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AGRICULTURAL UNIVERSITY OF SZCZECIN
FACULTY OF ECONOMICS AND ORGANIZATION OF FOOD ECONOMY

MODELLING OF ECONOMY IN SPECIALLY PROTECTED REGIONS

Proceedings of the international conference held on 9-11 june 1994 in Drawno, Poland

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APPLICATION OF GAME THEORY CRITERION FOR EXTENSION SERVICES FOR CONSTRUCTING ECOLOGICAL REGIONS

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Nowadays the demand for ecological food has a trend of growth. It is caused by the attitude to the consumer and also by the demands of ecological protection. There is no possibility to increase and/or intensify of the agriculture without, taking care of the environment. Because of these two reasons there is a need for planning new farms as oriented on production of ecological food and restructurization of old ones to the same orientation. This first step will allow the creation of ecological regions which will be very significant and efficient in the environmental protection process.

Application of the project of ecological food production needs a specific number of experts working in the extension area. The decision of creating a new ecological farm or restructurization an old one into an ecological one is a risky process. Because of this it is so important for the extension adviser to know all

the needed information and above all, to know all the possible implication of different decisions.

The present methods of supporting decision making in Polish extension services are based on such mathematical methods like linear programming and all the derived methods (like Integer LP or Mixed Integer LP). These methods do not consider the uncertainty.

The direction of work of scientists dealing with mathematical optimization was an attempt of incorporating in the most fulfilling way the uncertainty into the optimization models. Those attempts were succesful and resultes in development of a group of methods and algorithms that considered the uncertainty. But those methods and algorithms were too sophisticated to be applied in the extension services. The computing power was just too weak.

An example of such complicated methods are some criterion of game theory. During my research I have built a practical application of the Wald - Savage's criterion based on a typical spreadsheet EXCEL 5.0 by Microsoft. This spreadsheet, as a common software in Poland, may be used as a very useful platform for sophisticated decision support systems in the extension services at a low level.

The method

Mathematical programming (linear, non-linear, multiobjective, etc.) treated those problems of a single decision-maker, for whom the economizing problem is summarized by the objective function, instruments, and constraints. Game theory is the study of such situations where it is the possibility of more then one

decision-maker, in which case the value of the objective function for any one decision-maker depends not only on his own choices but also on the choices of the others.

The game theory is applied in a wide complex of sciences: mathematics, economics and mostly in the main "accelerator" of this science - in military science.

The main problem of game theory is the contradiction of the interests of the decision makers. One example could be: farmer contra nature. A standard form of a game against nature can look like as in the scheme 1.

Scheme 1: Standard game against Nature

		States of Nature (strategies of II player)				
		S_1	...	S_j	...	S_n
Instruments (strategies of I player)	S_1	C_{11}	...	C_{1j}	...	C_{1n}
	S_i	C_{i1}	...	C_{ij}	...	C_{in}
	S_m	C_{m1}	...	C_{mj}	...	C_{mn}

The set $\{S_i\}$ where i = 1, ..., m means the values of the instruments variables. This set is similar to analogical set in conventional LPM and it depends on the decision maker.

The second component of this game is the set of states of nature $\{S_j\}$, j = 1, ..., n. The states of nature can mean the state of weather, plant plagues, price levels and all other states of a factor that is connected with uncertainty.

The third element of the game is the pay-off matrix, built of the gross profits C_{ij} from a unit of S_i in the S_j state of nature.

A generalized form of the game theory is constrained games, that is those in which the mixed strategies of a finite rectangular game are further limited by linear inequalities. Such games allow a more realistic and convenient formulation of decision problems.

A model of a limited rectangular game may look like:

$$K(x,y) = \sum_{j=1}^{n} \sum_{k=1}^{t} x_j \; c_{jk} \; y_k, \tag{0.1}$$

$$x_1 + x_2 + \ldots + x_n = 1, x_j \geq 0, \quad j = 1, \ldots, n, \tag{0.2}$$

$$y_1 + y_2 + \ldots + y_t = 1, y_k \geq 0, \quad k = 1, \ldots, t, \tag{0.3}$$

$$a_{i1}x_1 + \ldots + a_{in}x_n \leq b_i, \quad i = 1, \ldots, m, \tag{0.4}$$

$$d_{h1}y_1 + \ldots + d_{ht}y_t \geq e_h, \quad h = 1, \ldots, s. \tag{0.5}$$

In this model c_{jk} are elements of the pay-off matrix, x_j and y_k are the mixed strategies of the first (the farmer) and the second (the nature) players, $K(x,y)$, where x and y are vectors, is the pay-off function that describes the paymant of the second player to the first one.

In planning of farm production under uncertainty the added constraints (4) are very useful for expressing the resource limitations, technical factors and all other that are important in the agricultural production. The limitations (5) are useful for including all available for the decision-maker information about the strategies of the nature. Very seldom the farmers are in the state of total ignorance, which is assumed in the classical models of games. Some information about the frequency of some state of nature is almost always available.

To the generalized constrained games some criteria were introduced three that have the best chances to be incorporated into practical applications for farming planning are:

- Savage's criterion,
- Hurwicz's criterion,
- Wald-Savage's criterion.

The Wald-Savage's criterion was introduced as one not having the weak sides of Savage's criterion. Wald-Savage's criterion makes sure that the gross profits won't be too small. The decision--maker, that uses the Wald-Savage's criterion can choose between bigger gross profit's minimum and smaller one and also between smaller and bigger regret[1] maximum. He can choose a solution that fits the best way his preferences and inclinations towards risk.

The Application

The spreadsheet EXCEL 5.0 is a very powerful tool that enables all operations on numbers. The data is provided in a form of tabulograms, which makes easy providing matrices or vectors as tables. Between numbers placed in such tables one can set relationships. One can also get new numbers as a solution of given rules on provided data.

The EXCEL 5.0 package contains also additional programs that enable more sophisticated operations on numbers. The most important tools are package of statistical analysis macros and solver of mathematical programming.

[1] The regret or risk is equal to the difference between planned value of a variable and their realized value.

The mathematical programming solver enables mini- maxi- and stabilization of a choosen variable through changing of other varables and holding on some constraints.

Because EXCEL is software that works under the WINDOWS operating environment there is a possibility for global data processing. The input data used for the building of the model can be not only be inserted into the cells of the spreedsheet but also imported from a big relational database working in this environment. The solutions in a form of non-processed numbers and/or professional generated reports can be exported directly into a word processing system, and/or back into the database.

The application, which I have prepared, is based on a spreadsheet EXCEL 5.0 and is supported by a system of management of relational databases ACCESS 1.2 and a sophisticated word processor WORD 6.0. All the applications, like the environment, are products of MICROSOFT.

The application solving model of a farm is started from Program Manager window. After a double click on it's icon EXCEL and this application starts automatically. The user controls the application through a menu.

The left part of a menu screen consists of buttons that start solvers. Three first are associated with described criteria of game theory.

The right panel of buttons is for the administrational use. They allow making charts, printing raports, importing data (thru MICROSOFT QUERY), closing the application.

Conclusions

The especially high level of risk in the management of farms that produce ecological food enforce new approches for farm planning. The solutions of plans must be multicriterial. A good way of solving such models may be the game theory criterion that can be solved by modern tools. The technology of numerical processing enables now a very easy way of solving such criteria by using very user friendly desktop computers and even more friendly software based on grafic user interface.

The proposed criteria of game theory provide the dicision maker with much more information that simple LP solutions. The use of standard software for WINDOWS environment makes sure that the tools may be very common and very close located to the farmer.

References

1. Alter, S. (1980), *Decision Support Systems: Current Practice and Continuing Challenges*, Addison-Wesley.
2. Basar T., Olsder G.J. (1981), *Dynamic Noncooperative Game Theory.*
3. Fudenberg D., Tirole J. (1991), *Game Theory*, The MIT Press, Cambridge, M.S. - London.
4. Intriligator, M.D. (1971), *Mathematical Optimization And Economic Theory*, Prentice-Hall, Englewood Cliffs, N.J.
5. McCosh A., Scott Morton M.S. (1977), *Management Decision Support Systems*, Macmillan, London.
6. Miklewski, A. (1986), *Zastosowanie wybranych modeli teorii gier do planowania produkcji w przedsiębiorstwie rolniczym*, praca doktorska, Akademia Rolnicza w Szczecinie, Szczecin.

7. Miklewski, A. (1992), *Teoria gier w planowaniu produkcji przedsiębiorstwa rolniczego a problem ryzyka*, w: Niepewność i ryzyko w działalności przedsiębiorstwa rolniczego, Instytut Badań Systemowych PAN, Warszawa.

8. Nabzdyk, T. (1994), *Zastosowanie wybranych modeli teorii gier w systemach wspomagania podejmowania decyzji uwzględniających ryzyko*, praca magisterska, Akademia Rolnicza w Szczecinie, Szczecin.

9. Nabzdyk, T. (1994), *Możliwości zastosowań nowoczesnych technik wspomagania decyzji w doradztwie rolniczym i gospodarstwach rolniczych*, w: Problemy doradztwa w restrukturyzacji i transformacji gospodarstw rodzinnych do gospodarki rynkowej, AR Szczecin, UMK w Toruniu, WODR w Barzkowicach, Barzkowice.

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