USING ECONOMIC OPTIMIZATION MODELS TO FIT INVESTMENT MEASURES FOR AGRICULTURE TO A REGION (ILLUSTRATED BY MEANS OF EXPERIENCE GAINED IN THE GERMAN DEMOCRATIC REPUBLIC)

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The adoption of scientific and technological advances in order to increase agricultural production implies rising demands on the scientific management of these advances. It has become necessary to use economic optimization models to help managers make decisions in an increasingly scientific way. Decisions regarding the modernization and renewal of the material and technological bases of crop and animal production in cooperative and state farms have a long term and lasting effect on production efficiency and, as a rule, are of a highly complex nature. For example, a model was developed to provide information relating to the agricultural use and development of a given region as comprehensively as possible. This was intended for large scale investment; for example, in the animal production sector, for rationalization and reconstruction of existing facilities or for new buildings, as appropriate. The mathematical background of the model consists of the algorithm for static linear optimization. It was possible to formulate the problem in 140 lines and 170 columns, and about 2,000 coefficients were used to quantify the relationships, conditions, and limitations.

The model links with major prerequisites which are being worked out for development according to the plan for socialist agriculture in the German Democratic Republic. These include long range draft plans for regional development which can be set up for administrative regions, such as counties or districts, or for regions that are distinguished by their special natural or economic conditions.

Once it is known, in principle, which are the preferred large regions for integrating investment measures for crop and animal production, the location has to be defined more precisely, and a decision made based on economic analysis. This is done by choosing macro locations, defined as regions in which the major production relations between the investment and its environment are being realized; for example, in animal production units, these are production and supply of feed, utilization of slurry, supply of labour, slaughtering and processing, and repair and services. Integration of investment measures result from the necessity of meeting the farm's need to extend its production capacity, and, in doing so, of making use of the possibilities of concentrating and specializing production, and, in this context, of optimally utilizing the production conditions of the macro location, and thus stimulating social development in the region concerned. Altogether, this approach is meant to contribute to (1) raising the output and effectiveness of production and (2) gradually improving the working and living conditions of the people working in agriculture.

The model described above was worked out to facilitate recording the most essential relationships--the input-output relationships--for making scientific decisions for such a complex task. It is meant to help in making statements on whether or not a proposed macro location would have sufficient resources for the regional integration of an intended investment and whether or not its use would be effective when compared with other locations, and measured by the initial investment cost and operating costs. At the same time, it is necessary to decide what the profile of agricultural production should be, and what the pre- and post-agricultural sectors in the given region should look like, given the long range objective of the overall national economy. This, in turn, provides conditions for a more precise detailing of long range and complex development plans for the whole region.

The investigations and model computations must allow for the major factors influencing the choice of location and the regional integration. According to the experience gained so far when integrating investment measures aimed at the expansion of animal production by rationalization and reconstruction of existing facilities or the construction of new units, the following factors proved to be most essential:

1. Securing adequate feed supplies for the livestock in the facilities, which are to be either newly erected or expanded by rationalization and reconstruction, and for livestock in the other units already producing in the given region.

2. Choosing the location of such investments, and making decisions on the concentration of animals to be kept, with due consideration to the existing or intended possibilities of effective utilization of slurry. Taking account of the requirements of socialist working and living conditions as well as of environment protection, the projected expenditure on slurry management should be low. An independent model for several variants of slurry management is first used for this purpose. The investment and technological costs, and the labour, energy, and material requirements are determined with due consideration given to the special local conditions. Slurry utilization has to be harmoniously integrated in the overall system of improving soil fertility for crop production by the appropriate organic and mineral fertilization.

3. Having the technical infrastructure, especially allocation of land, the local adaptation of the construction site, the development of the transport system, and water and energy supplies. Land use for construction purposes is subject to legal regulations. From the standpoint of the overall national economy, it should be confined to poor soils. The local adaptation for the most part comprises the preparation of the site when using standard projects. The inputs required depend on features of the terrain, the type of soil, and the groundwater table. Its site is, at the same time, an essential factor in overall building costs. The development of the transport system, even with extensive use of existing roads, often requires the tracing out of new routes and the fixing of their technological parameters. New animal production units or those extended by way of reconstruction make great demands on the regional water resources. Investment expenditures vary with the production profile of the unit and the related standard water requirement, as well as with the kind of water supply involved (public network or domestic wells). Parameters for energy supply and transformer plants are based on general practices for planning and project preparation of energy supply systems.

4. Meeting sanitary, safety, and veterinary requirements as stipulated in acts and regulations. Essential sanitary and veterinary aspects include, among others; avoiding excessive odours which might disturb dwellings and recreational areas; routing of roads, paths, and pipelines for the transport of animals, feed, and waste products to bypass built-up areas; providing sufficient land for the disposal of waste products with due consideration to ground and surface water conditions; excluding all possibility of emission hazards to the unit by existing or planned industrial plants; and maintaining safe distances between facilities to curb the spread of contagious diseases.

5. Increasing transport operations needed for both production proper and distributing the produce obtained. Transport distances should, as a rule, be kept as small as possible to minimize costs and losses, road load, and the

time cooperative farmers and workers need to reach their places of work.

6. Supplying replacement animals for the new or extended production units. It must be borne in mind that often there will not be sufficient animals available within the given macro location to secure replacments in line with the new requirements.

7. Having the necessary amount of labour available with the right qualifications. The investigations must therefore include the labour fund of the given region, its structure (age, occupation, and qualifications), and the possibilities of using it efficiently. It is also necessary to allow for the labour required for existing animal production as well as for the additional labour required for crop production in the macro location.

Most of the above factors for justifying the choice of a certain macro location and for regional and sector fitting of such investment measures can be quantified, and thus can be considered in model computations. When such investment measures are implemented in a given region, attention must also be paid to providing adequate living conditions for the people. The social infrastructure should be improved in an efficient way with as low an investment as possible. The following social infrastructure complexes are of prime importance: housing construction; institutions for care of children; education and public health services; trade and service sectors; and institutions and facilities for satisfying intellectual and cultural needs, and for sports activities.

Decisions on fixing the location and regional adjustments of investment projects can be prepared with due consideration of these aspects and of model computations. The model described above was worked out to provide the relevant information as comprehensively as possible. By using this model, it becomes possible to record and assess the essential factors involved in fixing locations and regional and sector fitting with all their multifarious interrelationships.

Starting from the planned growth of production, the following target functions are determined: minimizing production cost and investment, and maximizing net product and profit. With relatively low additional input, the model can be used to test several variants for the location under review so as to make full use of its available natural and economic resources. The model, therefore, is flexible and permits the testing of possibilities and consequences of fitting investment projects related to cattle and pig production. With certain modifications, it can also be used for investment projects in crop production, such as drying plants and processing and storage facilities.

The model can easily be used by enterprises other than the one where it originated. When it is applied to the same problem in another region, a large number of coefficients can be reused. The model computation provides information on the possibility, in principle, of fitting one or several investment objects into the macro location under review. This is essentially dependent on the results affecting the utilization of regional production resources. Thus, if the model shows demands on limited resources beyond those available in the location, it is necessary to clarify whether potential for expanding capacity would be available. If it is not, the intended scope of the investment project cannot be fitted into the regional scheme. In this case, it may be necessary to use another macro location with more substantial resources or to reduce the scope of the investment project.

If the regional production conditions are not sufficiently utilized, analogous adjustments have to be made in the opposite direction. When harmony is achieved between the expected use of the resources in the chosen location (or that considered to be correct) and the location requirements of the chosen investment project, the efforts can be concentrated on detailed information

regarding further consequences for the regional production structure.

The model results can be used to derive to what extent the major production sectors (including their land, labour, feed, and input requirements) would have to be developed so as to reach optimal targets in the macro location by combining new investments and existing production capacity. From this, it becomes obvious that results are worked out not only for new investments but rather for all the production within the territory of the macro location, and that this approach prevents one-sided decisions. Detailed results are computed for the scope and structure of land use, gross crop product (subdivided as market product, seed and planting material, and feed), feed conservation and use for the various species of animals, livestock by type and uses, gross animal product, labour input in animal production and crop production, level of investment, import and export of breeding animals and productive livestock in the territory of the macro location, and value coefficients of the production process.

Experience gained so far in using this methodology suggests that the approach described is suitable for scientific investigation of location and regional fitting of investment projects for animal production units, crop production, feed production, and other agricultural investments. This is not, however, sufficient in itself for scientific decisionmaking. Such decisions can only be made taking full account of the overall framework set by agricultural policy and of the socioeconomic conditions in the macro location concerned, in combination with the utilization of the results of the linear optimization model. In future work, the methodological instruments will see further improvement and definition and be supplemented by other methods. In principle, it is a first step towards the ever more fully planned and long term solution of the difficult and complex decision problems faced by cooperative farmers and workers in cooperative and state farms, as well as by government management agencies, so as to benefit every individual farm and enterprise as well as the socialist society of the German Democratic Republic as a whole.

RAPPORTEUR'S REPORT--Theodora S. Hyuha

Criticisms were made of underlying assumptions in the model about predetermined prices, social systems, and demand. There are agencies in the socialist system to determine prices and demand. These are external to this model. How relevant is the model to reality since it is linear and nondynamic, and since data may not be available in developing countries? There are limitations to the application of the model to developing countries. The model assumes that there is no trade, although its existence would hardly affect the predictions of the model. In the German Democratic Republic, the social system is determined by the socialist ideology. There is no difference between cooperatives and the state as they both serve the same purpose.