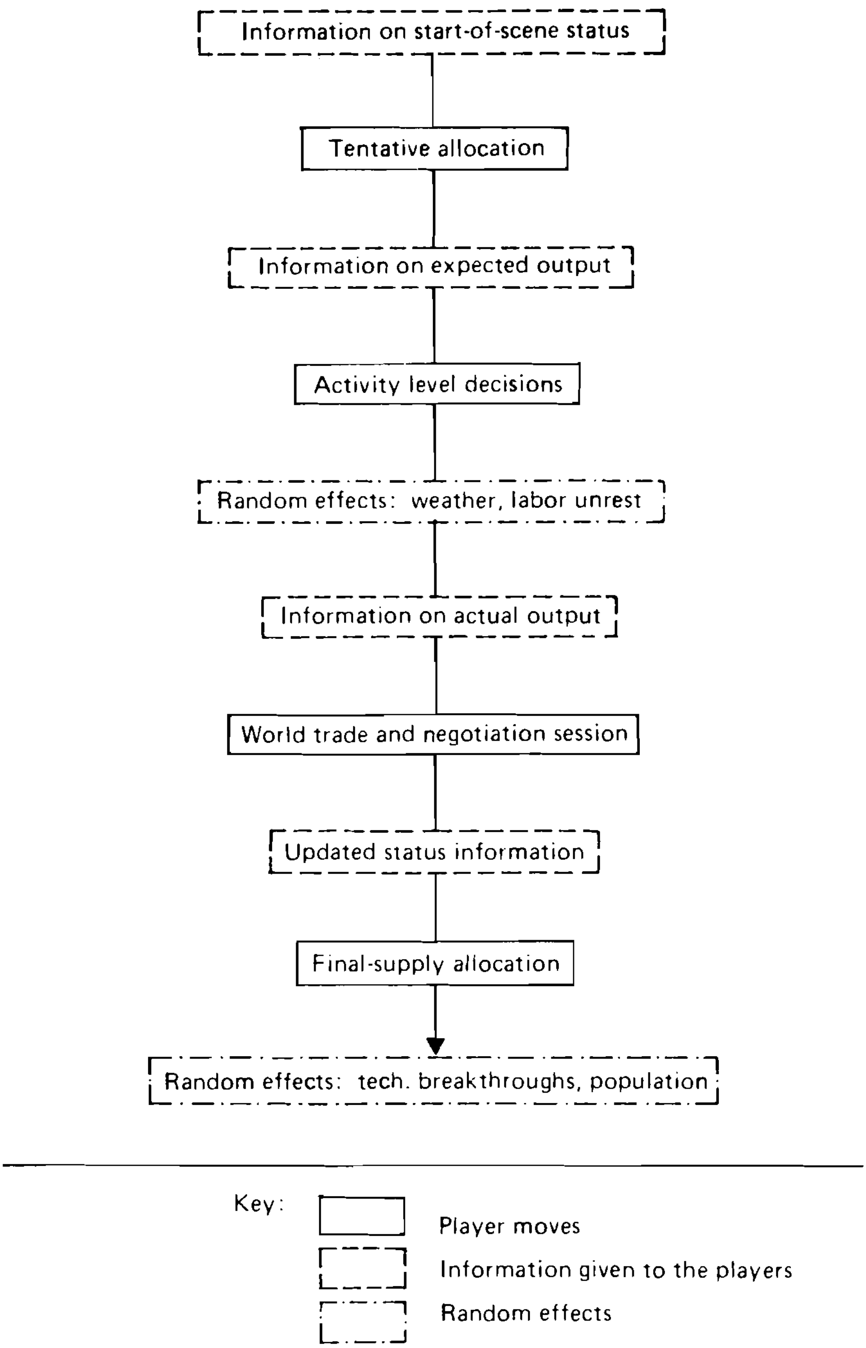

FIGURE 1 Move structure of each scene.

technological breakthroughs or the amount of labor unrest, are endogenous in the sense that, while they are the result of random (i.e., Monte Carlo) decisions, their probabilities of occurrence can be affected by player actions. The effect of the presence of these stochastic features is that the players have to plan in the face of some uncertainty as to the results of their decisions. In this respect the model differs markedly from standard econometric models, in which economic output is determined solely by input allocations – and it is hoped that it differs in the direction of realism.

THE ECONOMIC SECTORS

The eight economic sectors, in terms of which the economy of each of GEM's six regions is described, are as follows:

1 Mining (other than fuel)
2 Intermediate products
3 Durable goods
4 Consumption goods (other than food)
5 Food
6 Fuels
7 Electric energy
8 Services

The singling out of food as a separate sector and the decision to have energy represented by two sectors (6 and 7) reflect the special importance attached to long-range planning in these areas at IIASA and elsewhere.

To express input/output transactions among the sectors of the economy, it is convenient – and, in view of the high degree of aggregation, virtually mandatory – to use monetary units in order to be able to add together otherwise incommensurable quantities. Of course, the production process requires certain physical quantities as inputs to obtain a specific physical output, and the monetary value of these inputs and outputs may change as prices fluctuate. A simple way to deal with this situation is to choose a monetary unit and then to define one physical unit of the output of Sector i as that quantity of the ith commodity whose price, at the outset of the game, is one monetary unit. As the monetary unit we choose \$1B (one billion dollars).

The operation of the economy is described in terms of an input/output matrix that, for the purposes of GEM plays, can be presented in the format shown in Figure 2. The standard format for an input/output

		Into sector								Total req'd. inputs	Net product (= output − req'd. inputs)	Old inventory	Net imports	Available for final supply	Consumption	Government	Hard capital	Soft capital	New inventory
		1	2	3	4	5	6	7	8										
Input from sector	1																		
	2																		
	3																		
	4																		
	5																		
	6																		
	7																		
	8																		
Cost of inputs																			
Value added																			
Value of output																			

FIGURE 2 Input/output matrix of the operation of the economy.

matrix is shown in the left-hand side of the figure. This side of the figure can be filled in either with technical coefficients or with actual flow coefficients. The technical coefficients indicate the physical quantity produced by the sector on the left that has to flow into the sector listed above in order to produce one physical unit of output in that sector. The actual flow coefficients are expressed in monetary units (which – it should be remembered – are initially equal to physical units). When actual flow coefficients are used, the matrix provides an accounting of actual inputs and outputs and of the resultant surplus available for final supplies (i.e., each amount entered in the "available for final supply" column is the sum of the three quantities listed in the columns to the left as well as equal to the sum of the five final-supply items listed in the columns to the right).

In order to change from technical coefficients to monetary flow coefficients, it is necessary to multiply the column vector of technical coefficients corresponding to the ith sector with the activity level of that sector and then to form the inner product with the vector of current prices.

In applications to the real world, an input/output matrix can be interpreted as representing either the rates of flow at a given time or the average rate of flow over a given period (such as a year). In the context of GEM, we shall, for game-playing purposes, maintain the fiction that the economy of a region operates in two successive stages. In Stage I, the activity levels of the industrial sectors are chosen by the player directing that region, the required inputs for these activity levels are calculated, and the net product (i.e., the total output minus the required intermediate inputs) is determined. This, together with existing inventories and net additions derived from imports, constitutes the resources available to satisfy final demand. Given this information, the player, in Stage II, decides how to allocate these supplies between consumers, government, inventories, and capital investment (both "hard" and "soft"). Hard-capital investment consists in the expansion of production facilities, using existing technologies. Soft-capital investment represents R&D effort; it consists in promoting certain technological breakthroughs by attempting to enhance their probability of occurrence.

It should be noted that the options available to a player in both Stages I and II are subject to certain obvious absolute constraints. The activity levels chosen in Stage I are constrained by (a) the capacities of the sectors, (b) the total amount of effective labor available, and (c) the requirement that net production plus inventories must be nonnegative. In addition, in the special cases of Sectors 1 and 6, there are limits on known resource deposits, and production may not exceed the extraction of such known deposits. The allocation made in Stage II is subject to the constraints that final supplies must be nonnegative and that the final supplies must add up to the total available for this purpose.

In playing GEM, the options available to a player, as well as any constraints on his allocations, are clearly displayed to him. The constraints include the absolute ones just enumerated as well as "advisory constraints." The advisory constraints inform the player about (a) the amount of hard-capital investment required to offset capital depreciation, (b) the level of supplies (food and other commodities) to consumer households necessary to prevent death from starvation and civil unrest, and (c) the level of supplies to government necessary to prevent deterioration of government services (see below).

In standard econometric models the output of the economic sectors is completely determined once their activity levels have been set (provided, of course, that proper feasibility constraints have been met); this is not so in GEM, since there are two built-in random elements affecting the output. One is the uncertainty of the amount of labor unrest, which affects the size of the effective labor force (see the following section) and thereby indirectly affects the output of each sector. The other is the regional harvest conditions (weather, crop and cattle diseases, pests, and so on) that are simulated as follows: for each region and each scene, a random deviate δ is drawn from a normal distribution with quartiles at ± 0.05, and the nominal food output for that region and scene is then multiplied by $1 + \delta$.

POPULATION AND LABOR

Population, and labor in particular, is measured in units of one million persons. For each region, a fixed population growth rate has been assumed:

Region	S	E	C	O	N	D
Population growth rate per scene (in percent)	4	2.5	7.5	10	4	10

The population, P, if provided adequately with food, thus grows exponentially, except that the increment, ΔP, from Scene j to Scene $j + 1$ is replaced by $\Delta P + \delta$, where δ is a random deviate drawn from a normal distribution with quartiles at $\pm\Delta P/4$.

If the annual food supply (measured in monetary units) per population unit is f, then the predicted population declines from P to

$$P' = \frac{f^2}{0.0003 + f^2} P.$$

(For example, if the annual per capita food supply is worth $100, then the food supply per population unit is valued at

$$\frac{100 \times 10^6}{10^9},$$

or 0.1 monetary units. Hence $f = 0.1$ and $P' = 0.971 P$. (In other words, at this level of food supply, the population, over a 5-year scene, is reduced by about 3 percent.)

The total labor force, *TLF*, for simplicity, is set equal to 0.45 P for all regions.

The total labor force may be reduced in its effectiveness by labor unrest. If the amount of labor unrest is u, where $0 \leqslant u \leqslant 1$, then the effective labor force is

$$ELF = \frac{1}{1 + 4u^2} TLF.$$

(Thus, in the worst case, when $u = 1$, *ELF* is only 20 percent of *TLF*.)

The quantity u is a function of random fluctuations as well as of the proportionate scene-by-scene rate of increase, d, in per capita supplies to households. If $Cons_i$ is the personal consumption in Scene i (i.e., the monetary value of supplies allocated to households), Pop_i is the population in Scene i, and Q_i equals $Cons_i/Pop_i$, then

$$d = \frac{Q_{i+1} - Q_i}{Q_i}.$$

The allocation of supplies to households (described by a vector H) is a little more complex than the allocation of government supplies. First of all, a food allotment, H_5, is chosen. The remaining components of H essentially are to be in proportion to a given profile. However, there is some built-in flexibility, in that up to 20 percent of each of the components H_3, H_4, H_8 may be substituted by the others, and similarly up to 20 percent of the components H_6 and H_7 may be substituted by the other.

For u to remain constant, d has to equal some minimal rate of increments in total per capita supplies to households, which we simply assume here to be 5 percent per scene, or $d = 0.05$. If u is the labor unrest in one scene and u' that in the next scene, we set

$$u' = f(u, d),$$

where, in addition to $f(u, 0.05) = u$, we assume that $f(u, -0.5) = 1$ and $f(u, 1) = 0$ (i.e., halving per capita supplies causes labor unrest to rise to its maximal value of 1, whereas doubling supplies quells such unrest altogether). A relatively simple such function, which is adopted here, is

$$u' = \frac{22(1-d)u}{3(1-20d) + 38d + 19} \; .$$

Superimposed upon this function, we assume a random distribution as follows: let δ be a random deviate drawn from a normal distribution with quartiles at ± 0.05; then replace u' by

$$min[1, max(0, u' + \delta)] \, .$$

(This simply adds δ to u', except that cutoff points are introduced at 0 and 1.)

A fraction, s, of the effective labor force is skilled; the remainder, $1 - s$, is unskilled. The quantity $\sqrt{s}$ is called the "labor productivity multiplier," and the "available skilled-labor equivalent" is defined as follows:

$$SLE = \sqrt{s} \cdot ELF.$$

Note that if $s = 0$, then $SLE = 0$; if $s = 1$, then $SLE = ELF$. Note also that the marginal effect of an increased skill fraction is a decreasing function. Skilled-labor equivalents are treated as being freely interchangeable.

The skill level of the labor force is assumed to decline 10 percent per scene unless this trend is countered by governmental educational efforts, as evidenced by the government's efficiency level (see the next section). Note that labor productivity, which may be defined as GNP/TLF, is equal to $\sqrt{s} \cdot GNP/(1 + 4u^2)SLE$.

The reader may wonder about the particular functional forms used for various quantities in this section (and the same applies to those used in the next three sections). The principle employed throughout has been to select a relatively simple functional form that displays the properties intuitively appropriate to the case. It was believed that, especially for the purposes of this demonstration game, such a choice was justified on the form would hardly be noticeable in terms of play results. Moreover, should one later believe that it would be more realistic to replace a given function with a different function, such a substitution, as pointed out earlier, can be effected with ease.

GOVERNMENT

The government requires final supplies from Sectors 3, 4, 6, 7, and 8 in fixed proportion. The activity level of this supply vector determines government efficiency g. The government efficiency, in turn, affects (a) the skill level of the labor force, (b) the capital coefficients (both hard- and soft-capital), (c) the rates of inventory depreciation, and (d) the quality of information on commodity quantities available to the player for planning purposes.

We assume that g is measured on a scale from 0 to 1 and that it is a function solely of the per capita activity level x of the vector specifying supplies to the government. Let $x = a$ be that level of per capita supplies at which the government operates at efficiency $g = 0.9$. Then we set

$$g = \frac{9x^2}{a^2 + 9x^2},$$

which has the effect that doubling the supplies to government raises government efficiency from 0.9 to 0.97, whereas halving them lowers it from 0.9 to 0.69. (The quantity a as well as the components of the governmental supply vector is prescribed individually for each region.)

We turn next to the determination of the quantities affected by the level g of government efficiency.

Skill Level

The skill level s deteriorates at a rate of 10 percent per scene if no educational provisions are made. The amount of such education is assumed to be implicit in the efficiency level of the government. In order to maintain a skill level s (i.e., just to counteract the 10 percent deterioration), it is assumed that an efficiency $g = s$ is required. Below this efficiency, s declines; above it, s increases. The formula used is as follows:

$$s_{i+1} = \begin{cases} 0.9s_i + 0.1g_{i+1} & \text{if } g_{i+1} \leqslant s_i \\ [1 + \dfrac{(g_{i+1} - s_i)^2}{1 - s_i}]s_i & \text{if } g_{i+1} > s_i \end{cases}$$

where the indices i and $i + 1$ refer to Scenes i and $i + 1$. For total government inefficiency, $g_{i+1} = 0$, this formula yields $s_{i+1} = 0.9s_i$; for $g_{i+1} = s_i$ it yields $s_{i+1} = s_i$ as required; for maximal government efficiency, $g_{i+1} = 1$, it yields $s_{i+1} = s_i + s_i \cdot (1 - s_i)$ (that is, it raises the value of s from s_i by the fraction s_i toward its theoretical maximum value of 1).

Capital Coefficients

The vector of hard-capital coefficients, which specifies the capital inputs that are required to increase the capacity of a sector by one unit, suffers a proportional increase if government is inefficient. Specifically, if under ideal conditions ($g = 1$) a vector of hard-capital coefficients is C, it is replaced by

$$C/(2g - g^2)$$

if efficiency is g. [Note that $0 \leqslant 2g - g^2 \leqslant 1$ since $2g - g^2 = 1 - (1 - g)^2$.] The same rule applies in the case of a vector of soft-capital coefficients [which specifies the capital inputs required to raise the probability of a technological breakthrough from p to $(p + 1)/2$].

Inventory Depreciation

Inventories in Sectors 2 to 5 (under the ideal conditions of $g = 1$) are assumed to deteriorate at the following rates per scene:

Sector	2, 3, 4	5
Depreciation	0.10	0.25

(The depreciation rate in Sectors 1 and 6 is 0, and the term is not applicable to Sectors 7 and 8.) In general, these depreciation rates are multiplied by $2 - g$.

Quality of Information

During Stage I of operating the economy of his region, a player receives information about the resources that he may expect to have available to satisfy final demand, based on his tentative choice of activity levels; and the resources that he in fact has available for this purpose, following his definite choice of activity levels. There is uncertainty in any normal economic planning process; in order to simulate the heightened uncertainty due to governmental inefficiency, the two types of information just mentioned will be modified slightly. In fact, if the final output of a sector is x, the information given to the player is $x + \delta$, where δ is a random deviate drawn from a normal distribution with quartiles at $\pm 0.2(1 - g)x$. Note that this deviation is 0 for $g = 1$ and 20 percent for $g = 0$.

In applying this rule, the same deviate is used for the same output component, regardless of whether this information pertains to a tentative (expected) output or the output resulting from the player's definite choice of activity levels. (This is done to make it impossible for the player to increase the accuracy of his information by repeated sampling.)

CAPITAL INVESTMENT

As previously stated, there are two kinds of capital investment, "hard" and "soft."

Hard-capital investment requires durable goods (Sector 3) and services (Sector 8) as inputs. The capital coefficients c_3 and c_8 which specify the amounts of these inputs required to expand capacity by one unit (one unit being the amount of capacity needed to produce one unit of output), of course depend on the sector which is being expanded and on the available technology; however, it is assumed throughout that $c_8 = c_3/4$. (If several technologies are available, it is assumed that expansion utilizes the most recently acquired technology, unless the contrary is specified by the player.) All production capacity is assumed to depreciate at the rate of 25 percent per scene.

Soft-capital investment, too, requires inputs from Sectors 3 and 8 only. The soft-capital coefficients d_3 and d_8 specify the amounts of these inputs required to enhance the corresponding probability by one unit; the meaning of a "unit enhancement" is explained on page 16. In this case, too, for simplicity, a fixed ratio between d_3 and d_8 is stipulated; in fact, we set $d_8 = d_3$, with the value of d_3 depending on the technological breakthrough sought.

The details of handling technological advances and their consequences are the subject of the following two sections.

TECHNOLOGICAL BREAKTHROUGHS

It is assumed that each sector's production process is capable, in principle, of technical improvement resulting in a more economical method of production. Such an improvement is the consequence of a technological breakthrough, which is treated as an event having, for each scene, a certain probability of occurrence that can be estimated and also can be influenced by investment in appropriate R&D ("soft-capital investment").

A technological breakthrough in Sector i causes the technical-coefficient vector for Sector i,

$$(x_{1i}, x_{2i}, \ldots, x_{8i}, L_i)$$

(where "L" stands for "labor"), to be changed to a different vector:

$$(x'_{1i}, x'_{2i}, \ldots, x'_{8i}, L'_i).$$

Also, while the resource cost of a capacity unit for Sector i has been, say, c_3, $c_3/4$ (for Sectors 3 and 8 respectively), the new resource costs will be some other quantities c'_3, $c'_3/4$. Once a technological breakthrough in a sector has occurred, the player's further investment in capital-stock expansion in that sector, including the replacement of capacity depreciation, is automatically assumed to utilize the most recently acquired technology (unless the contrary is specified). As a result, the sector operates in a mixed mode, using partly the obsolete and partly the novel technology.

Specifically, the potential technological breakthroughs included in GEM are these: first of all, for each sector S_i ($i = 1,2,\ldots,8$), there are what may be considered normal technical-improvement breakthroughs, which for simplicity we standardize as follows:

TB_i = a technological improvement in Sector i, having the effect of reducing the last four technical coefficients from x_{6i}, x_{7i}, x_{8i}, L_i to 90 percent of their values, that is, to $0.9x_{6i}$, $0.9x_{7i}$, $0.9x_{8i}$, $0.9L_i$.

Each of these technological breakthroughs may occur repeatedly (but only once in each scene). Aside from these eight, there are six other potential breakthroughs, three of which are also production-process breakthroughs (but going beyond normal technical improvements). The remaining three are other developments improving the state of the economy. The index in each case refers to the industrial sector to which the breakthrough pertains:

TB_1' = the detection of hitherto unknown mineral reserves within the region, increasing the amount of known reserves by 100 $(r + 1)$ units, where r is a random integer drawn from a uniform distribution over the set from 0 to 9

TB_5' = the feasibility of large-scale nonagricultural food production

TB_5'' = the feasibility of controlling the weather, resulting in an improvement in average harvest conditions that cause the harvest to be increased by 1 percent in the following scene, by 2 percent in the scene thereafter, and so on, over what it would have been otherwise

TB_6' = the detection of hitherto unknown fuel reserves within the region, increasing the amount of known reserves by $100(r + 1)$ units, where r is a random integer drawn from a uniform distribution over the set from 0 to 9

TB_7' = the feasibility of producing electric energy from solar power plants

TB_7'' = the feasibility of producing electric energy from fusion power plants

Of these, TB_5', TB_7', and TB_7'' are production innovations. None of these are repeatable; however, any normal improvement in Sectors 5 or 7 (i.e., the occurrence of TB_5 or TB_7) is considered to apply to these new technologies as well, reducing their last four technical coefficients by 10 percent. Of the other three events, TB_1' and TB_6' are repeatable, while TB_5'' is not.

FORECASTS AND ENHANCEMENT OF TECHNOLOGICAL BREAKTHROUGHS

Plays of GEM are based on probabilistic forecasts regarding the occurrence of technological breakthroughs. For the time being, it is simply assumed that in the highly developed regions S, E, and N the basic probability of occurrence per scene is 0.10 for each TB_i, where "basic" refers to the case where there is no additional enhancement through soft-capital investment (see below). (These probability assumptions, like many other GEM parameters, can be easily modified later if information is available that would lead to more realistic values.) For the remaining breakthroughs, the scene probabilities are also assumed to be constant, as follows:

TB_1'	TB_5'	TB_5''	TB_6'	TB_7'	TB_7''
0.05	0.02	0.02	0.05	0.02	0.01

Note that for the nonrepeatable events (TB_5', TB_5'', TB_7', TB_7'') these scene probabilities are conditional on the events not having occurred in an earlier scene; once they have occurred, their subsequent scene probabilities will be zero.

In the developing regions C and O all of the above scene probabilities are replaced by one-half their values, and in the sixth region D they are replaced by one-quarter their values.

If the manager of a region wishes to enhance the probability of a technological breakthrough through soft-capital investment, he can do so by allocating equal quantities of durable goods (Sector 3) and services (Sector 8) to the region.

If the probability for the next scene is p, then raising it halfway toward its theoretical maximum value of 1, i.e. replacing p by

$$p + \frac{1}{2}(1 - p),$$

is referred to as a "unit enhancement." The cost (in resources from Sectors 3 and 8) of achieving a unit enhancement will be stated as

$$d_3 = d_8 = c,$$

where the value of c depends on the particular breakthrough being promoted:

Breakthrough	TB_i	TB_1'	TB_5'	TB_6''	TB_7'	TB_7''
Unit enhancement cost c	0.3	0.5	2.0	0.5	2.0	5.0

If $k \cdot c$ is allocated to enhancing the probability of the breakthrough (where $k > 0$), the resulting enhancement consists in replacing p by

$$p + \left[1 - \left(\frac{1}{2}\right)^k\right](1 - p).$$

Here k is called the "degree of enhancement."

If, as a result of an enhancement, the breakthrough still does not occur in the next scene, the effort is not assumed to have been totally wasted; as in the real world, some of the effort (in the case of GEM, one-half) carries over to the following scene. That is, if $k \cdot c$ is invested in Scene i, the effect in Scene $i + 2$ is as though $k \cdot c/2$ had been invested in Scene $i + 1$; similarly, the effect in Scene $i + 3$ is as though $k\ c/4$ had been invested in Scene $i + 2$; and so on.

Note that technological breakthroughs are region-specific. However, once a breakthrough has taken place somewhere, all scene probabilities related to that breakthrough in other regions are enhanced by one unit in subsequent scenes [that is, p is raised to $(p + 1)/2$]. Moreover, a new technology can be transferred to another region if the donor contributes the service portion of the required capital investment during the first scene when such investment is undertaken. The minimal level of investment, for this purpose, is the investment required for one capacity unit.

CROSS IMPACTS

Technological advances do not occur in isolation from one another. That is to say, the occurrence of one may influence the subsequent probability of occurrence of others. These mutual effects are referred to as "cross impacts." For instance, if there are two rival breakthroughs, such as TB_5 and TB_5', a player, once he has achieved one of these, may well decide to allocate fewer resources to the other, thereby reducing its probability of occurrence. Conversely, one breakthrough may technically facilitate another and thus raise its probability of occurrence; for instance, an advance in production technology in Sector 3 (e.g., TB_3) may thus trigger a similar advance in Sector 4 (i.e., TB_4).

To facilitate sales during the formal trading session, each player is provided with a small amount of international currency (generally equaling about 2 percent of his region's initial GNP, except for Region O, where it is substantially higher). It is expected that the players will balance their imports and exports sufficiently to stay within these cash flow limitations. If they cannot do so, they will have to rely on negotiated loans or gifts from other players.

A GEM scene covers 5 years, but since it is customary to state GNP and other economic indicators in annual figures, it is more convenient for the players if scene statistics in GEM, such as sectoral inputs and production, GNP, final supplies, and trades, are expressed in annual amounts. Thus, if Region X is said to have a GNP of \$800B in Scene i, this should be interpreted to mean that the average GNP during the 5 years covered by Scene i is \$800B. Similarly, a trade agreement in a given scene resulting, say, in the sale of 20 units of durable goods by X to Y is interpreted as a sale of 20 such units in each of the 5 years of that scene.

All trades involve an expenditure in services (reflecting the cost of transportation, finance, and so on). In GEM both buyer and seller are assessed 0.025 unit of services for each commodity unit traded.

The formal trading session proceeds as follows: for each commodity (1 through 6), the latest world price p_1 is announced (at the start of the game it is 1.00 for each commodity), and the players are invited to state their bids, i.e., the quantities of each of Commodities 1 to 6 they wish to sell (supply) or buy (demand). If, for a given commodity, the total supply and demand are s_1 and d_1, respectively, a second price

$$p_2 = \frac{\max(d_1, s_1/2)}{\max(s_1, d_1/2)} \cdot p_1$$

is announced. (Note that this formula implies that $p_1/2 \leqslant p_2 \leqslant 2p_1$.) New bids are then solicited. If $p_2 > p_1$, it is usually, but not necessarily, the case that, for the new total supplies and demands we have $s_2 > s_1$ and $d_2 < d_1$, and it may indeed happen that a "crossover" occurs as shown in Figure 3. The same is true for $p_2 < p_1$, with the s- and d-inequalities reversed.

If, indeed, a crossover occurs, the next price, p_3 (corresponding to the crossover point), is computed by the formula

$$p_3 = p_1 + (p_2 - p_1)\frac{d_1 - s_1}{d_1 - s_1 + s_2 - d_2}.$$

(The case $p_2 = p_1$, incidentally, is counted as a crossover, and in this case it is seen that $p_3 = p_1$.)

If no crossover occurs, the next price is computed as in the first step, except that the price is constrained by the original price interval:

$$\frac{1}{2}p_1 \leqslant p_3 \leqslant 2p_1.$$

This procedure of computing new prices and obtaining new bids is iterated several times, subject, however, to these additional constraints: (a) if the successive prices for a commodity are $p_1, p_2, p_3, \ldots$, and the final price is p^*, then $p^* = p_j$ where $j \leqslant 5$ (in other words, there are at most four

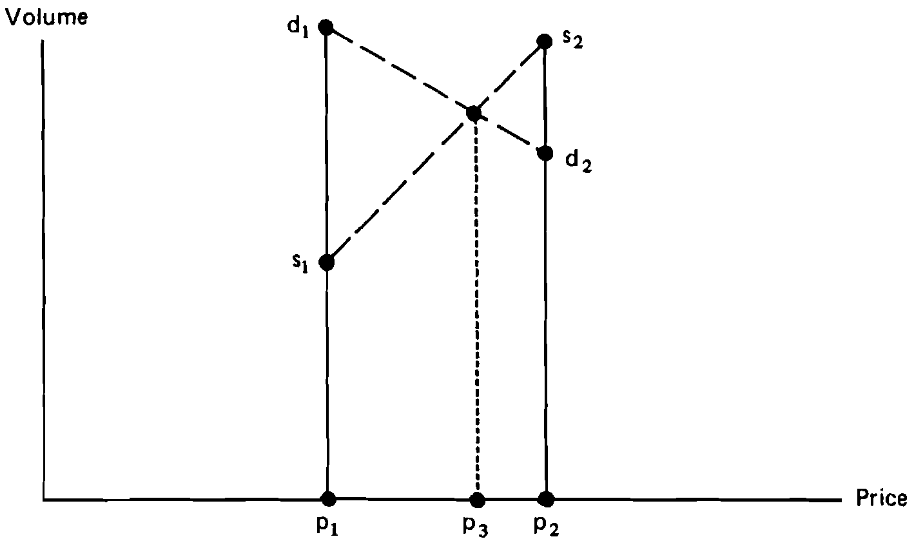

FIGURE 3 A supply and demand crossover.

iterations); (b) the process continues at most until, for each commodity, a crossover has occurred at some time; and (c) the bounds of the price interval, which at first are $p_1/2$ and $2p_1$, shrink with each iteration. These shrink as follows: a price p_i, in the next iteration, becomes a new lower (or upper) bound if the price movement is in an upward (or downward) direction.

Once the final prices p_j have been reached, they are announced to the players, who then place their final bids at these prices. For each commodity, the total volume traded is the smaller of the quantities s_j and d_j, and allocations between several buyers or several sellers are in proportion to their bids.

It should be noted that the above procedure for arriving at updated world prices lends itself to exploitation by a wily player, who may open the bidding with a first bid designed merely to drive the price in a direction more favorable to himself. Such behavior should be discouraged by properly instructing the players. In fact, throughout the play of GEM, a player should not attempt to "beat the rules" (as he might if this were a parlor game) but to use whatever expertise and insight he can bring to bear upon the play of the game to simulate reality as closely as his ability permits. The purpose, after all, of playing a game such as GEM should not be to "win" but to use the process of man/machine collaboration as a means of gradually producing an increasingly realistic model of real-world interactions.

DUMMY PLAYERS

Provision has been made to carry out plays of GEM when there are fewer than six players by automating the actions pertaining to one or more of the regions. This is done by prescribing specific policies to be followed by such "dummy players," as described below.

The advantage of this provision is not only to accommodate groups of fewer than six participants, but also to offer the important possibility of systematically exploring the relative value of preset policies by repeatedly exposing them to the vicissitudes of random events and interventions by opposing players.

For this purpose we define the choice of a "policy" as the assignment of importance ratings, as follows:

$\alpha_1, \alpha_2, \ldots, \alpha_8$ to the industrial sectors
$\beta_1, \beta_2, \beta_3$ to the three final-demand sectors: households, government, and capital investment

These ratings are to be integers from 1 to 4, where

1 indicates "no importance"
2 indicates "slight importance"
3 indicates "moderate importance"
4 indicates "great importance"

We further define a "maintenance operation" as consisting in running the economy in such a way that

- The per capita food supply f remains at its present level
- The government efficiency g remains at its present level
- The capacities of the eight industrial sectors remain at their present levels
- Depreciated inventory is replaced
- The level of supplies to households rises at the rate of 5 percent per scene (which prevents labor unrest from increasing)

A "strategy" for implementing a given policy must specify the actions, normally decided on by a player, to be taken with regard to the choice of activity levels, trade with other regions, and the allocation of final supplies. The specifications are as follows:

Choice of activity levels:

1. Let y be the final-demand vector that has to be met to achieve a maintenance operation; then the corresponding activity-level vector is

$$x = (I - A)^{-1} y,$$

where I is the identity matrix.
2. If any component of x exceeds the available capacity, that component should be reduced accordingly.
3. If the vector thus reduced still cannot be implemented because of excessive demands on resource inventories or labor, then the components x_i of x are reduced by amounts proportional to $5 - x_i$ until the existing resource and labor constraints are satisfied.
4. If implementation of the activity-level vector x would leave some excess resources as well as labor, then the components x_i of x are increased, within capacity limitations, by amounts proportional to x_i until at least one of the excess resources or the excess labor is used up.

Trade with other regions:

1. No contracts are made.
2. The quantities of commodities that the dummy region would want to supply to or demand from the world market are determined as follows: Let

I = current inventory (i.e., the inventory at the beginning of the scene, plus net output)
M = vector of supplies required to carry out the maintenance operation
F^+ = vector composed of
β_1 units of household supplies
β_2 units of government supplies
β_3 units of capital investment
F^- = vector composed of
$5 - \beta_1$ units of household supplies
$5 - \beta_2$ units of government supplies
$5 - \beta_3$ units of capital investment

Here, in allocating the components H_i of the household-supply vector, we make use of the flexibility stipulated earlier:

H_3 is replaced by $H'_3 = H_3 - \min(0.2H_3, 0.2H_8)$,
H_4 is replaced by $H'_4 = H_4 - \min(0.2H_4, \max[0, 0.2(H_8 - H_3)])$,
H_6 is replaced by $H'_6 = H_6 - \min(0.2H_6, 0.2H_7)$,
H_7 is replaced by $H'_7 = H_7 + \min(0.2H_6, 0.2H_7)$,
H_8 is replaced by $H'_8 = H_8 + \min(0.2H_3, 0.2H_8)$
$+ \min(0.2H_4, \max[0, 0.2(H_8 - H_3)])$.

We now form the vector

$$Y = \begin{cases} I - M - \gamma \cdot F^+ & \text{if } \gamma \geqslant 0 \\ I - M - \gamma \cdot F^- & \text{if } \gamma < 0 \end{cases}$$

where γ is a parameter yet to be chosen. The positive components of Y represent the surpluses, and the negative components represent the deficits associated with providing final supplies at a level γ above that required for maintenance. Now choose for γ the largest value (positive or negative) for which $Y_7 \geqslant 0$ and $Y_8 \geqslant 0$, $V(Y_1) + V(Y_2) + \ldots + V(Y_6) = 0$, where $V(Y_i)$ is the value of Y_i at its current price. The positive components among Y_1, Y_2, ..., Y_6 of the resulting vector Y will be the quantities desired to be supplied to the world market, while the negative components among Y_1, Y_2, ..., Y_6 represent the quantities desired to be purchased from the world market.

3. The quantities of commodities to be offered to or demanded from the world market, as determined under (2), apply to current world prices. As these prices are changed during the trading session, the quantities offered or demanded should be changed by percentages equal to the percentage changes in price, the sign being the same for sales offers, opposite for purchase demands. (For example, if the current world price of a commodity was 1.05 and is changed to 1.06 – an increase of 0.95 percent – then an offer to sell, say, 20 units of that commodity would be increased by 0.95 percent to 20.19.) In any of these transactions the quantity offered is constrained by the total amount on hand.

Allocation of final supplies:

To satisfy final demand, the following supply dispositions are made.

1. M is used to supply the maintenance operation.
2. The largest value of γ is chosen for which $M + \gamma \cdot F^{sgn\gamma} \leqslant I$, where I is the new inventory (after completion of trades) and $sgn\gamma$ denotes the sign of γ (i.e., + or −); then, if $\gamma \geqslant 0$, $\gamma \cdot F$ is used to supply $\gamma\beta_1$ units of additional household supplies, $\gamma\beta_2$ units of additional government supplies, and $\gamma\beta_3$ units of capital investment, while if $\gamma < 0$, household supplies required by the maintenance operation are diminished by $\gamma \cdot (5 - \beta_1)$, government supplies by $\gamma \cdot (5 - \beta_2)$, and capital investment by $\gamma \cdot (5 - \beta_3)$ (subject, of course, to their remaining nonnegative). Here, in the case of $\gamma > 0$, of each unit of extra capital investment, 90 percent is to go into hard-capital and 10 percent into soft-capital investment. Thus, the distribution of Commodities 3 and 8 allocated to extra capital investment is as shown in Figure 4. The hard-capital investment portion is distributed over Sectors 1 to 8 in the ratio $\alpha_1 : \alpha_2 : \ldots : \alpha_8$. The soft-capital investment portion is devoted to promoting a breakthrough (or breakthroughs) in the sector (or sectors) S_i for which $\alpha_i = \max(\alpha_1, \ldots, \alpha_8)$, to be split equally when there are several candidates.

It should be mentioned that the above provisions for automating the operation of a GEM region can also be invoked if a player wishes to have the information about the course of action that would be prescribed by the automated pursuit of a set policy, or if, after participation in several rounds, he wishes to relinquish further active participation in favor of merely setting a policy and turning over the further management of his region to automatic control.

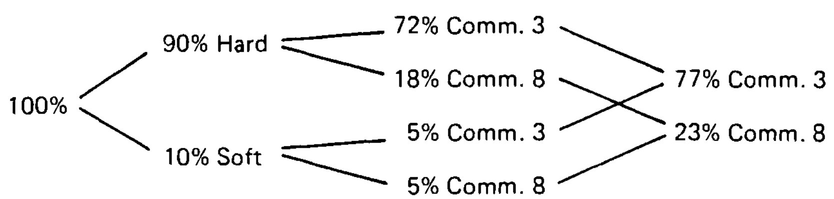

FIGURE 4 Distribution of Commodities 3 and 8 allocated to extra capital investment.

AN EXAMPLE OF A GEM PLAY

To convey a clearer idea of how an actual play of GEM would proceed, a sample set of printouts is reproduced in the Appendix.

Appendix

SAMPLE OF A GEM GAME

LIST OF ABBREVIATIONS

CI	capital investment
Cons	consumption
Dur	durable goods
Elec	electric energy
GV	government
HH	household
Int	intermediate products
inv	investment
Min	mining
prod	production
Serv	services

```
% gemgo

 region   S     data-file ready for playing
 region   E     data-file ready for playing
 region   C     data-file ready for playing
 region   O     data-file ready for playing
 region   N     data-file ready for playing
 region   D     data-file ready for playing

 the current world prices for tradable commodities are
   Min       Int       Dur       Cons      Food      Fuel
   1.00      1.00      1.00      1.00      1.00      1.00
 type y for yes if you want to change this option
n


 Start of scene  1 for region  S
 region S is represented by a  live player
 type y for yes if you want to change this option
y
 the supply policy is
 households  government capital inv
     2.          2.         2.
 type y for yes if you want to change this option
y
 type  3 integers separated by commas
4,3,4
```

```
 Start of scene  1 for region  E
 region E is represented by a  live player
 type y for yes if you want to change this option
n
 the supply policy is
 households  government capital inv
     2.          2.         2.
 type y for yes if you want to change this option
y
 type  3 integers separated by commas
3,2,2


 Start of scene  1 for region  C
 region C is represented by a  live player
 type y for yes if you want to change this option
y
 the supply policy is
 households  government capital inv
     2.          2.         2.
 type y for yes if you want to change this option
y
 type  3 integers separated by commas
2,2,4
```

```
 Start of scene  1 for region  O
 region O is represented by a  live player
 type y for yes if you want to change this option
y
 the supply policy is
 households  government capital inv
     2.          2.         2.
 type y for yes if you want to change this option
y
 type  3 integers separated by commas
2,4,4

 Start of scene  1 for region  N
 region N is represented by a  live player
 type y for yes if you want to change this option
y
 the supply policy is
 households  government capital inv
     2.          2.         2.
 type y for yes if you want to change this option
y
 type  3 integers separated by commas
3,3,2

 Start of scene  1 for region  D
 region D is represented by a  live player
 type y for yes if you want to change this option
y
 the supply policy is
 households  government capital inv
     2.          2.         2.
 type y for yes if you want to change this option
y
 type  3 integers separated by commas
3,3,3
```

```
The complete report for every region is
printed on the line printer
        Dummy players are ready for trade
        Live players have to type
gemact V - where V is the character for the region
```

****

Comments: On the first step of GEM the game-director calls the program "gemgo". All data are set up for the scene and all players have to decide, whether they want the first step of setting the activity levels for the different sectors to be performed by the program automatically. In that case they have the option of setting a policy for importance of supplies. In this example only the player representing region "E" decides to have an interactive session to state the activity levels. He is provided with the neccessary information, while all other players get the results for their regions.

Some important parameters at the start of scene 1 for region S

technical coefficients

from:	to sector	Min	Int	Dur	Cons	Food	Fuel	Elec	Serv
1	Min :	0.000	0.056	0.000	0.000	0.000	0.000	0.000	0.000
2	Int :	0.000	0.000	0.344	0.333	0.049	0.000	0.000	0.000
3	Dur :	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	Cons:	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.040
5	Food:	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.022
6	Fuel:	0.062	0.044	0.006	0.006	0.004	0.000	0.310	0.002
7	Elec:	0.125	0.056	0.011	0.014	0.004	0.021	0.000	0.013
8	Serv:	0.062	0.188	0.136	0.139	0.281	0.255	0.239	0.000

	Min	Int	Dur	Cons	Food	Fuel	Elec	Serv
labor coefficients:	0.043	0.027	0.016	0.021	0.019	0.024	0.018	0.062
capital coefficients from sector 3:	0.18	0.18	0.20	0.10	0.40	1.00	1.60	0.80
from sector 8:	0.05	0.05	0.05	0.03	0.10	0.25	0.40	0.20
previous activity levels:	20.00	364.00	600.00	379.00	233.00	72.00	75.00	795.00
annual inventory:	4.00	20.00	30.00	20.00	10.00	8.00	0.00	0.00
capacity:	24.00	400.00	660.00	400.00	250.00	80.00	80.00	880.00
technical level:	t 1	t 1	t 1	t 1	t 1	t 1	t 1	t 1
sectoral development policy:	2.	2.	2.	2.	2.	2.	2.	2.

	households	government	capital inv
supply policy:	4.	3.	4.

Monetary reserves: 35.0 GNP : 1722.1

Ore reserves: 3000.0 Fuel reserves: 4000.0

Total supplies to households: 1048.5 Total supplies to government: 452.0

Total food consumption: 221.2 Total energy consumption: 42.3

Government efficiency: 0.90 Skill level: 0.25 Labor unrest: 0.05

Population: 382.0 Skilled-labor equivalents: 85.1

Technological breakthroughs

	TB1	TB2	TB3	TB4	TB5	TB6	TB7	TB8	TB'1	TB''5	TB'6	TB'5	TB'7	TB''7
required inv from sector 3	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.50	2.00	0.50	2.00	2.00	5.00
accumulated enhancement units	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
probability of occurrence by scene end	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.05	0.02	0.05	0.02	0.02	0.01

required net product for maintenance in region : S

total HH supplies: 1100.92   total GV supplies: 452.00   total hard-capital inv : 78.77

from sectors	Min	Int	Dur	Cons	Food	Fuel	Elec	Serv
for HH supplies:	0.00	0.00	255.41	255.41	232.30	11.01	22.02	324.77
for GV supplies:	0.00	0.00	211.99	88.14	0.00	4.07	6.78	141.02
for hard-capital inv:			63.02					15.75
for depreciated inventory:	0.00	2.20	3.30	2.20	2.75	0.00	0.00	0.00
total supplies needed:	0.00	2.20	533.72	345.75	235.05	15.08	28.80	481.55
activity levels adjusted due to capacity constraints and 20% limits on changes:	18.12	323.57	533.72	376.64	250.00	60.98	72.65	772.18
resulting expected net output:	0.00	2.30	533.72	345.75	233.01	15.09	28.81	482.12
net output plus inventory:	4.00	22.30	563.72	365.75	243.01	23.09	28.81	482.12
present surplus:	4.00	20.10	30.00	20.00	7.97	8.01	0.01	0.57
long-term net surplus:	0.00	0.10	0.29	0.29	-2.03	0.02	0.00	0.00

these activity levels will leave you with 3.74 units of unemployed labor

	Min	Int	Dur	Cons	Food	Fuel	Elec	Serv
desired net exports:	0.06	0.39	0.72	0.58	-1.89	0.13	0.00	0.00
resulting inventory:	3.94	19.71	29.28	19.42	9.85	7.87	0.00	0.00

expected monetary trade balance:

	Min	Int	Dur	Cons	Food	Fuel	Elec	Serv
imports:	0.00	0.00	0.00	0.00	1.89	0.00	0.00	0.00
exports:	0.06	0.39	0.72	0.58	0.00	0.13	0.00	0.00

the activity levels may be changed to a level without deficit in inputs using the
set supply policy: households government capital inv
4. 3. 4. and setting f+ 0.01 and f- 0.00

```
required net product for maintenance in region :  S

total HH supplies: 1142.86   total GV supplies: 465.56   total hard-capital inv   : 81.92

               from sectors   Min     Int      Dur      Cons     Food     Fuel     Elec     Serv

for HH supplies:             0.00    0.00    265.14   265.14   241.14    11.43    22.86   337.15
for GV   supplies:           0.00    0.00    218.35    90.78     0.00     4.19     6.98   145.25
for hard-capital inv:                         65.54                                         16.38
for depreciated inventory:   0.00    2.20      3.30     2.20     2.75     0.00     0.00     0.00
total supplies needed:       0.00    2.20    552.33   358.13   243.89    15.62    29.84   498.78

activity levels adjusted due to capacity constraints
and 20% limits on changes: 18.76   334.92    552.33   390.12   250.00    63.15    75.25   799.82
resulting
expected net output:         0.00    2.76    552.33   358.13   232.40    15.66    29.89   502.01

net output plus inventory:   4.00   22.76    582.33   378.13   242.40    23.66    29.89   502.01

present surplus:             4.00   20.56     30.00    20.00    -1.49     8.05     0.05     3.23

long-term net surplus:       0.00    0.56      1.61     1.61   -11.49     0.09     0.00     0.00

these activity levels will leave you with       1.01 units of unemployed labor
                             harvest condition        1.00

desired net exports:         0.33    2.22      4.09     3.27   -10.66     0.75

resulting inventory:         3.67   18.35     25.91    16.73     9.17     7.29

expected monetary trade balance:
                             Min     Int       Dur      Cons     Food     Fuel
                 imports:    0.00    0.00      0.00     0.00    10.66     0.00
                 exports:    0.33    2.22      4.09     3.27     0.00     0.75
```

Some important parameters at the start of scene 1 for region E

technical coefficients

from:	to sector	Min	Int	Dur	Cons	Food	Fuel	Elec	Serv
1	Min :	0.000	0.056	0.000	0.000	0.000	0.000	0.000	0.000
2	Int :	0.000	0.000	0.344	0.333	0.049	0.000	0.000	0.000
3	Dur :	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	Cons:	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.040
5	Food:	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.022
5	Fuel:	0.062	0.044	0.006	0.006	0.004	0.000	0.310	0.002
7	Elec:	0.125	0.056	0.011	0.014	0.004	0.021	0.000	0.013
8	Serv:	0.062	0.188	0.136	0.139	0.281	0.255	0.239	0.000

	Min	Int	Dur	Cons	Food	Fuel	Elec	Serv
labor coefficients:	0.043	0.027	0.016	0.021	0.019	0.024	0.018	0.062
capital coefficients from sector 3:	0.18	0.18	0.20	0.10	0.40	1.00	1.60	0.80
from sector 8:	0.05	0.05	0.05	0.03	0.10	0.25	0.40	0.20
previous activity levels:	10.00	260.00	480.00	305.00	188.00	20.00	60.00	651.00
annual inventory:	6.00	20.00	15.00	15.00	15.00	20.00	0.00	0.00
capacity:	12.00	300.00	540.00	350.00	210.00	22.00	64.00	750.00
technical level:	t 1	t 1	t 1	t 1	t 1	t 1	t 1	t 1
sectoral development policy:	2.	2.	2.	2.	2.	2.	2.	2.

supply policy:	households	government	capital inv
	3.	2.	2.

Monetary reserves: 27.0 GNP : 1341.3

Ore reserves: 300.0 Fuel reserves: 1200.0

Total supplies to households: 885.0 Total supplies to government: 336.5

Total food consumption: 169.9 Total energy consumption: 47.6

Government efficiency: 0.85 Skill level: 0.09 Labor unrest: 0.18

Population: 559.0 Skilled-labor equivalents: 66.8

Technological breakthroughs

	TB1	TB2	TB3	TB4	TB5	TB6	TB7	TB8	TB'1	TB''5	TB'6	TB'5	TB'7	TB''7
required inv from sector 3	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.50	2.00	0.50	2.00	2.00	5.00
accumulated enhancement units	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
probability of occurrence by scene end	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.05	0.02	0.05	0.02	0.02	0.01

```
required net product for maintenance in region :  E

total HH supplies:  929.25   total GV supplies:  336.50   total hard-capital inv   : 62.97

      from sectors          Min     Int     Dur     Cons    Food    Fuel    Elec    Serv

for HH supplies:            0.00    0.00   199.79  199.79  178.42   17.66   18.58  315.02
for GV   supplies:          0.00    0.00   159.84   64.94    0.00    6.06    7.07   98.59
for hard-capital inv   :                    50.38                                   12.59
for depreciated inventory:  0.00    2.30     1.73    1.73    4.31    0.00    0.00    0.00
total supplies needed:      0.00    2.30   411.73  266.46  182.73   23.71   25.65  426.20

activity levels adjusted due to capacity constraints
and 20% limits on changes: 12.00  251.07   411.73  292.71  197.17   22.00   60.69  656.37
resulting
expected net output:       -2.06    2.30   411.73  266.46  182.73  -14.93   26.72  436.22

net output plus inventory:  3.94   22.30   426.73  281.46  197.73    5.07   26.72  436.22

present surplus:            3.94   20.00    15.00   15.00   15.00  -18.65    1.07   10.02

long-term net surplus:     -2.06    0.00     5.01    5.01    0.00  -37.58    0.00    0.00

these activity levels will leave you with       0.72 units of unemployed labor
                             harvest condition       1.00

desired net exports:       -0.11    6.51     9.89    9.89    4.88  -31.07    0.00    0.00

resulting inventory:        4.05   13.49     5.11    5.11   10.12   12.42    0.00    0.00

expected monetary trade balance:
                            Min     Int     Dur     Cons    Food    Fuel
               imports:     0.11    0.00    0.00    0.00    0.00   31.07
               exports:     0.00    6.51    9.89    9.89    4.88    0.00

there is no simple way in which the performance of the economy
can be improved above this level
```

```
% gemact S

 type one character for the region
S
 player is not ready to state activity levels or is a dummy player

% gemact E

 type one character for the region
E
 type y for yes if you want the last reported
 allocation of activity levels to be the final
n
 if you are interested in another set of recommended activity levels
 type y and then your new policy
y
 indicate your new set-supply policy in the order
 household, government, capital inv
 type  3 integers separated by commas
3,3,3

                      Min    Int    Dur    Cons   Food   Fuel   Elec   Serv
 required net prod    0.0    2.3  411.7  266.5  182.7   23.7   25.7  426.2

 activity levels     12.0  251.1  411.7  292.7  197.2   22.0   60.7  656.4

 expected net prod   -2.1    2.3  411.7  266.5  182.7  -14.9   26.7  436.2

 plus inventory       3.9   22.3  426.7  281.5  197.7    5.1   26.7  436.2

 present surplus      3.9   20.0   15.0   15.0   15.0  -18.6    1.1   10.0

                     units of unemployed labor:    0.72

 if you are interested in another set of recommended activity levels
 type y and then your new policy
n
```

```
 if you want to allocate tentative activity levels
 type y and then your set of activity levels
y
 type  8  real numbers separated by commas
12.0,255.0,420.0,300.0,200.0,22.0,30.0,670.0

                       Min    Int    Dur    Cons   Food   Fuel   Elec   Serv
 required net prod     0.0    2.3  411.7   266.5  182.7   23.7   25.7  426.2

 activity levels      12.0  255.0  420.0   300.0  200.0   22.0   64.0  670.0

 expected net prod    -2.3    0.8  420.0   273.2  185.3  -16.3   29.4  445.4

 plus inventory        3.7   20.8  435.0   289.2  200.3    3.7   29.4  445.4

 present surplus       3.7   18.5   23.3    21.7   17.5  -20.0    3.8   19.2

                      units of unemployed labor:   -0.63

 if you are interested in another set of recommended activity levels
 type y and then your new policy
n
 if you want to allocate tentative activity levels
 type y and then your set of activity levels
n
 please call the program again, there are no other options left
```

```
% gemact E
 type one character for the region
E
 type y for yes if you want the last reported
 allocation of activity levels to be the final
n
 if you are interested in another set of recommended activity levels
 type y and then your new policy
n
 if you want to allocate tentative activity levels
 type y and then your set of activity levels
y
 type  8  real numbers separated by commas
12.,250.,415.,297.,200.,22.,64.,671.


                          Min     Int     Dur     Cons    Food    Fuel    Elec    Serv
 required net prod        0.0     2.3    411.7   266.5   182.7    23.7    25.7   426.2

 activity levels         12.0   250.0    415.0   297.0   200.0    22.0    64.0   671.0

 expected net prod       -2.0    -1.5    415.0   270.2   185.2   -16.0    29.8   448.4

 plus inventory           4.0    18.5    430.0   285.2   200.2     4.0    29.8   448.4

 present surplus          4.0    16.2     18.3    18.7    17.5   -19.7     4.1    22.2


                        units of unemployed labor:   -0.42


 if you are interested in another set of recommended activity levels
 type y and then your new policy
n
```

```
 if you want to allocate tentative activity levels
 type y and then your set of activity levels
y

 type  8  real numbers separated by commas
12.,250.,415.,295.,200.,22.,64.,665.

                        Min     Int     Dur     Cons    Food    Fuel    Elec    Serv
 required net prod      0.0     2.3    411.7   266.5   132.7    23.7    25.7   426.2

 activity levels       12.0   250.0    415.0   295.0   200.0    22.0    64.0   665.0

 expected net prod     -2.0    -0.8    415.0   268.4   185.4   -16.0    29.9   442.7

 plus inventory         4.0    19.2    430.0   283.4   200.4     4.0    29.9   442.7

 present surplus        4.0    16.9     18.3    16.9    17.6   -19.7     4.2    16.5

                       units of unemployed labor:    0.00


 if you are interested in another set of recommended activity levels
 type y and then your new policy
n
 if you want to allocate tentative activity levels
 type y and then your set of activity levels
n
 please call the program again, there are no other options left
call this program again
```

```
% gemact E
 type one character for the region
E
 type y for yes if you want the last reported
 allocation of activity levels to be the final
y

 some useful information about the activity levels
 is printed on the line printer
 your region is ready for the world trade
```

****

Comments :

Now that the player for region "E" has finally decided on the activity levels, all regions are ready to start the official trading. Again only one player participates in the interactive session, but all other players may interrupt the trade at any step and restart it from the beginning or from the point where it was stopped, changing their status to that of a live player. Otherwise their offers are determined by the program according to demands and prices.

The official trade is completed with detailed reports on the results for all regions. The next step will be the allocation of supplies in all regions. Again the example shows it for one live player in region "E" and one dummy player in region "S". In order to improve the proportions among the different sectors, goods may be sold and purchased in bilateral informal trade steps. Such a trade is shown for regions "E" and "S".
The allocation of supplies is finished, after the hard- and soft-capital assignment to all the different sectors and technologies is done. Then the game-director calls the program "gemfin" which sets up all data for the next scene and prints an overview for all regions.

The curious results are due to a very bad policy and to the fact that the aim was to show as many different options as possible for one player and not to obtain optimal results for any of the regions. Also the algorithm for the dummy players is only set up to obtain a feasible allocation of resources and not to optimize the performance of a given economy.

results of activity-level allocation for region E

total HH supplies: 929.25 total GV supplies: 336.50 total hard-capital inv : 62.97

from sectors	Min	Int	Dur	Cons	Food	Fuel	Elec	Serv
for HH supplies:	0.00	0.00	199.79	199.79	178.42	17.66	18.58	315.02
for GV supplies:	0.00	0.00	159.84	64.94	0.00	6.06	7.07	98.59
for hard-capital inv :			50.38					12.59
for depreciated inventory:	0.00	2.30	1.73	1.73	4.31	0.00	0.00	0.00
total supplies needed:	0.00	2.30	411.73	266.46	182.73	23.71	25.65	426.20
activity levels adjusted due to capacity constraints and 20% limits on changes:	12.00	250.00	415.00	295.00	200.00	22.00	64.00	665.00
resulting expected net output:	-2.00	-0.80	415.00	268.40	185.37	-15.97	29.90	442.70
net output plus inventory:	4.00	19.20	430.00	283.40	200.37	4.03	29.90	442.70
present surplus:	4.00	16.90	18.27	16.94	17.64	-19.69	4.25	16.50
long-term net surplus:	-2.00	-3.10	11.52	10.19	2.64	-36.16	0.72	0.00

these activity levels will leave you with 0.00 units of unemployed labor

harvest condition 1.02

```
% gemtrade

 region S is represented by a  dummy player
 type y for yes if you want to change this option
n
 region E is represented by a  live player
 type y for yes if you want to change this option
n
 region C is represented by a  dummy player
 type y for yes if you want to change this option
n
 region O is represented by a  dummy player
 type y for yes if you want to change this option
n
 region N is represented by a  dummy player
 type y for yes if you want to change this option
n
 region D is represented by a  dummy player
 type y for yes if you want to change this option
n

 state your trade offers. type one character for the region.
E
 last offers made:
           1       2       3       4       5       6
          Min     Int     Dur     Cons    Food    Fuel

 current prices
          1.00    1.00    1.00    1.00    1.00    1.00
 volume                     -
         -0.8     0.9    14.0    12.7     5.4   -32.2
```

```
 to change your  offers type an integer for the commodity and
  separated by comma a real number for the volume
 type commodity,volume or zero if no more changes
Ø
 these offers will leave you with      27.Ø units of monetary reserves
 and available products of
           4.8     18.3    416.Ø    270.7    194.9    36.2
 type y for yes to confirm this set of offers
y


                        Trade offers for step          1
           Min       Int       Dur      Cons      Food      Fuel
 Price    1.ØØ      1.ØØ      1.ØØ      1.ØØ      1.ØØ      1.ØØ

     S    Ø.35      2.23      4.Ø1      3.14    -1Ø.49      Ø.77
     E   -Ø.8Ø      Ø.87     13.97     12.69      5.43    -32.16
     C    Ø.85      Ø.ØØ     -Ø.11     -Ø.11      Ø.ØØ     -Ø.64
     O    1.Ø6     -5.94    -4Ø.5Ø    -19.Ø6     -Ø.33     64.77
     N    Ø.4Ø      2.ØØ      5.66      4.66      2.ØØ    -14.72
     D    Ø.6Ø      Ø.8Ø      1.28      1.48      1.ØØ     -5.16

  supply 3.26       5.9Ø     24.91     21.97      8.43     65.54

  demand Ø.8Ø       5.94     4Ø.61     19.16     1Ø.82     52.68

 new prices for tradable commodities are:
           Min       Int       Dur      Cons      Food      Fuel
          Ø.5Ø      1.Ø1      1.63      Ø.87      1.28      Ø.8Ø
 type y for yes if all live players are ready
  to continue the trade session
y
```

```
 state your trade offers. type one character for the region.
E
 last offers made:
             1        2        3        4        5        6
            Min      Int      Dur      Cons     Food     Fuel

 current prices
           0.50     1.01     1.63     0.87     1.28     0.80
 volume
          -0.8      0.9     14.0     12.7      5.4    -32.2

 to change your  offers type an integer for the commodity and
  separated by comma a real number for the volume
 type commodity,volume or zero if no more changes
0
 these offers will leave you with 42.4 units of monetary reserves
 and available products of
           4.8     18.3    416.0    270.7    194.9     36.2

 type y for yes to confirm this set of offers
y

 last offers made:
             1        2        3        4        5        6
            Min      Int      Dur      Cons     Food     Fuel

 current prices
           0.50     1.01     1.63     0.87     1.28     0.80
 volume
          -0.8      0.9     14.0     12.7      5.4    -32.2
```

```
 to change your  offers type an integer for the commodity and
  separated by comma a real number for the volume
 type commodity,volume or zero if no more changes
6,-40.0
 type commodity,volume or zero if no more changes
0

 these offers will leave you with 36.1 units of monetary reserves
 and available products of
          4.8     18.3    416.0     270.7    194.9     44.0

 type y for yes to confirm this set of offers
y
                       Trade offers for step          2
           Min       Int       Dur       Cons      Food      Fuel
 Price    0.50      1.01      1.63       0.87      1.28      0.80

     S    0.04      1.11      4.61       1.44     -7.87      0.24
     E   -0.80      0.87     13.97      12.69      5.43    -40.00
     C    1.05      0.00     -0.07     - 0.07      0.00     -0.43
     O    0.32     -2.30    -10.40      -8.19      0.16     32.41
     N    0.04      0.76      5.66       2.00      1.24    -16.61
     D    0.08      0.46      1.38       0.75      0.93     -5.73

  supply 1.53      3.21     25.62      16.87      7.76     32.65

  demand 0.80      2.30     10.47       8.26      7.87     62.77
  new prices for tradable commodities are:
           Min       Int       Dur       Cons      Food      Fuel
          0.50      1.00      1.32       0.50      1.30      0.94
 type y for yes if all live players are ready
    to continue the trade session
n
 type y for yes if you want to continue this trade later
 without starting from scratch again
y
 to continue the trade call this program again
```

```
% gemtrade

 type y for yes if you want to continue the interrupted trade
y
 region S is represented by a  dummy player
 type y for yes if you want to change this option
n
 region E is represented by a  live player
 type y for yes if you want to change this option
n
 region C is represented by a  dummy player
 type y for yes if you want to change this option
n
 region O is represented by a  dummy player
 type y for yes if you want to change this option
n
 region N is represented by a  dummy player
 type y for yes if you want to change this option
n
 region D is represented by a  dummy player
 type y for yes if you want to change this option
n

 state your trade offers  type one character for the region.
E

 last offers made:
           1        2        3        4        5        6
          Min      Int      Dur      Cons     Food     Fuel

 current prices
          0.50     1.00     1.32     0.50     1.30     0.94
 volume
         -0.8      0.9     14.0     12.7      5.4    -40.0
```

```
 to change your  offers type an integer for the commodity and
  separated by comma a real number for the volume
 type commodity,volume or zero if no more changes
Ø
 these offers will leave you with 21.7 units of monetary reserves
 and available products of
        4.8    18.3   416.Ø   27Ø.7   194.9    44.Ø
 type y for yes to confirm this set of offers
n

 last offers made:
         1       2       3       4       5       6
        Min     Int     Dur     Cons    Food    Fuel

 current prices
        Ø.5Ø    1.ØØ    1.32    Ø.5Ø    1.3Ø    Ø.94
 volume
       -Ø.8     Ø.9    14.Ø    12.7     5.4   -4Ø.Ø


 to change your  offers type an integer for the commodity and
  separated by comma a real number for the volume
 type commodity,volume or zero if no more changes
2,2.Ø
 type commodity,volume or zero if no more changes
6,-37.Ø
 type commodity,volume or zero if no more changes
Ø
 these offers will leave you with 25.6 units of monetary reserves
 and available products of
        4.8    17.2   416.Ø   27Ø.7   194.9    41.Ø
 type y for yes to confirm this set of offers
y
```

```
                  Trade offers for step        3
        Min     Int     Dur     Cons    Food    Fuel
Price   0.50    1.00    1.32    0.50    1.30    0.94

    S   0.06    1.57    4.61    0.90   -6.60    0.47
    E  -0.80    2.00   13.97   12.69    5.43  -37.00
    C   1.30    0.00   -0.09   -0.09    0.00   -0.52
    O   0.34   -3.95  -24.53  -14.50   -0.10   46.27
    N   0.10    2.01    7.59    1.39    3.41  -18.28
    D   0.13    0.69    1.38    0.49    1.46   -5.01

 supply 1.92    6.28   27.55   15.47   10.29   46.74

 demand 0.80    3.95   24.61   14.59    6.70   60.82


the new prices are final
final offers at these prices should be made


new prices for tradable commodities are:
        Min     Int     Dur     Cons    Food    Fuel
        0.50    1.01    1.18    0.50    1.29    1.00

type y for yes if all live players are ready
       to continue the trade session
state your trade offers. type one character for the region.
E
last offers made:
          1       2       3       4       5       6
        Min     Int     Dur     Cons    Food    Fuel

current prices
        0.50    1.01    1.18    0.50    1.29    1.00
volume
       -0.8     2.0    14.0    12.7     5.4   -37.0
```

```
to change your  offers type an integer for the commodity and
 separated by comma a real number for the volume
 type commodity,volume or zero if no more changes
6,-35.5
 type commodity,volume or zero if no more changes
0
 these offers will leave you with     22.9 units of monetary reserves
 and available products of
        4.8    17.2   416.0   270.7   194.9    39.5
 type y for yes to confirm this set of offers
y
                     Trade offers for step         4
         Min      Int      Dur      Cons     Food     Fuel
 Price   0.50     1.01     1.18     0.50     1.29     1.00

     S   0.05     1.69     6.43     1.21    -9.49     1.02
     E  -0.80     1.17    13.97    12.69     4.84   -31.33
     C   0.53     0.00    -0.08    -0.08     0.00    -0.46
     O   0.13    -4.74   -29.06   -15.97    -0.25    50.06
     N   0.05     1.45     7.50     1.64     3.57   -15.34
     D   0.05     0.44     1.24     0.51     1.34    -3.95

  supply 2.03     8.11    29.14    16.06    10.93    51.08

  demand 0.80     4.74    31.31    16.59     9.74    57.87

 the trade report is printed on the line printer
 to continue players should type
 gemsup V - where V is the region
 to allocate the final supplies
```

Trade session results for region E

some initial values for the trade session

	Min	Int	Dur	Cons	Food	Fuel
Net output:	-2.0	-0.8	415.0	268.4	185.4	-16.0
Inventory:	6.0	20.0	15.0	15.0	15.0	20.0

Monetary reserves: 27.0

final values

	Min	Int	Dur	Cons	Food	Fuel
final prices:	0.50	1.01	1.18	0.50	1.29	1.00
final net exports	-0.80	1.17	13.97	12.69	4.84	-31.33
final exports in monetary terms:	-0.40	1.18	16.48	6.35	6.22	-31.33

Monetary balance -1.51

resulting inventory	6.8	18.8	1.0	2.3	10.2	51.3

Resulting monetary reserves 25.5

Trade session results for region S

some initial values for the trade session

	Min	Int	Dur	Cons	Food	Fuel
Net output:	0.0	2.8	552.3	358.1	229.1	15.7
Inventory:	4.0	20.0	30.0	20.0	10.0	8.0

Monetary reserves: 35.0

final values

	Min	Int	Dur	Cons	Food	Fuel
final prices:	0.50	1.01	1.18	0.50	1.29	1.00
final net exports	0.05	1.69	6.43	1.21	-9.49	1.02
final exports in monetary terms:	0.02	1.71	7.59	0.61	-12.20	1.02

Monetary balance -1.24

resulting inventory	4.0	18.3	23.6	18.8	19.5	7.0

Resulting monetary reserves 33.8

```
% gemsup E

 Start of final supply allocation. Type one character for the region
E
 your region is represented by a live  player
 type y for yes if you want to change this option
n

 Level of HH supplies   1.02   Level of GV supplies   1.02
                   Level of capital inv   1.02

             Min     Int     Dur    Cons     Food    Fuel    Elec    Serv
 Total available input for demand
            4.80   18.03  416.03  270.71  195.53   35.36   29.90  442.70
 for HH     0.00    0.00  204.45  204.45  182.58   18.07   19.02  322.37
 for GV     0.00    0.00  163.57   66.46    0.00    6.20    7.23  100.90
 for CI     0.00    0.00   49.62    0.00    0.00    0.00    0.00   14.82
 for new inventory
            2.00    0.80    0.00    0.00    0.00    7.99    0.00    0.00
 surplus or shortage for this allocation
            2.80   17.24    0.00    0.00   12.95    6.72    0.03    2.82

 type y for yes if you want to change the level of household supplies
n
 type y for yes if you want to change the absolute allocation
 of food to households
n
 type y for yes if you want to change the level of  government supplies
n
 type y for yes if you want to change the level of total capital investment
n
 type y for yes if you want to have another tentative run just now
n
 type y for yes if you want to try with a different set supply policy
y
type  3 integers separated by commas
4,4,2
```

```
Level of HH supplies   1.02   Level of GV supplies   1.02
                       Level of capital inv   1.01

              Min      Int      Dur     Cons     Food    Fuel    Elec    Serv
Total available input for demand
              4.80    18.03   416.03   270.71   195.53   35.36   29.90  442.70
for HH        0.00     0.00   204.58   204.58   182.70   18.08   19.03  322.58
for GV        0.00     0.00   163.67    66.50     0.00    6.20    7.24  100.96
for CI        0.00     0.00    49.07     0.00     0.00    0.00    0.00   14.66
for new inventory
              2.00     0.80     0.00     0.00     0.00    7.99    0.00    0.00
surplus or shortage for this allocation
              2.80    17.24     0.00     0.00    12.83    6.71    0.01    2.84

type y for yes if you want to change the level of household supplies
y
type one real number for the new value
1.03
                  . )
                  . ) *no change ; all questions answered with no*
                  . )
Level of HH supplies   1.03   Level of GV supplies   1.02
                       Level of capital inv   1.01

              Min      Int      Dur     Cons     Food    Fuel    Elec    Serv
for HH        0.00     0.00   205.78   205.78   183.77   18.19   19.14  324.47
                  .
                  . *no change in this data see above*
                  .
surplus or shortage for this allocation
              2.80    17.24     0.00    -1.45    11.76    6.50    0.00    0.00

type y for yes if you want to have another tentative run just now
n
type y for yes if you want to try with a different set supply policy
n
You cannot state these levels of supply because of shortage
 call this program again to state the supplies finally
```

```
# geminfo S E

 type one character for the donor region
S
 type one character for the recipient region
E
 if the donor loans some money to
 the recipient, indicate the volume, else Ø
Ø
 indicate the exchange in the following way
 commodity,price,volume
 where commodity is an integer in the range from 1-6
 while price and volume are real numbers
 an empty line ends the informal trade
4,1.Ø,8.Ø
 indicate the exchange in the following way
 commodity,price,volume
 where commodity is an integer in the range from 1-6
 while price and volume are real numbers
 an empty line ends the informal trade

                          Results of informal trade

          donor region  S
                 Min     Int     Dur     Cons    Food    Fuel
 starting inventory for the next scene
                 4.Ø     21.1    15.1    13.3     9.3     7.1

                             Monetary reserves    41.8

          recipient region   E
                 Min     Int     Dur     Cons    Food    Fuel
 inventory        6.8    18.8     1.Ø    1Ø.3    1Ø.2    51.3

                             Monetary reserves    17.5

informal trade finished, may be continued with another call
```

```
% gemsup E

 Start of final supply allocation. Type one character for the region
E
 your region is represented by a live  player
 type y for yes if you want to change this option
n

 Level of HH supplies   1.03   Level of GV supplies   1.03
                   Level of capital inv   1.03
            Min     Int     Dur    Cons     Food   Fuel    Elec    Serv
 Total available input for demand
            4.80   18.03  416.03  278.71  195.53   35.36   29.90  442.70
 for HH     0.00    0.00  205.78  205.78  183.77   18.19   19.14  324.47
 for GV     0.00    0.00  164.63   66.89    0.00    6.24    7.28  101.55
 for CI     0.00    0.00   49.94    0.00    0.00    0.00    0.00   14.92
 for new inventory
            2.00    0.80    0.00    0.00    0.00    7.99    0.00    0.00
 surplus or shortage for this allocation
            2.80   17.24    0.00    3.48   11.76    6.43    0.00    0.00

 type y for yes if you want to change the level of household supplies
y
 type one real number for the new value
1.02
 type y for yes if you want to change the absolute allocation
 of food to households
y
 type one real number for the new value
180.0
 type y for yes if you want to change the level of  government supplies
y
 type one real number for the new value
1.02
 type y for yes if you want to change the level of total capital investment
y
 type one real number for the new value
1.04
```

```
 Level of HH supplies   1.02   Level of GV supplies   1.02
                    Level of capital inv   1.04

            Min      Int      Dur     Cons      Food    Fuel     Elec     Serv
 Total available input for demand
            4.80    18.03   416.03   278.71   195.53   35.36    29.90   442.70
 for HH     0.00     0.00   203.78   203.78   180.00   18.01    18.96   321.32
 for GV     0.00     0.00   163.03    66.24     0.00    6.18     7.21   100.57
 for CI     0.00     0.00    50.43     0.00     0.00    0.00     0.00    15.06
 for new·inventory
            2.00     0.80     0.00     0.00     0.00    7.99     0.00     0.00
 surplus or shortage for this allocation
            2.80    17.24     0.00     8.68    15.53    6.79     0.13     4.54
 type y for yes if you want to have another tentative run just now
n
 type y for yes if you want to try with a different set supply policy
y
type  3 integers separated by commas
4,3,4
```

```
 Level of HH supplies   1.03   Level of GV supplies   1.02
                   Level of capital inv   1.03
             Min     Int     Dur    Cons     Food    Fuel     Elec     Serv
 Total available input for demand
             4.80   18.03  416.03  278.71  195.53   35.36    29.90   442.70
 for HH      0.00    0.00  206.33  206.33  184.26   18.23    19.19   325.33
 for GV      0.00    0.00  163.76   66.54    0.00    6.21     7.24   101.01
 for CI      0.00    0.00   50.08    0.00    0.00    0.00     0.00    14.96
 for new inventory
             2.00    0.80    0.00    0.00    0.00    7.99     0.00     0.00
 surplus or shortage for this allocation
             2.80   17.24    0.00    3.12   11.28    6.40     0.00     0.00
 type y for yes if you want to have another tentative run just now
n
 type y for yes if you want to try with a different set supply policy
n
 type y for yes if you want to allocate the capital investment
on these  supply levels
y
                 Allocation of hard-capital investment

            Min     Int     Dur    Cons     Food    Fuel     Elec     Serv
 Your sectoral development policy is
            2.      2.      2.      2.      2.      2.       2.       2.

 type y for yes if you want to change this option
y
 type  8 integers separated by commas
3,2,4,4,3,4,2,2,
```

```
 total available for hard-capital inv :   58.53
 to sector Min :    Ø.13
 type a new value or -1.Ø if no change
 total available for hard-capital inv :   58.33
 to sector Int :    3.1Ø
 type a new value or -1.Ø if no change
2.5
 total available for hard-capital inv :   55.83
 to sector Dur :    6.57
 type a new value or -1.Ø if no change
7.Ø
 total available for hard-capital inv :   48.83
 to sector Cons:    2.13
 type a new value or -1.Ø if no change
3.Ø
 total available for hard-capital inv :   45.83
 to sector Food:    4.96
 type a new value or -1.Ø if no change
5.Ø
 total available for hard-capital inv :   4Ø.83
 to sector Fuel:    1.34
 type a new value or -1.Ø if no change
2.Ø
 total available for hard-capital inv :   38.83
 to sector Elec:    5.88
 type a new value or -1.Ø if no change
6.Ø
 total available for hard-capital inv :   32.83
 to sector Serv:   34.43
 type a new value or -1.Ø if no change
32.38
```

Allocation of soft-capital investment in terms of durable goods

```
total available for soft-capital inv :          3.25
to   TB1   :    0.00
type a new value or -1.0 if no change   .2
total available for soft-capital inv :          3.05
to   TB2   :    0.00
type a new value or -1.0 if no change   .2
total available for soft-capital inv :          2.85
to   TB3   :    1.08
type a new value or -1.0 if no change   .3
total available for soft-capital inv :          2.55
to   TB4   :    1.08
type a new value or -1.0 if no change   .3
total available for soft-capital inv :          2.25
to   TB5   :    0.00
type a new value or -1.0 if no change   .3
total available for soft-capital inv :          1.95
to   TB6   :    1.08
type a new value or -1.0 if no change   .4
total available for soft-capital inv :          1.55
to   TB7   :    0.00
type a new value or -1.0 if no change   .3
total available for soft-capital inv :          1.25
to   TB8   :    0.00
```

```
 type a new value or -1.Ø if no change   .3
 total available for soft-capital inv :          Ø.95
 to   TB'1  :    Ø.ØØ
 type a new value or -1.Ø if no change   .3
 total available for soft-capital inv :          Ø.65
 to   TB''5 :    Ø.ØØ
 type a new value or -1.Ø if no change   .2
 total available for soft-capital inv :          Ø.45
 to   TB'6  :    Ø.ØØ
 type a new value or -1.Ø if no change   .3
 total available for soft-capital inv :          Ø.15
 to   TB'5  :    Ø.ØØ
 type a new value or -1.Ø if no change   -1
 total available for soft-capital inv :          Ø.15
 to   TB'7  :    Ø.ØØ
 type a new value or -1.Ø if no change   .15
 total available for soft-capital inv :          Ø.ØØ
 to   TB''7 :    Ø.ØØ
 type a new value or -1.Ø if no change   -1

 type y if you want to state this allocation as the final
y

 a final overview of the supply allocation results
 is printed on the line printer
```

Results of final supply allocation for region E scene 1

levels of supply to

Households 1.03 Government 1.02 capital investment 1.03

	Min	Int	Dur	Cons	Food	Fuel	Elec	Serv
Total available input for demand	4.80	18.03	416.03	278.71	195.53	35.36	29.90	442.70
used for household demand	0.00	0.00	206.33	206.33	184.26	18.23	19.19	325.33
used for government demand	0.00	0.00	163.76	66.54	0.00	6.21	7.24	101.01
used for capital investment			50.08					14.96
used for new inventory	2.00	0.80	0.00	0.00	0.00	7.99	0.00	0.00
remaining products	2.80	17.24	0.00	3.12	11.28	6.40	0.00	0.00
starting inventory for next scene	4.80	18.03	0.00	3.12	11.28	14.39	0.00	0.00
allocation of hard-capital investment to sectors	0.20	2.50	7.00	3.00	5.00	2.00	6.00	32.38

allocation of soft-capital investment in terms of durable goods

TB1	TB2	TB3	TB4	TB5	TB6	TB7	TB8	TB'1	TB''5	TB'6	TB'5	TB'7	TB''7
0.20	0.20	0.30	0.30	0.30	0.40	0.30	0.30	0.30	0.20	0.30	0.00	0.15	0.00

Results of final supply allocation for region S scene 1

levels of supply to

Households 1.03 Government 1.05 Capital investment 1.20

	Min	Int	Dur	Cons	Food	Fuel	Elec	Serv
Total available input for demand	3.95	21.08	575.89	376.91	248.61	22.64	29.89	502.01
used for household demand	0.00	0.00	263.08	263.08	239.26	11.34	22.68	334.52
used for government demand	0.00	0.00	222.59	92.55	0.00	4.27	7.12	148.08
used for capital investment			72.78					21.74
used for new inventory	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
remaining products	3.95	21.08	15.13	21.29	9.35	7.12	0.00	0.00
starting inventory for next scene	3.95	21.08	15.13	21.29	9.35	7.12	0.00	0.00
allocation of hard-capital investment to sectors	0.29	4.78	9.03	3.50	8.00	6.50	9.00	43.97

allocation of soft-capital investment in terms of durable goods

TB1	TB2	TB3	TB4	TB5	TB6	TB7	TB8	TB'1	TB''5	TB'6	TB'5	TB'7	TB''7
0.20	0.20	0.20	0.20	0.40	0.50	0.20	0.20	0.20	0.20	0.30	0.50	1.00	0.43

World overview at scene end

region	S	E	C	O	N	D	World
population	395.70	576.40	963.71	157.72	247.64	1903.67	4244.84
GNP	1689.90	1322.60	447.09	207.82	1513.58	769.27	5950.27
monetary reserves	41.76	17.49	9.66	32.72	31.40	15.96	149.00
ore-reserves	2981.24	288.00	1992.00	98.80	1983.97	2192.77	9536.79
fuel-reserves	3936.85	1778.00	479.29	3920.80	2750.00	2480.00	15344.94
labor unrest	0.02	0.22	0.14	0.15	0.11	0.38	0.17
per capita GNP raise	-0.05	-0.04	-0.11	-0.08	-0.06	-0.06	-0.07
unemployed	1.01	0.00	0.55	0.12	1.21	0.38	3.27
total hard-capital inv	106.34	72.60	24.05	19.39	85.33	37.66	345.37
per capita food cons.	0.67	0.36	0.20	0.34	0.96	0.17	0.45
per capita energy cons.	0.15	0.11	0.02	0.15	0.30	0.01	0.12

Technological breakthroughs overview

	TB1	TB2	TB3	TB4	TB5	TB6	TB7	TB8	TB'1	TB''5	TB'6	TB'5	TB'7	TB''7
S			xx	xx	xx						xx			
E		xx	xx	xx	xx	xx	xx	xx						
C					xx		xx							
O							xx							
N			xx		xx	xx		xx	xx					
D	xx													
occurrence of TB's since start of GEM	1	1	1	1	1	1	1	1	1	∅	1	∅	∅	∅

THE AUTHORS

Olaf Helmer came to IIASA in 1977 from a position as Harold Quinton Professor of Futures Research at the University of Southern California.

Lutz Blencke came to IIASA in 1977 from the Computing Institute of the Academy of Sciences of the German Democratic Republic.

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