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APPLICATION OF OPERATIONAL RESEARCH METHODS TO
AGRICULTURE AND THE FOOD-PROCESSING INDUSTRY ^{1/}

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Introduction

The Federal Training Centre for Managers in Agriculture and Industry was founded in 1958, its main purpose being to train managers and technicians in agricultural and food-processing enterprises.

Training comprises long or short-term functional training courses lasting one or three months, and seminars lasting six to twelve days depending on the subject to be studied. During these courses and seminars, the managers and technicians are introduced to a range of scientific subjects which are essential to successful business, dealing with the theoretical, technical and practical aspects of business organization and management, operational psychology, technology, financial administration, etc.

The Centre's main activities are two-fold, being directed towards:

- i) Training and business improvement; comprising:
 - Training of managers and technicians;
 - Socio-economic training;
 - Professional training, and
 - Business organization in units or complete functional entities.
- ii) Automatic data processing.

Modern business management in a market economy where organizational forms are continually developing requires precise information on entrepreneurial activities. The more traditional information systems and data processing methods fail to satisfy modern requirements in terms of both quantity and quality, and improved indicators are essential to successful business management, better implementation of business policies and prompt decision-making.

Business data retrieval, processing and presentation is currently being modernized by means of various technical and electronic systems, ranging from simple technical aids, such as calculators, to computers of unimaginable capabilities.

The Federal Centre is concerned with the introduction of automatic data processing, as well as with the training of programmers, operators

and other specialists needed for such systems.

Application of operational research methods

Modern planning methods are being adopted by the economical enterprises with a view to establishing new forms of planning and economy. All innovations are based on the most recent scientific developments and the latest possibilities; they are user-oriented and facilitate the application of the most modern approach with the greatest degree of economic benefit.

One of the more recent system optimization methods based on mathematical and statistical methods is that of operational research. Since 1967 the Centre has been concerned with the training of specialists in agriculture and the food-processing industry through courses, seminars and practical operational research.

Foreign trainees

One of the Federal Centre's regular activities is the training of foreign trainees, acquainting them with Yugoslav agriculture, the food-processing industry and other branches of the economy. The course is directed towards scientific and technical achievements in the industrial and rural environment, with particular emphasis on such subjects as self-management, organization of work, technology and automatic data processing. Specialized (advanced) training courses have been held for periods of seven days to one year, participants numbering up to fifty-five per group or country. The specialized staff of the Federal Centre are supplemented by lecturers from universities, institutes and other institutions, as well as by experts from the enterprises in which practical training is given. Hitherto, foreign participants have come from the following countries:

Africa: Algeria, Chad, Congo, Egypt, Ethiopia, Gabon, Ghana, Ivory Coast, Libya, Morocco, Niger, Nigeria, Senegal, Sudan, Tanzania, Upper Volta and Zambia.

Asia: Afghanistan, Burma, China, Iran, India, Indonesia, Khmer Republic and Thailand.

Americas: Chile, Columbia, Costa Rica, Ecuador, Peru and Venezuela.

Europe and
Middle East: Czechoslovakia, France, Iraq, Jordan, Lebanon, Spain
and Syria.

Lectures are usually delivered in English, though other combinations are used, such as Arabic/English/Serbo-Croat.

Application of operational research methods in agriculture and food-processing industry

Developments in agriculture and the food-processing industry, manifest in ever-increasing production, processing and commercialization, are closely connected with trends towards integration and harmonization of business management and development. Thus, a need has arisen for more modern methods and decision-making procedures within such complex systems. The Centre went ahead with the establishment of a team of senior specialists in the application of operational research methods, starting in 1967 with:

1. Training of managers and technicians; and
2. Application of operational research methods.

Training of managers and technicians

Personnel training in the application of operational research methods to agriculture and the food-processing industry is effected through courses and seminars.

Courses

The aim of these courses is to train specialists from agricultural and food-processing enterprises in the application of operational research methods under determined business conditions and in the development of basic and integrated enterprises.

The participants in these courses are from the development, planning and analytical services of the economic and production sectors.

The syllabus is highly specialised, including training in operational research methods, organisation and business economics. The

theoretical instruction is supplemented by practical examples of the methods applied, practical advanced training being given on an individual or group basis with the assistance of the instructors.

The courses last two to four months depending on the range of methods being applied; they are arranged in cycles of twelve to twenty-four days co-ordinated with periods of less intensive development and analytical activity in the enterprises in which the participants are employed.

Seminars

So as to improve management techniques, executives, managers and technicians are provided with information about the advantages of operational research methods during seminars and consultations, several of which have been organized, lasting two to five days.

Application of Operational Research Methods

The Centre is not only concerned with providing advanced training in agriculture and the food processing industry, imparting theoretical knowledge about methods and techniques but it is also concerned with research into the application of this knowledge under specific working conditions. Experts from the Federal Centre have applied operational research methods to several agro-industrial combines, agricultural estates, factories and co-operatives. At present, they are working on a project entitled "Developmental optimization of the Vojvodina agro-industrial complex".

The application of these operational research methods were requested by responsible people who had concluded that classic decision-making methods and techniques failed to provide the requisite feeling of security. They felt that operational research methods through the application of computer techniques could accelerate the achievement of a more comprehensive basis needed to make business decisions and could explore all possible alternatives. Operational research methods involving linear programming and other systems can be used separately or on a complementary basis. In the field of micro-economics, there are twenty-seven applicable models and the regional aspects of the

Vojvodina agro-industrial complex constitute a special research field.

Application of linear programming methods

Linear programming is applied to different economic fields, using the simplex method to define the structural model and taking as parameters all possible alternative activities, starting from the market and product introduction, raw material supplies and semi-finished product to subsequent processing phases, including actual production and work organization variants. Calculations provide solutions with information on the optima adopted and the dual values of the maximum and minimum resources, as well as information on resource valorization through production phases and the dual not adopted. Therefore, each linear programming model assesses the optimization of possible alternatives within certain constraints, whereby specific activities are selected on the basis of their complex consequences and the maximization of given values. The complexity of the mechanism effect depends on the sector being defined by model. Hitherto, the Centre has applied linear programming methods in order to optimize:

- Crop production;
- Crop and cattle production;
- Mixed feed production;
- Milk production, processing and marketing;
- Meat production, processing and marketing;
- Sunflower production, processing and marketing of fruit and vegetables.

Some model characteristics

Applied linear programming models use the simplex method with a structural model definition, taking as parameters all actual conditions, alternatives and starting bases. Thus, all models have common characteristics irrespective of the differences in the economic fields being defined. The main matrix with the intersection of activities and resources, i.e. vectors and equations or inequalities, includes all input information on observed productions by phases, operations and possible organizational alternatives. This part of the model defines precisely all the technical characteristics and conditions of the given

production processes which form the basis and prerequisites for its accomplishment. Thus, crop production models start from soil quality requirements, taking into consideration the plant rotation laws and other conditions, characters of seeds, products, isolation, equipment capacities, human labour requirements for various working periods up to maximum potential yield under different conditions (irrigated or not), and the marketing sales conditions.

Apart from herd movements and feeding which depend on cattle categories, cattle production models require certain buildings for determined conditions of production organization. Industrial production models start from raw material sources and the observed production rhythm and possible alternatives and include all capacity requirements for materials, packing and storage (by-products) up to maximum national and foreign market values.

In production, processing and marketing linear models the basic part is defined on a most comprehensive basis - not the simple sum of several factors affecting production processes, but they must represent the emergent qualities of all interdependent conditions of given vertically integrated forms, possible market conditions being expressed as hypothetical alternative raw material sources or as the marketing of semi-finished versus finished products.

The second part of the matrix, i.e. righthand side of model (PHS), which defines the initial resource base, has been applied under different hypotheses with a variety of constraints. For instance:

Crop production models start from different assumptions about soil or from defining variations of equipment capacities and human labour, limited by existing capacities or opportunities of purchasing new equipment capacities or from introducing the hypothesis of no equipment and no qualified labour, so that the models optimize structure and work organization.

Livestock production models allowed for changes in existing herd conditions, housing capacity restrictions and machinery introduction practices.

Industrial production models define technical resources capacities and product marketing possibilities with given constraints.

The righthand side of the model represents special optimization conditions and the solutions thus calculated are within the given resources.

Comparative analysis of these solutions provides the information needed for making decisions on investment policy, purchasing, sales etc.

The criteria functions of applied models are given as economic functions for the purpose of maximizing production or minimizing costs. Economical utility is maximized in these models, but the cost of mixed feed production is minimized.

Applied models also use various purchase and selling price hypothesis permitting the optimization of alternative resource use to aid complex business decision making.

Elaboration and application of linear models

Only some characteristics of applied linear programming models have been described owing to the restrictions of a paper of this kind. However, it can be seen that the methods used are very complex and critical for decision-making, and the Centre's responsibilities can be appreciated.

Linear programming models can only be successfully elaborated by working with a team of experienced specialists to provide the necessary input information.

In other words, people responsible for the application of models under real agro-industrial conditions must collaborate with teams of production and economic specialists employed in the enterprises for which the models are being elaborated. Involving a team of this kind has advantages other than assuming accuracy of input information, in that confidence in the method and its results is inspired, thus improving the chances of their successful application.

Besides providing current information, linear programming models in their application have a long-term use. Each model elaborated represents an intellectual investment, which can be effectively used for years to come.

The main matrix mostly remains invariable, since the introduction of new information only involves slight changes of coefficients or new alternatives, such as price or product-mix changes. When the above mentioned team co-operates advantageously with the model users over an extended period of time, the Centre sends consulting missions to the enterprise and economists discuss all the phases in preparation for actual decision making. This collaboration which includes not only the application of scientific achievements to organisation and management, but also the acquisition of information through the Centre's consulting services is typical of this institution in all its activities.

Application of other methods

In its dealings with agricultural and industrial enterprises, the Centre has also applied other methods and techniques corresponding to the various research objectives.

Other methods have usually been applied on account of their complementarity to linear programming method, such methods being simulation methods.

Simulation methods

Simulation methods tend to systematise different hypotheses used as a base for calculating possible solutions with corresponding levels of economic effects. The optimum solution is not chosen, but the starting bases and solutions obtained with their given properties and results are presented to the competent authorities in order to let them evaluate corresponding alternatives.

Thus, a series of standard solutions have been elaborated using computer techniques in the fields of research into:

- cattle breeding

- pig breeding
- crop production
- capacities and labour utilization
- financing

Application of simulation methods

This standard programme series was based on actual research requirements in the above fields.

For instance, research into cattle production on a combined enterprise is based on the existing dairy cow herd, and considers the biological parameters appropriate to cattle as well as the possible variations of herd reproduction policies in order to stimulate the existing herd fluctuations over a period of ten years, with calculations being given monthly for livestock categories, in terms of milk, reproduction and fattening animals.

Since the results obtained did not satisfy the development requirements, the possible effect of purchasing pregnant heifers during the observed period was calculated. Following perusal of the solutions adopted, a standard programme was elaborated for feeding cattle on a monthly basis, indicating requisite feed-stuff production and purchasing.

All calculations reflected the economic benefit expressed as the difference between sales price and actual production costs, enabling comparative analysis and facilitating decision making.

Pig breeding programmes have been elaborated in order to provide more effective information on a weekly basis on livestock categories, in terms of feed-stuff consumption and sale of fattened animals, thus contributing to more effective management of such enterprise.

These programmes have also been used for the calculation of economic effects of piglet weaning after 7, 21 or 35 days, thus confirming programming adaptability. Crop production models can accommodate a great variety of combinational alternatives. Each production cycle is charged with variable costs per hectare, including direct equipment costs for seeding

structure. On the other hand, crop yields are simulated for a series of presumed years based on climatic variations (maxima/minima), whereafter acceptable variants are selected following analysis. However, not every acceptable variant can be used because seeding structures under actual production conditions cause demand to exceed capacities. Thus, the previous programme is complemented by separate calculations of the labour/capacity equilibrium, indicating alternative possibilities of work organization and operational priorities. Separate programmes can be developed to aid financial policy making. These may assume possibilities of obtaining outside engaging loans and credits, whose origins and borrowing conditions can be followed in three-month stages for a series of years. Such decision making should be present in the management of each enterprise.

Finally, it is to be noted that the Centre has also carried out research under the economic conditions of individual farms by regions and property structures. The combination of simulation methods and techniques have yielded more useful results for specialization of production in the private sector.

Past and future activities in the application of operational research methods

The above offers some insight into the activities of this Centre in the field of training managers and technicians in the application of operational research methods.

A summary of the experience gained during the application of operational research methods represents an even more complex task as it involves the experience accrued by a large number of specialists, whereas the staff of the Centre were only performers and consultants in matters of methodology. The benefits to be derived from these methods are manifest in the fact that enterprises concerned continue to utilise intensively the existing models and elaborate new models, when necessary, to improve results.

From the standpoint of mastering and applying the method, it can be concluded that the work on micro-economic models for complete enterprises

and units in a variety of economic fields has enabled the Centre to embark upon the three year project entitled "Developmental optimization of the Vojvodina agro-industrial complex," which has developed successfully alongside with other projects.

Specialists needed for the operation and development of agro-industrial complexes

Under current social conditions, new scientific, technological and economic problems have to be repeatedly solved by managers and technicians in agriculture and the food-processing industry. The question of effective management is becoming increasingly difficult and complicated. Enterprises increase in size daily, their organizational structure and human relations grow more complex. In a word, management in the traditional manner is becoming increasingly difficult.

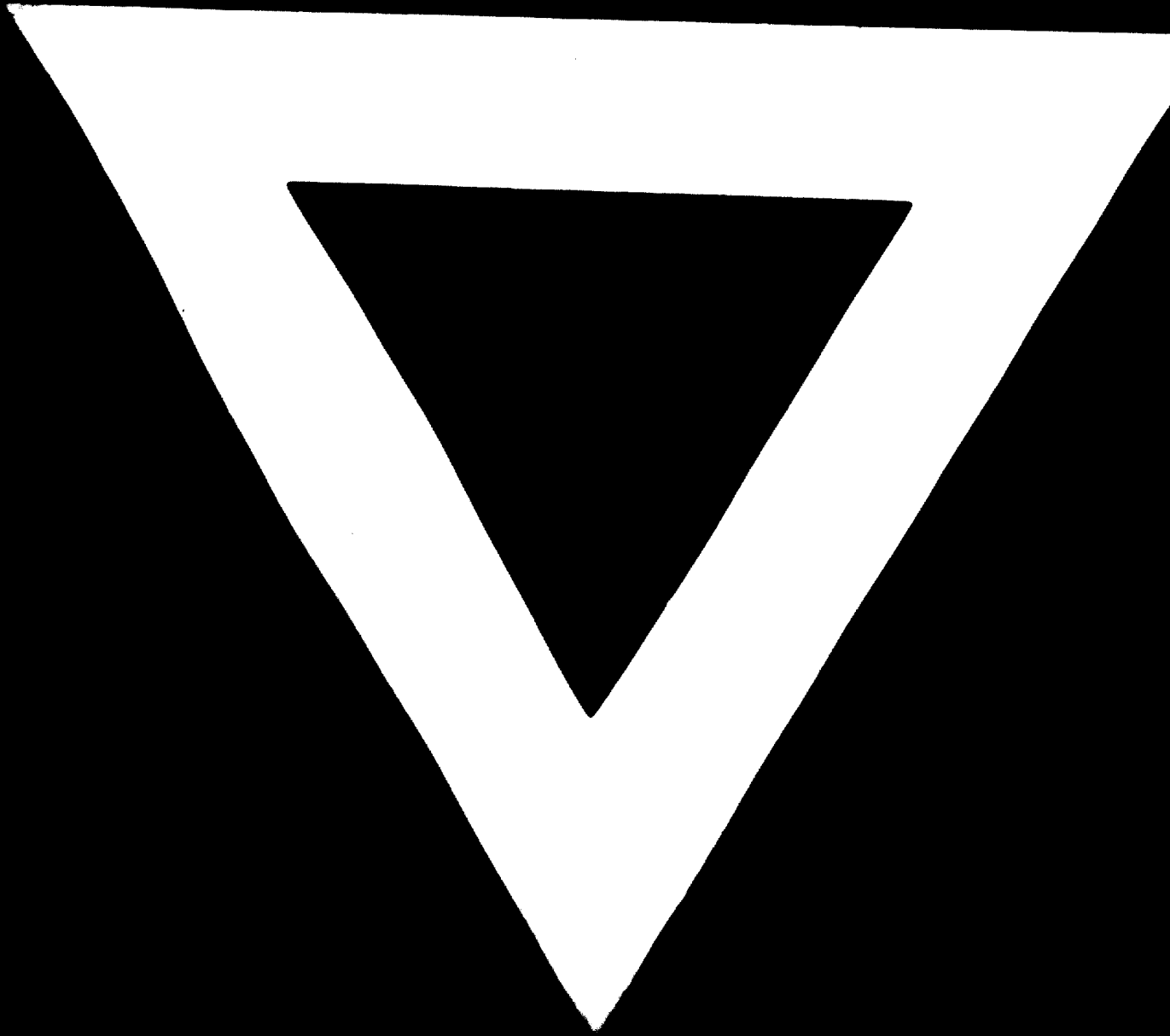
Economic development is outstripping managerial development, and the successful incorporation of managers in complex integrated enterprises in agriculture and industry is essential.

To ensure the effective operation of a large agro-industrial complex, staff requirements are as follows

- Organizers of complex operational and management systems with a corresponding technical and economic planning team as well as a socio-economic team;
- Methodologists and programmers for the application of operational research methods,
- Organizers of information systems; and
- System-analysts, programmers, operators and other data processing experts with experience on mini-computers and electronic computers.

The ever-growing need for specialized personnel can be met by means of continuous systematic functional training in all specialist fields. Knowledge acquired through normal channels is insufficient and has to be supplemented by training at the Centre and similar institutions if satisfactory results are to be obtained. The Federal Centre has had

hitherto over 20,000 participants in different courses and seminars. To avoid over-specialization, technicians in agriculture and the food-processing industry also receive socio-economic training at the Centre, thus contributing to more successful management. The past experience, current practices and future aims of the Federal Centre ensure that the Centre's functional training of specialists in agriculture and the food-processing industry will continue to be successful, even in the complicated systems of an agro-industrial complex. In achieving its objectives, the Federal Centre collaborates with outside experts, such as specialists from enterprises and different institutions, university professors as well as experts from abroad.



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