

SYSTEMS RESEARCH INSTITUTE
POLISH ACADEMY OF SCIENCES

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS

CONTRACTED STUDY AGREEMENT REG /POL/1

**"CONCEPTS AND TOOLS FOR STRATEGIC REGIONAL
SOCIO-ECONOMIC CHANGE POLICY"**

STUDY REPORT

PART 3

APPENDIX: SOFTWARE AVAILABLE

**COORDINATOR, IIASA: A. KOCHETKOV
COORDINATOR, SRI PAS: A. STRASZAK**

ZTS/ZPZC/ZTSW 1-36/85

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Consisting of 3 Parts

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III. AN INTERACTIVE MICROCOMPUTER SYSTEM FOR THE ANALYSIS OF ECONOMIC MODELS

by

Andrzej Ziólkowski, Wojciech Cichocki and Cezary Iwański

III.1 Introduction

The economic reform which is presently being introduced in Poland created a demand for economic models based on new legal, fiscal, economic etc. regulations and a demand for computer-aided tools for the development and analysis of these models.

Changes of the economic rules that have been introduced, are essential. The managers must now deal with the problem they never faced before, e.g. with the nonlinear global wage regulator. Their previous experience and knowledge has lost its value, so that they must quickly learn how to live with the new rules. It seems that computer modeling is an appropriate solution for this kind of problems. The experiments on real life systems, are so costly, if at all possible, that the learning process is too slow. To the contrary, experiments on a computer model are cheap and give good chances to gain knowledge needed in decision making process.

In the last few years several computer models for a firm were developed at the Systems Research Institute: Cichocki, Stefański and Ziólkowski (1983), and Stefański and Ziólkowski (1984). On the basis of this experience in 1984 a new project was started with a goal to design a universal tool for the analysis of simple economic models on COMPAN-8, a small, 8-bit, Polish made microcomputer. At the same time a very similar tool was elaborated for the MERA-40 16-bit Polish made microcomputer. As the differences between these two systems are minor and are mainly caused by hardware limitations we shall call both the same generic name: ANAGRAF system.

In the paper the ANAGRAF system for the analysis of simple economical models is presented. The most important features of our approach are the use of graphical presentation of the results and a fully interactive process of the model development and analysis.

To assure the latter feature, a special non-procedural language has been developed. With the help of this special language the user can very easily update his or her model and obtain results in a graphical form for slightly modified models as resulting from e.g., variants of environmental behaviour, variants of labor productivity etc. All the results can be presented in one figure for comparison.

III.2 ANAGRAF's functions

The main functions of the ANAGRAF system are:

- creation and updating of the model definition in an interactive mode,
- evaluation of actual values of the model variables according to given definitions,
- presentation of results in a graphical form,
- presentation of results in a numerical form,
- saving on, and resorting from disk files of specific model definitions,
- displaying an actual model definition.

To create a model the user must define how to calculate variables used in the model. In the ANAGRAF system the model description consists of formulas. Each formula defines one variable. Some examples of correct formulas are given below:

A = 52.7

B = ((A - D) * F + (A - E) ** 2) / 100

C = D + 3, IF R/K > 50 : C = D + 9, IF (R/K < 30) OR (S=0) : C=D+6

The first one defines a variable A as a constant. In the second formula a variable B is defined as a function of variables A, D, F and E. The way in which the arithmetic formulas are written is very similar to that used in most computer languages as, e.g., BASIC or FORTRAN. The third formula is an example of a conditional definition of a variable. In this case a formula for the calculation of the value of variable is chosen depending on given conditions. The computer scans the expression from the left to the right. First, the value of variable C is set to D + 3. Then, the computer checks the conditions given after the word IF. If none of the condition is satisfied, the final value of this formula will be D + 3 (this corresponds to the ELSE clause used in many computer languages).

If any other of the conditions is satisfied, the formula written after first satisfied condition met during scanning of the expression will be chosen. So in our example if the first condition is satisfied, the variable C will be set to $D + 9$. If the first condition does not hold but the second is satisfied, C will be set to $D+6$. If both these conditions are satisfied, C will be set to $D+9$ because this formula was written after the first satisfied condition.

The language used in the ANAGRAF system is non-procedural. The order of putting the formulas in is not important. The order in which the formulas are calculated is automatically established during the analysis of interdependences between the variables. This feature is very attractive for an interactive work. To extend the model, the user may simply add new variables and formulas. If he wishes to modify the model, he can just write a new formula for the existing variable.

The most important function of the system is a graphical presentation of dependences between the variables used in the model. Using compact commands of the ANAGRAF system, the user can obtain a graphical presentation of a dependence of any variable upon any other variable. The system supports three types of curves:

- ordinary curves,
- parametric curves,
- isoquants.

Dependence between variables can also be printed in a numerical form if needed.

Because the user can change his model in an interactive mode, he may also need to store and then restore some version of the model. He may also need to display or print the formulas of his model. All this functions are also supported by the ANAGRAF system.

III.3 Interactive model development and analysis

The features of the ANAGRAF system are very helpful in the interactive work. The essential feature is a nonprocedural language for model definition, specially designed for this purpose.

Quite complex models can be defined in this language, because conditional evolution of formulas is possible, yet the language is still very simple and easy to use. The user need not care about the order of formulas, he rather specifies a relation between the variables than an algorithm. Extremely simple is model modification. New variables and formulas can be added to the model and the existing formulas can be modified at any time of the model development process.

In the ANAGRAF system it is possible to obtain more than just one curve in a graph. For example, the user can draw some function of one variable with one command and then in the same graph another function of the same variable. He can also draw some function with one command, then change the value of some model parameter, and draw the function once again. In this way he can investigate how some model parameter influences the model's behaviour. Of course, he changes not only the value of some parameter but the entire formula. In fact, he can compare in one graph two or more different models. In practice it may be more convenient to use different names of variables for introducing new model variants but the ease of model modification is essential in the interactive work. Interactive modelling is mainly a learning process in which the human decision maker gathers experience so that he must have a possibility to perform experiments. The facilities of ANAGRAF system allow one to perform efficiently all such experiments in an interactive mode.

III.4 System commands

The basic commands in the ANAGRAF system are those to introduce a new variable and formula defining it, and that to update a formula of an existing variable. Both have the same form given below:

```
< variable > = < arithm. expr.>, [ IF < logical expr.>:< variable >
= arithm. expr.>]...
```

The part in the square brackets is optional and may be repeated many times. All variables in a model have unique names. To assure readability, the names may be as long as 30 characters. A name may consists of few words separated with spaces. But such long names are not convenient because of a considerable typing effort.

In the ANAGRAF system an original solution to this problem is used. The full name of a variable consist od capital and small letters, digits and spaces. The user must type the variable name in the full form only,once in the definition of the variable. Then, in all other commands an abbreviation of the name can be used to save the typing effort. An abbreviation consists only of capital letters and digits used in full name. Below some examples of full names and their abbreviations are given:

Full name	Abreviation
Cost of Material	CM
Cost of Material	COSTMAT

However the user must remember that not only the full name but also its abbreviation must be unique.

The variable can be deleted from the model with the command in the form:

< variable > # e.g., CM #

The command

< variable > ? e.g., CM ?

displays an actual definition of the variable.

The commands to store the model definition on a disk file or to restore it are also very simple:

Write: [<drive>:] < file > [<extension >] eg. W: MODEL 1 .DAT

Read: [<drive>:] < file > [<extension >] eg. R: MODEL 2

The parts of the command in the square brackets are optional.

If not given, default values are assumed. Like in the name of variable the small letters in the command name need not by typed so that, for example, instead of Write only W can be written.

More complex are commands for drawing curves or printing tables.

The command given below draws a function of one variable:

Plot Function: < variable >, [< variable >] ..., X = < variable >

(< min. >..<>max.>, Y = (<min.>..<>max.>)

eg.,

PF: D, E, F, X = A (-10..10), Y (0..100)

In the command the list of dependent variables (functions to be drawn), the name of a independent variable and the ranges for x and y axes are defined. In the above example the functions:

D (A), E(A) and F(A) are to be drawn. The independent variable

A varies from -10 to 10. The range for the values of function

is from 0 to 100. The values out of this range will not be shown in the figure.

The command to draw parametric functions, isoquants or to print numerical tables are very similar in the form to the command given above. As it was mentioned earlier, the user can draw many curves in one graph with a sequence of commands. To clean the screen and to start with a new figure the command:

New Figure

is used. A hard copy of drawn graphs may be obtained by typing the command:

Hard Copy : number of copies

If the number of copies is not given, a default value of copies equal to one is adopted.

III.5 Remarks on implementation

The ANAGRAF system translates the model description from a source form to an internal form in which the Reverse Polish notation is utilized. Each variable definition can be translated separately but not all errors can be detected at that moment. All information necessary to recreate the source form of the model eg.: variable name, additional parentheses in the expressions is stored in memory, so that the source form with all changes introduced during a modelling session can be obtained, i.e. displayed printed and stored in a disk file if desired.

Let us consider what are the actions of the ANAGRAF system to perform a command to plot function of one variable. This example will explain to some extent how the system is constructed. The command is first interpreted. In this phase some errors can be detected as eg., a wrong command syntax, or variable name misspelling. Then, the program analyzes which formula must be calculated to perform the given command. Usually only few formulas are necessary because the variables that are not to be displayed and not influence the result need not be calculated. Then, the order in which the formulas should be calculated is defined. In this phase some other errors can be detected eg., undefined variables, looping in definitions. In fact, these errors are not related to the command but are rather caused by a wrong model definition. Then, the program sets the value of an independent variable,

calculates necessary formulas and plots the function in a graphical form. These actions must be repeated many times for different values of an independent variable in the range specified in the command.

The ANAGRAF system is written in FORTRAN with some small parts written in the assembler language.

III.6 Application to tax analysis

The ANAGRAF system has been used to implement the simulation model which allows us to illustrate the effects of applying different forms of the tax regulators connected with wage funds. We analyse those effects from the point of view of an enterprise. Currently, there are four different tax formulas which can be applied in Poland:

$$1. F = F_0 \left(1 + k \frac{\Delta S}{S_0} \right)$$

$$2. F = F_0 (1 + p)$$

$$3. F = k \frac{F_0}{S_0} S$$

$$4. F = F_0 \left(1 + k \frac{\Delta P}{P_0} \right)$$

where:

F - standard wage funds for the current year,

F₀ - standard wage funds for the previous year,

k - correcting coefficient,

S - production level in the current year,

S₀ - production level in the previous year, with

$$\Delta S = S - S_0$$

p - standard admissible increment of wage funds for a given year,

P - profit of the enterprise in the current year,

P₀ - profit of the enterprise in the previous year, with

$$\Delta P = P - P_0.$$

Those wages paid to the workers which exceed the standard wage funds F are charged with the strongly progressive tax paid from the profit of the enterprise. Tax formulas, which are the instrument of the economic policy of the government, are applied to the enterprise by the economic authorities for the period of 5 years. Thus the choice of the tax formula and its numerical parameters is very important for the further performance of the enterprise. Dynamic effects of the financial regulator are rather difficult to predict

in the coming year because of the strong nonlinearity of this regulator.

Computer simulation model which has been realized using ANAGRAF system, allows to observe changes of the chosen parameters of an enterprise in the coming 5 years. Among 72 input quantities of the model one can distinguish the following groups:

- information concerning the year 1985 which is treated as the basic one in further computations, including:
 - revenue
 - turnover tax
 - costs
 - profit tax
 - wages paid to the workers
 - standard wage funds
 - production level
 - employment
- quantities which specify the policy of the development of the enterprise in the coming five years, including data concerning the expected profits, production level, costs, wages and employment
- quantities which describe the environment, including the inflation rate, profit and turnover taxes and tax formula corrected with wage funds.

The output of the computerized model contains about 90 resultant quantities calculated for subsequent years, including the increase of profit, increase of production level, costs, profit attained before and after tax (regarding tax regulator connected with wage funds), increase of nominal and real average wages.

Using the ANAGRAF system one can easily update his or her model and easily obtain results for different versions of the expected development of the enterprise, for different tax formulas bound up with wage funds and different values of their parameters. All results of a simulation can be presented in tables and in a graphical form.

III.7 Concluding remarks

The ANAGRAF system presented in this paper is designed as a tool for economic modeling. Not all of economic models can be

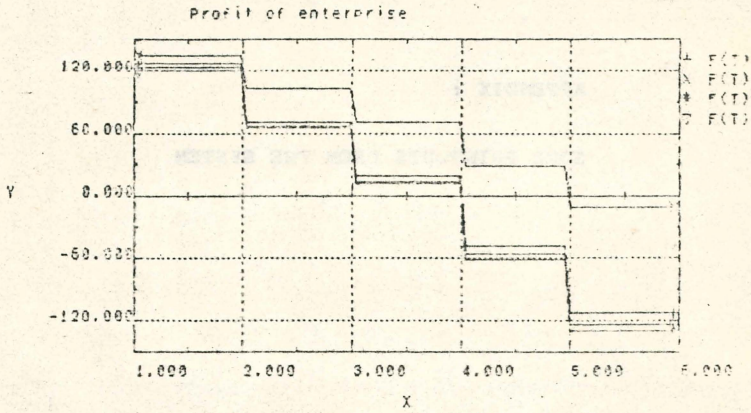
analysed with the ANAGRAF system but the class of models that can be analysed is quite broad. Of course, the ANAGRAF system need not be used in economic modeling only. It may be applied to any kind of modeling where models are in the form of nonlinear static functions. The most important features of the system are a graphical presentation of results and a fully interactive modelling mode.

References

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- J. Stefański, A. Ziółkowski (1984): Interactive models of microeconomic systems. Proc. of VI WOGSC Congress. AFCET. Paris 1984.

APPENDIX :

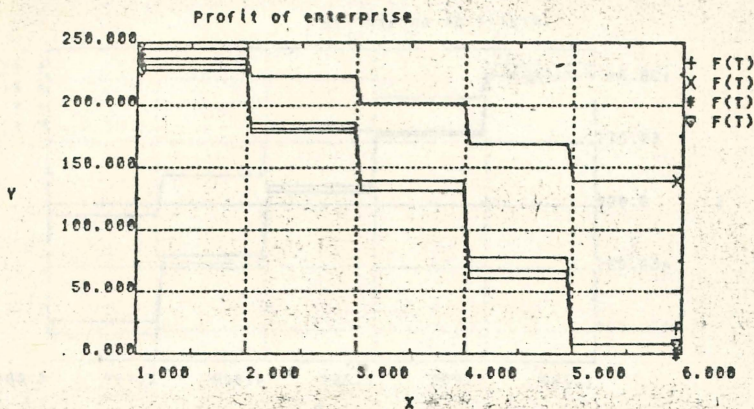
SOME PRINTOUTS FROM THE SYSTEM



X = F year
Y = F profit

: I
: F

- + 1st tax formula
- x 2nd tax formula
- * 3rd tax formula
- v 4th tax formula



X : T year
Y : F profit

: T
: F

+ 1st tax formula

X 2nd tax formula

* 3rd tax formula

v 4th tax formula

===== Modified (higher) tax free wage found 1985

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STUDY REPORT

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