STRATAGEM

A personal computer-based management training game on energy-environment interactions

Version 4.0

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This manual is an abbreviated version of a longer document
which is available for download at
http://ivem.eldoc.ub.rug.nl/ivempubs/Software/Stratagemmanual/

1. INTRODUCTION

1.1 History

STRATAGEM is an operational game specifically designed for use with corporate and public managers and with university students. The game was originally developed to educate government officials responsible for energy and environment programs in Latin America. It offered them the opportunity to gain experience in making decisions required to achieve balanced growth in the capital stocks influencing their country's population growth, material standard of living, economic output, international trade, environmental quality, and energy use. However, it has also been used by officials with similar responsibilities in industrialized countries. University students in North America, Eastern Europe, and Western Europe have successfully used the game. The game has been played by people from more than 30 nations, and it is being adopted for use in many universities and management training centers. IVEM has incorporated this game in its annual students' training program in environmental sciences since 1986.

STRATAGEM employs a technology for gaming that was developed by Dennis Meadows in 1984 at the International Institute for Applied System Analysis (IIASA) near Vienna, Austria. The game itself was developed by Dennis Meadows, Donella Meadows, Ferenc Toth, and Norman Marshall. The approach incorporates three elements:

- a sophisticated simulation model of the system represented by the game
- a personal computer which makes the computer model easily available for use, and which serves as an accounting device and
- a playing board, with associated pieces, that serves as an accounting device, aids in communication, and helps the players visualize the important interconnections in the model.

The current version of the game contains sufficient complexity to tax the analytical and management skills of any participant. It serves in its present form to illustrate a number of important guidelines that are easily overlooked in practice when investment programs are developed to enhance the productivity of a region's energy, environmental, and human resources. The game may be used alone or as the basis for a 3-5 day course on the dynamics of regional development and the determinants of long-term natural resource productivity.

1.2 Set-up of this manual

This manual follows more or less the steps in using the STRATAGEM game. It includes the description of the game in general terms and describes the general state of affairs in the starting situation for the playing team, and contains also the role descriptions for the various ministers of the national cabinet. Per role description also the relevant parts of the output form are reproduced in order to get acquainted with the way the results of the decisions taken are formulated, and with the input requirements that follow from the decisions that are made for the next period in the game.

2. GAME DESCRIPTION

2.1 Introduction to STRATAGEM

STRATAGEM simulates in a simplified form the national economy of a country that has reached a stage of development like that found widely in Latin America. The game covers a time span of two generations (60 years). This is split in 12 periods of five years. Per five year planning period a series of decisions (concerning production and consumption of food, goods and energy and concerning investments and trading) must be taken that are used as input into the computer. The PC serves here as an accounting device, that presents the effects of the decisions taken in the form of a description of the situation at the end of the last planning period. A full cycle of the game thus consists of one set of decisions by the team (the input parameters) and a description of the newly calculated state of affairs at the end of that planning period (the output parameters).

Five different role are implemented in the game. Each role can be played by one or two participants. So a team of five to ten persons is required for playing STRATAGEM. Players are free to implement a wide range of social and economic decisions. Their actions must be carefully designed to be consistent with the cause-effect relationships that govern the behavior of the society if they want to reach a high level of development. A group of more than 10 persons can be divided into separate teams of about 5-10 players. Approximately 8 groups (maximum number: 10) can be handled by one computer-printer combination, and a game-operator with an assistant. In this way the results of all the teams can be compared with each other. There are no interactions between the teams.

During the game there are twelve sets of decisions to be taken - each influencing the development of the region over a five-year cycle. Each set is divided into 5 sectors which are managed by at least one person:

1) population & household consumption
2) energy production & energy efficiency
3) food production & environment
4) goods production & human services
5) international financing.

Per cycle of the game each of these sectors is supplied with an output form from the computer which indicates

a) the actual situation as derived by processing inputs from previous cycles
b) the decisions to be taken for the current cycle.

The international banking sector is supplied with a form on which all the decisions must be written. This form should be handed to the game operator who will feed the data into the computer. After calculation of the results by the computer this sequence will be repeated 11 times, so the game spans 60 years.

The game is normally played in one 4-8 hour period without interruption. However, STRATAGEM is also suited for part-time use over several weeks or more. For example, students in a university course might play the game over the entire semester - submitting the decisions for one cycle each week. This approach gives much more time for reflection, negotiation, and the development of sophisticated strategies. It also permits the professor to integrate the principal lessons of the game with the schedule for the course.

2.2 Goals and strategies

A cardinal aspect of the game is that players collectively have all the information about cause-effect relationships that govern the success of their decisions. There are no exogenous influences (unless an oil price increase is implemented), no random influences, and no unknown relationships. Consequently, if a team does well, it can assume full credit. If it does poorly, there are no "outside" influences to blame. All of the information about the cause-effect relationships is contained in the role descriptions. Thus, before playing the game it is best for each player to read through all of them, paying special attention to the description of the sector he or she will manage.

The goal of STRATAGEM is to reach a stable, sustainable, high productivity society. A not uncommon outcome however, is stagnation, with growth in population offsetting all gains in the economy. It is even possible to "crash" the society. If players let debt rise out of control, environment deteriorate too far, labor productivity slip, energy shortages mount, or population grow too high, the economy of the region can spiral downward out of control. To avoid this each team has to make a set of important policy decisions:

- Will it borrow to the limits of its credit or not?
- Will it raise standard of living of the population quickly, even though that reduces the goods available for invest ment, or will it let population grow rapidly for the first few cycles while attempting to achieve high growth rates in the economy's capital stocks?
- Will the team pursue balanced development, or will it emphasize growth in one sector - hoping that the surplus items from that sector can be exported to pay for needed imports in other commodities?
- What balance of investments in energy production and energy conservation does it wish to maintain?
- At what point does investment in environmental protection, energy efficiency, and other important sectors reach the point of diminishing return- the point where the next unit of investment costs more than it produces?

Several different strategies can give an attractive development path, but each team must work out their own strategy with a careful understanding of the many delays and cause-effect relationships that govern the behavior of the country. It is an important first step in the game to let the team discuss on the course to follow, in order to reach a high level, sustainable state.

There are several insights that can improve the effectiveness of policies. Among the useful guidelines five are of particular value:

1) Notice the difference in the lifetime of the capital stocks. All else equals, it is more cost effective to invest in the capital stocks that have longer lifetimes.
2) Notice the difference in energy requirements and environmental impacts of the investment alternatives.
3) Do not invest in any capital stock beyond the point of diminishing returns. At some point every capital stock costs more to increase than it produces in marginal output.

4) Note that many investments impose related "hidden" costs on the country. Whenever a team invests in goods production capital, for example, it must also add to the stock of energy production capital and to the stock of environmental protection capital in order to maintain balance in the system.
5) Be aware of long delays in the system. For example, money invested in energy production capital raises the energy available only two cycles later.

2.3 Starting conditions

The country has a modest population, just 200 people. The standard of food consumption is fair (2 in a range of 0-5), so that death rates are low (18/1000/year in the simple and standard version of the game). However, the material standard of living is low (2 in a range of 0-15), so that the population birth rate is high (41/1000/year). As a consequence the population growth rate is 2.3 percent per year - giving a doubling time of about 30 years (that is only 6 cycles in the game!). This growth rate is quite standard in Third World countries, where also values up to 4 percent per year can be found. Though the nutrition levels could be raised substantially, the country currently exports food in order to obtain the funds that are required to import energy. No investments have been made in energy efficiency, so that each unit of food production capital and goods production capital uses three times as much energy as it would, if maximum investments had been made in energy saving capital. Last cycle part of the about 15000 units of energy available have been imported; still the country lacks the energy required to operate all current food and goods capital. The national sources of domestic energy behave like waterpower: they cannot be depleted. In the early cycles of the game, the country receives appreciable returns on investments in energy production capital. Later seriously declining returns to scale will be encountered. These become so serious that it may be impossible to produce all the energy required domestically. However, a team may find itself with excess energy. This can be exported to earn money for imported food or goods. It may also be carried over - that is: left in the TOTAL ENERGY AVAILABLE box - for use in subsequent cycles of the game.

It is important to note that the energy sector plays a crucial role in the game. It requires a great deal of capital, creates an impact on the environment, and often produces energy shortages that force capital to be idle in the food and goods sector.

There are five ways to reduce or eliminate energy shortages:

1) A team can invest in more energy production capital. However, this gives increased energy supply only two cycles after the investment is made.
2) A team can allocate money to energy imports. This gives increased energy supply in the next cycle, but it may be very expensive.
3) A team can invest in energy efficiency capital. This reduces energy requirements in the next cycle already.
4) A team can shift investment away from energy-consuming capital stocks (food and goods production) and into human service capital or environmental protection capital, which consume no energy.
5) Finally, a team can reduce goods allocated to the population, so that less energy needs to be allocated to the population. This last strategy is rather weak in the first cycles of the game, since the population's demand for energy is rather small then. However, it is the only approach that becomes effective in the same cycle.

Even though the country is initially exporting food, the agricultural sector operates at much lower productivity than it might. The government has let your environment deteriorate seriously, and has not invested much in the food production capital. Environmental degradation currently reduces food output considerably, and maximuminvestments in production capital could raise food output by about six folds (ultimately constraint by available land and maximum land productivity). There is also substantial room for increased productivity in the goods sector. Labor productivity is only one-ninth of what could be attained through maximum investments in goods production capital and human service capital.

The output form for the first cycle indicates whether or not the team starts with a debt of 1000 units. If there is no debt, the cabinet may borrow money for only 10 percent per year. One earns 1 money unit for each unit of energy, food, or goods that you export. One must pay 1.1 money unit for each unit of food or goods that are imported. Therefore, it is not a good strategy to export a commodity, for example goods, and then use the money to import the same commodity. The cabinet loses 10 percent and one cycle's use of the commodity in such exchange. One pays 1.0 money unit for each unit of energy imported.

Terms of trade will shift against the country, if its debt rises too high relative to average exports. In that event, all imports rise in cost and the annual interest rate on debt rises too. Additionally, the energy price may be doubled for two cycles during the game by an OPEC action, implemented by the game operator.

3. ROLE DESCRIPTIONS

The goal is to devise a sustainable development route. As an example, the text below contains real-world equivalents in the opening scenario. Typical real-world equivalents of the situation described in the starting situation are as follows:

Food

A bowl of rice and beans three times a day.

Type of goods in individual households

A primitive wood-burning or kerosene stove, perhaps made out of a discarded piece of corrugated metal; a radio in more affluent homes, TVs only for the rich; few goods in stores and the cost of imported products puts most of them out of the reach of average citizens; most people walk, take public transport, or ride bicycles; very few private cars on the road.

Services

Few schools, poorly equipped; boys encouraged to attend, girls to stay at home and help with the family; one hospital to serve 250.000 people; most never see a dentist (teeth pulled rather than filled).

Energy source and quality

Hydroelectricity for use primarily in downtown business and government areas; frequent brownouts. Some imported oil for transport.

State of food production

Productivity declining as land is being exhausted by over-cultivation and single-crop farming techniques.

State of the environment

Soil erosion and frequent mud slides; no currency for reforestation or land reclamation; serious sewage, industrial waste and air pollution problem in built up areas.

Type of industry

Basic commodity manufacturers in large cities attract flocks of low-wage earners.

State of financial affairs

International demand for food exports provides some financial stability but export earnings must be used to buy energy and basic goods.

3.1 Role description STRATAGEM sector 1

Population and Household Consumption

Goal
Your objective is to obtain a stable population with a high standard of food and goods consumption and a high level of human services.

Initial conditions
You have 200 people. Food consumption standards are moderate - 2 units of food per person per year (= 10 units food per person per cycle!). The maximum possible in the game is 5 units per year. Material standards are low - 2 units of goods per person per year, where 15 units of goods per person per year is possible. Nor are human services (health and education) well developed. Currently the ratio of human service capital to population is only 2.25; 20 is possible.As a consequence your region is experiencing a very high birth rate, 41 per 1000 people per year and a rather low death rate, 18 or 22 per thousand per year (depending on starting conditions). Though your population is not richly fed, you don't presently consume everything you grow. The extra food was exported to earn money for your energy imports. During the last cycle you exported 1000 units of food. Goods may also be exported. However, you have not been exporting goods. All goods not used by the population have been invested inside your region. Your most important problem is to allocate enough goods to consumption, so that the material standards will rise enough to reduce birth rates, without at the same time lowering investment so far that economic growth stagnates.

Decisions: (the numbers refer to the numbers on the game board)

1) Allocate Total Food Available to:
   - Food for Population
   - Food for Export
2) Allocate Total Goods Available to:
   - Goods for Population
   - Goods for Export
   - Goods Available for Investment

Your actions indirectly affect:
- the birth and death rates, thus the size of the population, hence the size of the labor force,
- the energy required for the population, hence the energy that is available to the agricultural and goods production sectors,
- export income, and
- import requirements.

The cause-effect relationships of interest to you include:

a) BIRTH RATE

The normal birth rate depends on the average goods consumption per year. Actual consumption of goods per person per year is averaged over three cycles to obtain the average consumption (it starts at 2.0 in the range 0-15). The normal birth rate can vary from 10 to 30 per 1000 people per year. This relationship is shown in Figure 1. Its actual value is given in the output form.

Figure 1: Normal Birth rate

The actual birth rate is a product of the normal birth rate and the birth rate multiplier from human services, a multiplier reflecting the level of health and education services. This multiplier ranges from 1 to 1.5; it depends on the ratio of human service capital to the total population (which can vary between 0 and 20). It is shown in Figure 2. Its actual value is given in the output form.

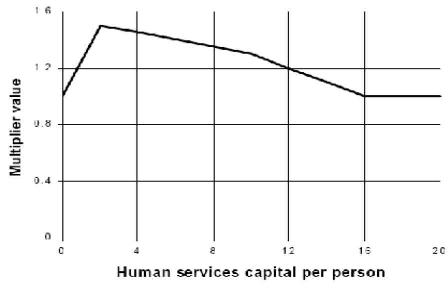

Figure 2: Birth rate multiplier as a function of human services

b) DEATH RATE

The normal death rate (ranging from 10 to 60 per 1000 people per year) is determined by food consumption per person per year (which can range from 0 to 5). The influence of food consumption per capita on the normal death rate is shown in Figure 3. Its actual value is given in the output form.

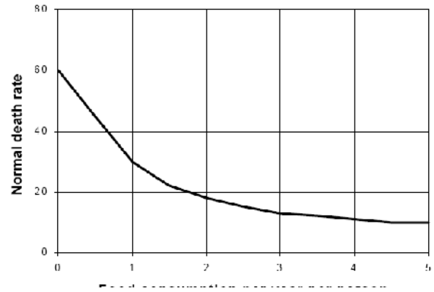

Figure 3: Normal death rate as a function of food consumption per year per person

The actual death rate is the product of normal death rate and the death rate multiplier from quality of the environment, a multiplier (ranging from 1 to 1.75) that depends on the quality of the environment. Quality of environment is 1.0 when everything is perfect and 0 under the worst possible ecological circumstances. This multiplier is illustrated in Figure 4. Its actual value is given in the output form.

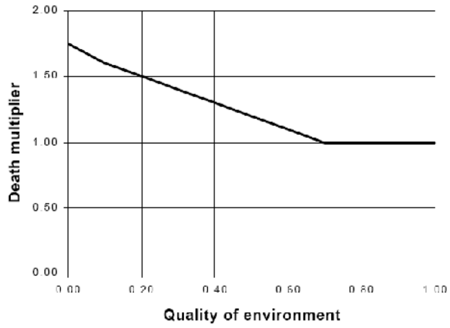

Figure 4: Death rate multiplier as a function of the quality of the environment

PLEASE NOTE:

• For each unit of goods you allocate to goods for population your colleague(s) in the energy sector must allocate 0.2 units of energy to energy for population. This demand has absolute priority over other allocations of energy like carryover, exports, or to support production in the agricultural and industrial sectors.
• The allocation of food and goods made at the beginning of each cycle determines the rate of population growth during that cycle.
• Significant reductions in per capita food or goods consumption from one cycle to the next will lower production in the corresponding sector. The relationships are shown in two curves that are included in the role descriptions for the food and the goods sectors (Figures 7 & 11).

Date : time :
Country : SHOW, Status at the start of period : 0 - 4, the year : 0

POPULATION AND HOUSEHOLD CONSUMPTION

The population is 200, resulting from a growth rate of 11.5% .
This percentage is based on :
an annual birth rate of 1.49 * 27 => 41 per 1000;
an annual death rate of 1.00 * 18 => 18 per 1000.
Last period each person received per year:
Food: 2.00 (range: 0-5); Goods: 2.00 (range: 0-15).
Human services capital per person was: 2.25 (range: 0-20).

Available for use in this period:
FOOD : 3300, of which ..... is for consumption, and ..... for export;
GOODS: 3500, of which ..... is for consumption, ... is for export, and
. .... for investment (total depreciation was 430).

3.2 Role description STRATAGEM sector 2

Energy Production and Energy Efficiency

Goal

Your primary objective is to ensure that there is enough energy to operate the goods consumed by the population and to operate the stocks of food production capital and goods production capital. You can reach this goal by requesting energy imports, by investing in energy production capital, or by reducing energy requirements through investments in energy efficiency capital. A secondary goal may be to export energy for funds that can finance food or goods imports.

Initial conditions

Your region has made no investments in energy efficiency, so that energy use by each unit of food production capital and goods production capital is high. The energy required to operate each unit of food production and the energy required to operate each unit of goods production capital is over three times greater than it would be with maximum investment in energy efficiency capital. Domestic energy production does not cover your domestic needs. Last cycle you imported energy, a serious drain on your export earnings, and still you do not have enough energy available during the first cycle to provide full capacity utilization of the food production and goods production capital stocks.

Decisions: (the numbers refer to the numbers on the game board)

3) Allocate Total Energy Available to:
   - Energy for Population (= 1/5 of 'goods for population')
   - Energy for Export
   - Energy carried over to Next Cycle
   - Energy Available for Production
4) Allocate Energy Available for Production to:
   - Energy for Food Production
   - Energy for Goods Production
5) Allocate some portion of the Goods Available for Investment to:
   - Energy Production Capital under Construction
   - Energy Efficiency Capital under Construction

Your actions indirectly affect:
- energy import requirements
- the goods available for investment in the other capital stocks
- the capacity utilization in the agricultural and the industrial sectors
- funds available for imports or debt repayment
- the quality of the environment

The cause-effect relationships of interest to you include:

a) ENERGY PRODUCTION

Energy production depends only on the amount of energy production capital. The energy sector is modeled in analogy to hydropower capacity, a renewable energy resource. There is no depletion, but there are diminishing returns to investment. This means that if you maintain your energy production capital at a constant level, it will produce the same amount of energy each year forever (achieving this will, however, require enough investments each cycle to offset depreciation). However, each further addition to the energy production capital stock produces a smaller and smaller additional amount of energy. (In your output form this is reflected in a diminishing value of the average energy output per unit energy production capital stock). The relationship between energy production capital and energy production is shown in Figure 5. There is a high and low output version of this relationship depending on the starting conditions.

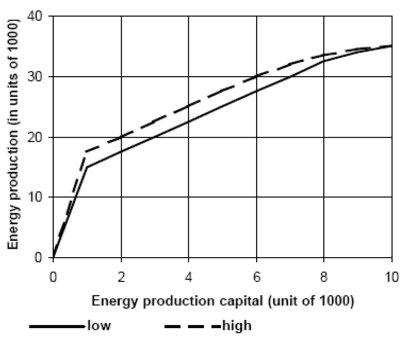

Figure 5: Energy production per cycle as a function of energy production capital (in units of 1000's)

PLEASE NOTE:
• In each cycle you must allocate 1 energy unit to the population for each 5 units of goods they receive in that cycle. This is implemented in the computer code, so Energy for Population is not an independent input decision.
• The lifetime of energy production capital and of energy efficiency capital is 25 years. Thus one-fifth of these capital categories is removed from production at the end of each cycle, after the production for that cycle has been calculated.
• When you have surplus energy, you may export the energy at the rate of one money unit for each energy unit sold.

Alternatively, you may simply leave the surplus units in the box, TOTAL ENERGY AVAILABLE, and carry it over to the next cycle. Thus the energy available at the beginning of each cycle is the sum of last cycle's production, plus imports, plus energy carried over. • Money allocated to energy imports in one cycle does not serve to reduce an energy deficit during that same cycle. Money spent on energy import purchase energy that only shows up in the stock of Total Energy Available at the beginning of the next five-year cycle.

• Your allocations of energy to food and goods production determine the Capacity Utilization (CU) of the respective capital stocks. Capacity utilization is defined as:

Capacity Utilization = energy allocated / energy required for full capacity utilization

• Since energy efficiency capital investments can only work on new capital, you are limited in the rate at which you can invest in energy efficiency capital. In each cycle the maximum possible investment in energy efficiency capital is equal to the sum of two investments (food production capital investment +goods production capital investment) made during the same cycle. So:

ENERGY EFFICIENCY INVESTMENT is smaller or equal: FOOD Prod.Cap.Inv. + GOODS Prod.Cap.Inv.

This variable is referred to as respectively CUF (food) and CUG (goods). It may vary from 0 to 1.1. Any energy in excess of that required providing both sectors with 110% capacity utilization is wasted. Note that by allocating up to 10% more energy than is required for full use of a production capital stock, you can effectively enlarge your capital stock by up to 10% above its actual level.

b) ENERGY EFFICIENCY

Each unit of food or goods production capital requires an amount of energy that is calculated as the product of the energy consumption multiplier and the normal energy required per unit of food or goods production capital. The values for the normal energy requirements per 5-year cycle are: 12.5 units of energy for a unit of food production capital, and 20 units of energy for a goods production capital unit. Investments in energy efficiency capital will lower the energy consumption multiplier (range: 0.3 - 1). One unit of energy efficiency capital will achieve full energy savings for one unit of capital. The relationship is shown in Figure 6.

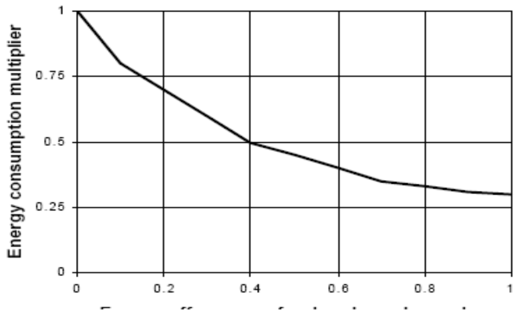

Figure 6: Energy consumption multiplier as a function of energy efficiency capital per unit of total capital in food and goods production

Date : time :
Country : SHOW, Status at the start of period : 0 - 4, the year : 0

ENERGY PRODUCTION AND EFFICIENCY

Last period 12000 energy units were produced. The import was 1500; carried over were 1000 units. So 14500 energy units are available.
This will be used as follows :

domestic energy use	(.....)	(400 was required last period)
food production	.....	(10000 is required for full capacity)
goods production	.....	(6000 is required for full capacity)
export	.....	(last period you exported 0)
carry-over	.....	(last period you carried over 1000)

The average energy consumption multiplier is 1.00 this period (range: 0.3-1), so for one period you need :
12.5 units of energy to operate one food production capital unit,
20.0 units of energy to operate one goods production capital unit.

This period 12000 energy units will be produced by 800 capital units (an average of 15.00 units of energy per unit energy production capital stock). From this capital stock 160 will be depreciated at the end of this period, leaving 640 units, unless you make new investments.

The energy efficiency capital is 0 of which 0 is depreciated at the end of this period, leaving 0 capital units, unless you make new investments.

In this period you will place under construction :
.... units of energy production capital,
.... units of energy efficiency capital.

3.3 Role description STRATAGEM sector 3,

Food Production and Environmental Protection

Goal
Your objective is to produce the food required to feed your population and support the necessary exports. This should be done in a way that maintains the environment at a high level of quality (max = 1.0).

Initial conditions
You have made no investments in environmental protection yet; thus the quality of the environment has deteriorated drastically. See for the actual value the output sheet. Thus you are losing significant part of the productive potential of your agricultural capital. In other words, your food production is significantly lower than it would be if the environmental quality were 1.0. Nevertheless, you remain a net exporter of food. Your population still has only moderate food consumption levels, and is growing rapidly. Because the energy sector has made no investments in energy efficiency, it is still comparatively expensive to fulfil the energy demands of your sector.

Decisions: (the numbers refer to the numbers on the game board)

5) Allocate some portion of the goods available for investments to:
- Food Production Capital Under Construction and
- Environmental Protection Capital under Construction

Your actions indirectly affect:
- the goods remaining for investment in the other physical capital stocks,
- export income,
- quality of the environment,
- the death rate of the population,
- total energy requirements in the region.

The cause-effect relationships of interest to you include:

a) FOOD PRODUCTION
Food production is the product of arable land AL (constant at 1000 hectares) and the land productivity per unit of area ALP. The land productivity ALP is a function of several parameters: ALP = ALPN * MFC * MFP * QE
ALPN = normal land productivity per year per unit of area (constant at 1.25);
MFC = the multiplier calculated from changes in the population's food consumption per capita from the last cycle to this cycle. (range: 0.4-1.0, as shown in fig. 7);
MFP = the land output multiplier from food capital, which depends on the ratio of active food production capital to agricultural area. The relationship is shown in figure 8. Active food production capital is the product of currently producing capital and the capacity utilization factor for food capital during the cycle (CUF, ranging from 0.0 to 1.1). Energy shortages will reduce the active food production capital correspondingly.
QE = quality of the environment, ranging from 0 to 1. It is governed both by regeneration and degeneration whose behaviors are described below.

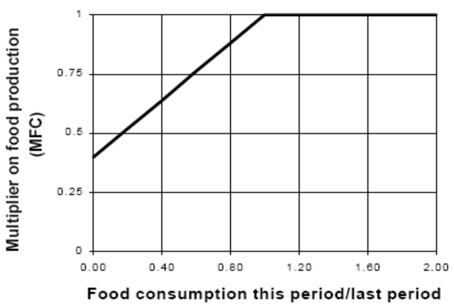

Figure 7: Multiplier on food production as a function of the ratio of food consumption this cycle to the last

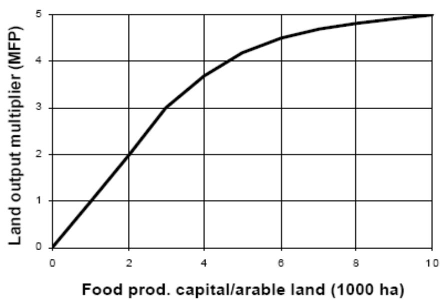

Figure 8: Multiplier on food production as a function of the active food production capital per unit of area (MFP)

PLEASE NOTE:
• The energy required each cycle to support full food production is the product of food production capital, normal energy use (a constant equal to 12.5 in this version of the model), and the energy consumptionmultiplier (which ranges from 0.3-1.0).
• The lifetime of food production capital is 25 years, Thus one-fifth of the food capital is removed from production at the end of each cycle, after the production for that cycle has been calculated.
• In the output form a formulae for the "expected food production" is given:
EXPECTED FOOD PRODUCTION = Constant * MFC * MFP * QE where the Constant equals AL * ALPN * 5 = 6250 (the cycle length is 5 years). The expected production is calculated using a default value for MFC (=1) assuming enough energy for full use of the production capital stock. In the calculations after your decisions this quantity is replaced by its actual value. The actual food production then equals this expected value times the capital utilization factor CUF.

b) ENVIRONMENTAL PROTECTION

The environment is degenerated by energy production capital, goods production capital, and food production capital. The negative influences of these capital stocks can be offset by investments in environmental protection capital. Each unit of environmental protection capital will offset the impact of 3.0 units of production capital.That means: the damage equals the quantity (AFC + AGC + EC) - 3 x EnvPC, where AFC = Active Food production Capital AGC = Active Goods production Capital EC = Energy production Capital EnvPC = Environmental Protection Capital.

The relationship governing degeneration is shown in figure 9. Note that food production capital and goods production capital are multiplied by their respective capacity utilization factors to determine their impact on the environment. This simply indicates that if energy shortages prevent some production capital from being used during one cycle, the unused capital does not affect the environment during that cycle.

The environment can regenerate itself. The annual regeneration percentage depends on the current quality of the environment, which ranges from 0 to 1. The relationship is depicted in figure 10. Note, when quality of environment equals either 0 or 1, there is no regeneration.

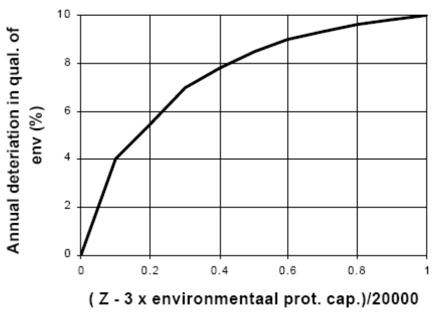

Figure 9: Annual percentage of environmental degradation as a function of the sum of differences of active production capital (Z) and environmental protection capital, scaled to 20,000. Z = AFC + AGC + EC

PLEASE NOTE:
• The lifetime of environmental protection capital is 30 years, thus one-sixth of the environmental capital stock is removed from production at the end of each cycle, after the production for that cycle has been calculated. • In practice the value of the quality of the environment lies in the interval 0.05–0.95, due tot the decreasing regeneration power and minor effects of rounding procedures in the balance of deterioration and regeneration.

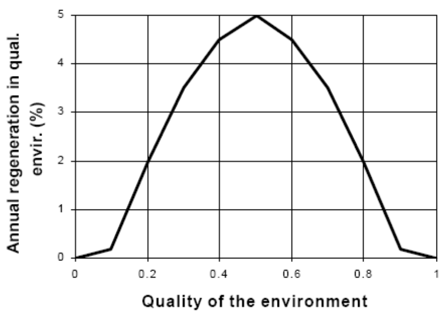

Figure 10: Annual percentage of environmental regeneration capacity as a function of quality of the environment

Date : time :
Country : SHOW, Status at the start of period : 0 - 4, the year : 0

FOOD AND ENVIRONMENT

Food production last period was 3300,
the import was 0, so 3300 units of food are available.
Last period the capacity utilization in the food industry was 1.00
and the consumption multiplier on food production was 1.00

The food capital stock is 800, of which 160 will be depreciated
at the end of this period, leaving 640 capital units, unless you make
new investments.

The environmental protection capital is 0 of which 0 will be
depreciated at the end of this period, leaving 0 capital units,
unless you make new investments.

Expected food production =	constant *	MFC *	MFP *	QE
3450	6250.00	1	0.80	0.69
(ranges:)		(0.4-1)	(0-5)	(0-1)

In this period you will place under construction :
.... units of food production capital,
.... units of environmental protection capital.

3.4 Role description STRATAGEM sector 4

Goods Production and Human Services

Goal
Your principal objective is to produce sufficient goods to satisfy the consumption needs of the population, the investment needs of the economy, and the requirements for export income from goods. You should also raise the health and education standards of the population, which in their turn will raise labor productivity and reduce the birthrate, by investing in human service capital.

Initial conditions
Productivity per capita of the labor force is low, about 1/9th of what could be attained by maximum investment in goods production capital and human service capital. Your region's labor force is not receiving a very high standard of living - that is, the goods allocated for the population during the previous cycle were low. They equaled only 2 units per person per year (= 10 units per person per cycle), 15 units per year is the maximum.Similarly, human services (health and education) are also low. Presently the ratio of human service capital to population is only 2.25; a maximum of 20 is possible.

Decisions: (the numbers refer to the numbers on the game board)

5) Allocate some portion of the Goods Available for investment to:
- Goods Production Capital Under Construction and
- Human Services Capital under Construction.

Your actions indirectly affect:
- the amount of goods available for investment in the other physical capital stocks,
- the quality of the environment,
- the productivity of labor,
- the birth rate.

The cause-effect relationships of interest to you include **a) GOODS PRODUCTION** and **b) HUMAN SERVICES**

The production of goods each cycle is the product of the labor force LF (always 25% of the population) and the labor productivity per capita LP (expressed in goods per laborer). The labor productivity is a function of several variables: LP = LPN * MGC * MGP * MHS
LPN = the normal labor productivity per year (constant at 1.155 in this version of the model);
MGC = the multiplier calculated from changes in the population's goods consumption per capita from the last cycle to this one (range: 0.4-1.0 as shown in fig. 11);
MGP = the multiplier from goods production capital, which depends on the ratio of active goods productioncapital to the labor force. The relationship is shown in figure 12. Active goods production capital is the product of currently producing capital and the capacity utilization factor for goods capital during the cycle (CUG, ranging from 0.0 to 1.1). If there are energy shortages, the active goods production capital during the cycle will be reduced, and output will be correspondingly lower. The capacity utilization factor CUG is the ratio of the energy allocated to goods production and energy required for full production of the capital stock.
MHS = the multiplier from human services capital which depends on the ratio of human services capital per capita. The relationship is shown in figure 13.

Figure 11: Multiplier on goods production as a function of the ratio of goods consumption this cycle to the consumption last cycle (MGC)

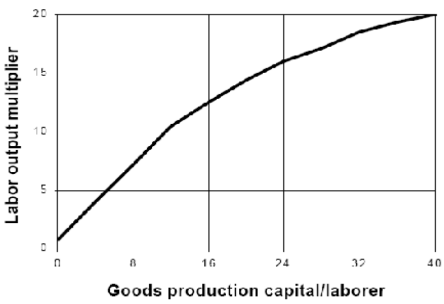

Figure 12: Multiplier on goods production as a function of the active goods production capital per laborar (MGP)

PLEASE NOTE:

- The energy required to support goods production is the product of full goods production capital, normal energy use per cycle (a constant equal to 20 in this version of the model), and the energy consumptionmultiplier (ranging from 0.3 to 1.0).
- The average lifetime of goods production capital is 25 years, and the average lifetime of human services capital is 45 years. Thus one-fifth of the goods production capital stock and one-ninth of the human services capital stock are removed from producing capital at the end of each cycle after the cycle's production has been calculated.

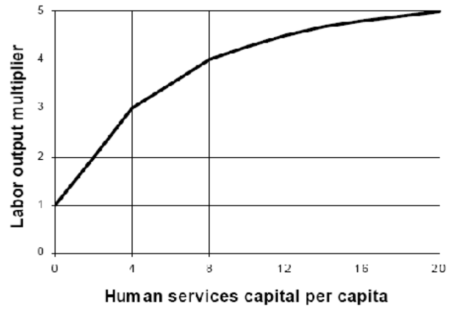

Figure 13: Multiplier on goods production as a function of the ratio of human services capital per capita (MHS)

- In the output form a formulae for the "expected goods production" is given:

EXPECTED GOODS PRODUCTION = constant * LF * MGC * MGP * MHS
where the constant equals LPN * 5 (= cycle length) = 5.775.

The expected production is calculated using a default value for MGC (=1) assuming enough energy for full use of the production capital stock. In the calculation after your decisions, this quantity is replaced by its actual value. The actual goods production then equals the expected production times the capital utilization factor CUG.

Date : time :
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GOODS PRODUCTION AND HUMAN SERVICES,

Goods production last period was 3000.
The import was 500, so 3500 units of goods are available.
Last period the capacity utilization in the goods industry was 1.00
and the consumption multiplier on goods production was 1.00

The goods capital stock is 300, of which 60 will be depreciated
at the end of this period, leaving 240 capital units, unless you
make new investments.

The human service capital is 450 of which 50 will be depreciated
at the end of this period, leaving 400 capital units, unless you
make new investments.

Expected goods production =	constant *	LF *	MGC *	MGP *	MHS
3450	5.775	50	1	5.60	2.1
(ranges:)			(0.4-1)	(0-20)	(0-5)

In this period you will place under construction :
.... units of goods production capital,
.... units of human services capital.

3.5 Role description STRATAGEM sector 5

International finance, Exports, Imports and Debt

Goal
You handle the region's foreign trade. You convert exports into their money equivalents, manage its debt, and allocate money to imports. Your objective is to manage the country's trade, so that there are enough goods, energy and food to attain satisfactory consumption and investment levels, while avoiding unbearable interest payments and preventing serious erosion in the terms of trade. In the financial world the GNP (Gross National Product) and the GNP per capita are important parameters of the economic well being of a region. Growth of these parameters indicates economic growth and will improve your prestige in the international financial world.

Initial conditions
You start with a slight surplus of exportable food and you may have a debt (depending on de starting conditions) to the international banks. Your interest rate is 10 percent, much lower than the return you can earn on many investments in productive capital. The Gross Domestic Product (GDP) of your country is measured as the sum of the output of the goods production and food production sector. Its initial value is indexed at 100. It’s current value and its growth or decline will be printed on your output form. Next to that a value of the GDP per capita will be presented in order to show the implications of population growth.

DECISIONS: (the numbers refer to the numbers on the game board)

6) Collect Foreign Aid, if any, and convert Energy for Export, Food for Export, and Goods for Export into money Available for Exports.
7) Borrow money if you wish to provide for greater imports (possible if your Maximum Loan is greater than 0).
8) Repay part of your Debt if you wish to reduce interest charges and lower the price of imports.
9) Allocate Money Available for Imports to one or more of the three possible imports: energy, food and goods.

Your actions indirectly affect:
- the amount of energy, food, and goods available in the next cycle,
- the interest rate, hence the interest charges, paid on your region's debt,
- the price of purchased energy, food, and goods, and
- a possible IMF intervention.

The cause-effect relations of interest to you include:

a) FOREIGN AID
Foreign aid is an exogenous input to the game, determined by the game operator. Typically there is no foreign aid.

b) IMF INTERVENTION
If your debt rises above 1/2 of your Gross Domestic Product (approximated here by the sum of total food and total goods production) 10% of your total goods production at the start of the next cycle will be used for repayments due to IMF intervention.

c) EXPORTS
The export price of food, energy and goods is constant at 1.0. Total exports are averaged over three cycles to determine your maximum debt and your interest rate.

d) IMPORTS
Imported materials are not available for use in the cycle during which money is allocated to them. They first show up in the stocks of available food, goods and energy at the beginning of the next cycle.

The possibility to invest money in technology imports is indicated on the board. This is not used in this version of the game.

The terms of trade will deteriorate, if your debt rises above average exports. The import prices of food and goods are normally 1.1. The normal price of energy imports is 1.0. These prices are multiplied by the import price multiplier, which grows from 1 to 2, if the ratio of debt to average exports rises to 5. The relationship governing the price multiplier on imports is shown in figure 14. An OPEC OIL EMBARGO may also be activated by the game operator to raise oil prices temporary; normally this factor is not employed in the game.

e) DEBT

The interest rate paid on your debt each cycle depends on the ratio of debt to average exports. It rises from 10% per year (that is 50% per cycle) to 20% per year, if debt rises to 5 times the average exports. The relationship is shown in figure 15.
You are not allowed to increase your debt with new loans, if the current debt is greater than your region's average exports. Of course your debt may rise above average exports, if your exports fall or if interest charges accumulate.
If you have excess money, you can "repay" more debt than you actually owe. In that case you will earn interest on the loan at the prevailing rate.

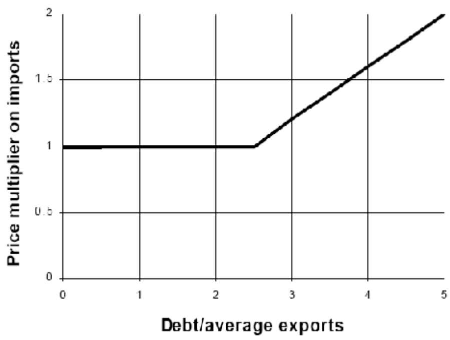

Figure 14: Multiplier on import prices as a function of the ratio of debt to the average exports

Figure 15: Interest rate as a function of the ratio of debt to the average export

PLEASE NOTE:

• The last part of the output form summarizes the decisions taken per cycle. Please fill out this form after your team has made all the decisions, and hand it over to the game operator.

Date : time :
Country : SHOW, Status at the start of period : 0 - 4, the year : 0

TRADE AND INTERNATIONAL FINANCE

At the start of this period the debt is 1000, the interest rate 10 %/yr.
Last period you paid 300 for interest charges.
The maximum loan in this period is 0.
Your GDP growth was 0 so your GDP index is now 100.
The GDP per capita index is 100.0

Your balance sheet:
money from energy export: (.....)
money from goods export: (.....)
money from food export: (.....)
money from foreign aid ..... (determined by game operator)
new loans: .....
---------- +
SUM OF THESE: (.....)
repayments: .....
---------- -
AVAILABLE FOR IMPORTS (.....) divided as follows:

for energy ..... (the import price is 1.00)
for food ..... (the import price is 1.10)
for goods ..... (the import price is 1.10)

Imput SHEET for STRATAGEM

Date : time :
Country : SHOW, Status at the start of period : 0 - 4, the year : 0

INPUT-SHEET STRATAGEM

After your team has made all decisions for the next period, please fill out the form below. The game-operator will use that form to enter the data. All entries should be multiples of 10. Please check this!

ALLOCATIONS		INVESTMENTS		INT. TRADE	
Food domestic	:......	food prod	:......	foreign aid	:......
exports	:......	env. protect	:......	new loans	:......
Goods domestic	:......	goods prod.	:......	repayments	:......
exports	:......	humservices	:......		
investm.	:......	energyprod	:......		
Energy		energyeff	:......	IMPORTS	
foodprod	:......			for energy	:......
goodsprod	:......			for food	:......
exports	:......			for goods	:......
carryover	:......				