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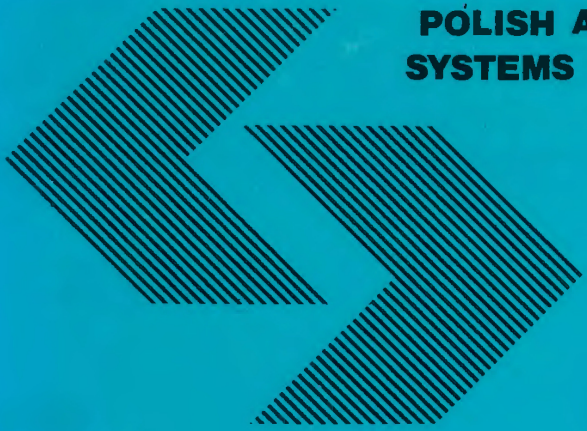

STRATEGIC REGIONAL POLICY

A. STRASZAK AND J.W. OWSIŃSKI
EDITORS

PART II

WARSAW 1985

SYSTEMS RESEARCH INSTITUTE
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STRATEGIC REGIONAL POLICY

Paradigms, Methods, Issues and Case Studies

A. Straszak and J.W. Owsiński
editors

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VII. SOFTWARE

MICRO-COMPUTER IMPLEMENTATION OF MEADOWS' GAME STRATEGEM-1 FOR REGIONAL PLANNING

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1. INTRODUCTION

High quality of planning depends most of all on well educated, conscious planners. In particular when considering strategic planning the planner should be conscious of dynamics and of relations among economic idicators, population, consumption, state of environment and other quantities. He should also foresee long term results of undertaken planning decisions. The game STRATEGEM-1 elaborated by D. Meadows, [1], [2], seems to be useful and attractive tool for training planners and decision makers. Players in the game take part as planners dealing with development of a country or a region. They play using typical playthings as table, pawns, money. However, results of their decisions are calculated by a simulation model implemented on a microcomputer.

The simulation model has been developed on Video-Genie microcomputer. Original Meadows' version has been extended by graphic procedures and utilised during the game session performed at the Conference. The graphical output proved to be useful for the players in understanding time relations.

2. GENERAL ASSUMPTIONS OF THE GAME

STRATEGEM-1 is an educational simulation game. It allows the players to analyse the dynamic and interrelations of main economic indices, population, consumption, and state of environment as depending on the decisions taken.
The following sectors are considered in the game:
- POPULATION and HOUSEHOLD CONSUMPTION SECTOR
- FOOD PRODUCTION and ENVIRONMENTAL PROTECTION SECTOR

- GOODS PRODUCTION and HUMAN SERVICES SECTORS
- ENERGY PRODUCTION and ENERGY EFFICIENCY SECTOR
- INTERNATIONAL FINANCE, EXPORTS, IMPORTS and DEBT SECTOR.

Five human players participate in the game. They are responsible for the particular sectors.

Basic players' decisions deal with:
- allocation of total food available among consumption of population and export,
- allocation of total goods available among consumption of population investments and export,
- allocation of total energy available among consumption of population, goods production,
- allocation of investment goods among sectors of goods production, environmental protection, food production, human services, energy production and energy efficiency,
- loans of money from the international finance sector and repayments of debt,
- allocation of money available for imports of energy, goods and food.

Decisions are taken in cycles. At each cycle, which relates to 5 years, the computerized model simulates state of the sectors as result of the decision undertaken.

The following quantities are derived:
- population,
- food, goods, energy and services production,
- production capital and capital depreciation,
- debt of economy,
- state of environment

and number of indices related to particular sectors.

The quantities are calculated in artificial, comparable units. They form the basis for the players' decisions in the next cycle. Game session is assumed to have ten cycles. The decisions are taken collectively.

Discussion of the players preceding the decisions making is important part of training process.

Goal of the players' strategies is formulated as a balanced development of economy which includes:
- high consumption of goods and food per capita,
- effective use of production capital,
- balanced foreign trade,
- good disposition of the environment.

In the simulation model, most of the nonlinear relations are given in graphical from. In the following the basic model assumptions are presented. Detailed information is given on sheets related to particular sectors and presented to the players.

Population dynamics depends on consumption of food, goods and of environment state. In particular birth rate decreases along with increase of goods consumption, death rate increases due to decrease of food consumption and to decrease of the environment state quality.

Quality of environment is decreased by production activities in sections of food, goods and energy production. Production of services and energy efficiency sectors are assumed as clean, non decreasing the environmental quality. The state of environment can be improved by investments in environmental protection capital. The environment can regenerate itself. The annual regeneration percentage depends nonlinearly on the current state which ranges from 0 to 1. In particular highly poluted environment the state close to 0 can hardly regenerate. Decreasing quality of environment decreases productivity in food sector.

The production sectors are described by nonlinear production functions in multiplier form of production capital, employment and other factors. In particular increasing indices of food and human services consumption increase the labor productivity. The production capital is formed in 5 - year investment cycle. Depreciation of the capital is taken into account and its rate depended on the sector considered.

Production capacities are limited by energy supply. Under energy restrictions production capital is not fully used. Indices of energy use in particular sectors can be decreased by investments

in energy efficiency sectors. This sector describes development of new, energy preserving technologies. Population has priority as the energy user. Its energy demand is in proportion to goods consumption and should be fully covered.

Debt of economy considered in the international finance, export, import and debt sector, influences the export-import relation. Increasing debt in relation to export makes terms of trade worsen. It makes also interest rate of loans worsen. If the debt is greater than 1/3 of the value of production of goods, food and energy together, a part of investment goods can be taken by game operator off.

In the model two variants of simulation are implemented, related to developing countries and to high equilibrium countries. The two variants differ in initial states and in some economic indicators.

For example a developing country is assumed to have less population, higher birth rate, lower consumption per capita of goods and food, worse environment quality state, higher indicators of capital use in production of goods, food and energy, higher indicators of energy use in production of goods and food. The country is assumed also to be exporter of food.

The game is appropriate for educational purposes. It allows the players to play the roles of planners. The players can observe influence of the decisions taken on economic development. They become conscious of dynamics and of relations among economic indicators, population, consumption, state of environment. During the game the players use physical things such as pawns, money, cubes replacing food, goods and energy. Decisions and main information are presented on a table.

The game equipment includes also simulation model implemented on microcomputer (mentioned before), sheets for recording decisions and simulation results, sheets with detailed information for players on relations in particular sectors, decisions, goals.

3. MICROCOMPUTER IMPLEMENTATION OF STRATEGEM-1

The algorithm of the game has been developed on VIDEO-GENIE microcomputer (compatible with TRS-80 MODEL I). The program is written in Level II Basic and includes all the functions necessary for introducing data, calculating current state in each cycle and demonstrating results. The initial conditions of the game are introducted into DATA - statements and are read after start of the program. Using those data the computer calculates the state of economy for the first cycle of the game. Then, in the interactive way, players' decisions are introduced from the keyboard. Each group of decision is checked for feasibility and some type of information is displayed on the screen. See an example below:

```
YOUR DECISION IS:
FOOD PRODUCTION = 190
ENVIRONMENT PROT = 200
GOODS PRODUCTION = 260
HUMAN SERVICES = 250
ENERGY PRODUCT = 200
ENERGY EFFICIENCY = 400
IS THAT CORRECT? (Y/N).
```

After introducing all data needed, the computer calculates a new state for the next cycle.

The players can again observe results of their decision and introduce new decisions for next cycle. Decisions and results for each cycle are stored in the computer, so that, at any stage of the game, a player can recover useful information. If a player wants to obtain information conected with each sector he selects the option: FULL. In this case he can observe current state of each sector. See an example for Population and Household Consumption Sector:

```
POP.    CONS
YEARS: 15-19
PO:1     260
PO:2    2050
PO:3    7340
PO:4       2
```

PO:5 24
PO:6 2.5
PO:7 4.19
PO:8 40

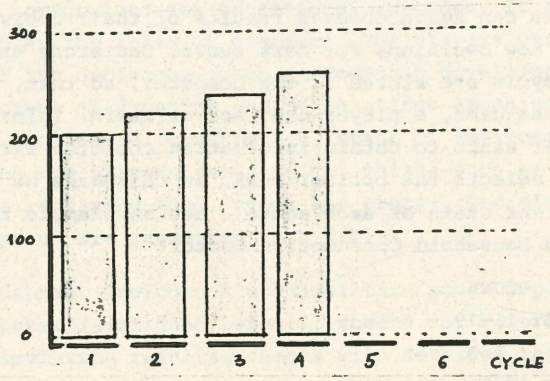
If the player selects the option: SUMMARY, he will observe summary results for the current cycle. See below:

SCORE SHEET
YEARS: 15-19

1. POPULATION 260	8. FOOD CAP P 1.56425
2. FOOD PC 2	9. IND CAP P 6.78571
3. GOOD PC 2.5	10. ENE CAP P 16.3636
4. POP.GR. 0.016	11. TOTAL FOOD 2050
5. DEBT -490	12. TOTAL GOOD 7340
6. QUAL.ENV. 25	13. TOTAL ENER 15000
7. EN.EF.MULT 0	14. AV. SCORE 101275

The players can also observe histograms (bar graphs) of variables at each stage of the game. For that they ought to select appropriate number of variable from selectoral sheet or score sheet. If for example, the player chooses number 1 the following histogram will be plotted on the screen.

POPULATION



Moreover the exact values of the variables can be displayed in the following form

1. POPULATION

CYCLE	VALUE
1	200
2	220
3	240
4	260

Graphic and numerical information are very useful for players' decisions during the game.

The program needs 32 kbyte of RAM memory and the printer is optional.

REFERENCES

Meadows, D.: Description of sectors in STRATEGEM-1 (unpublished) 1984.

Meadows, D.: STRATEGEM-1, training simulation game (private communication), November 1984.

DISCUSSIONS

Paper by K.W. Kim

Discussion participants: K. Polenske, R. Espejo, K. Kim.

It was clarified in the discussion that it is possible to apply the approach outlined to interconnected systems, and that this solely depends upon the availability of appropriate data. With regard to centralization-distribution question it was stated that at the moment of presentation the software systems were still created and run in a centralized manner. The problem of distribution was at the time being solved, both on the theoretical and on the technical levels. The main issue was to provide adequate links in cases when models are run in different locations.

Paper by A. Umnov

Discussion participants: R. Espejo, J. Hołubiec, A. Umnov.

Certain technical and methodological aspects of the software were discussed, and in particular: the model was presented as being manipulated mostly on the output rather than input side, so that it is possible to change a desirable state of the system once a solution is obtained and its rationality is assessed. Furthermore, the constraints to which solutions are subject allow avoiding of not quite uncommon spatial bang-bang solutions, practically infeasible in some situations (e.g. full specialization in foreign trade).

Paper by L. Kruś and J. Sosnowski

No discussion was recorded - main exchange of opinions took place in an informal way during the game playing.

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