Making Investment Decisions with Economic-Mathematical Problem for Long-term Period in Agricultural Farms

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Summary: The problem of determining the production structure of the agricultural farms can be solved for short-term and long-term period. When the problem is solved in perspective, the solution should identify the size of investments, their direction, and how the created durable tangible assets (DTA) should be used.

To realize the investment process financial and investment decisions should be made. To this aim investment projects for each possible option are worked out. The choice is made through comparison of the developed projects according to separate indicators or according to a combination of them. The main disadvantage of this approach is that the choice is made without paying attention to the interdependence between the projects and between them and other already realized or possible to be realized activities.

While considering the problem with the investment use, the issue of the complex recognition of all conditions and interactions could be solved successfully with an economic-mathematical problem for production structure of the agricultural enterprise determination providing that a model for investment alternatives assessment is built in it properly.

The aim of the paper is to present an approach for more adequate incorporating of the conditions connected with the use of durable tangible assets and investment funds in linear dynamic economic-mathematical models for determining the production structure of the agricultural enterprise.

Key words: production structure of the agricultural enterprise, linear dynamic economic-mathematical model, modeling of investment process, investments, investment choice.

Introduction

To determine the production structure (PS) of an individual farm (IF) means to determine the area under crops, the number of animals and other activities that need to be developed in order to obtain the maximum profit or income."[7, pg. 3] In other words, determining PS of IF means providing an answer to the questions posed as to how much and how it will be produced.

The problem of determining the PS can be dealt with in a short-term and long-term perspective. Short-term planning is related above all to annual operational planning, where the problem

of using capital assets and investment funds is not solved and cannot be solved. This will be possible only if the problem is viewed as a long-term one[1].

The investment activity in real assets is a process of the transformation of capital into long-term assets and capital assets, in particular. For this purpose, individual investment projects are developed for each possible direction of investments, their efficiency is determined, and the most efficient alternative is chosen according to a selected criterion or set of criteria. The selected project is included in the IF. An integral part of this solution is the decision related to the sources of financing the investment. No matter whether the capital is part of the own capital or a loan, or a combination of both, to create, maintain and expand the activity of farm, increase its efficiency and, in certain cases, cover the seasonal differences between income and costs, it is necessary to specify the financing vehicles. Specific financial and investment solutions are involved in the implementation of this process.

For this purpose – as mentioned above – it is recommended that investment projects for each possible alternative for capital investment are elaborated. This approach (investment choice on the basis of developed investment projects for each possible alternative) generates good results. **In the evaluation of several independent projects, the task is to accept or reject the project** depending on the extent to which it meets the selected criteria. **The problems of evaluation of mutually incompatible or correlated investment projects are much more complicated**. Therefore, **the main weakness of the already mentioned approach to selecting, developing and evaluating investment projects** is the fact that **this choice is neither based on the interrelatedness between these projects**, nor on the correlation between **between the latter and the already existing or possible ones**. These are relationships, arising mainly from limited resources (labor, capital, land, etc.), or limited opportunities (for sale of the output, technological limitations, etc.), if there are such, of course. Therefore, this approach is not so appropriate for cases, where deficit resources are used and/or many limiting conditions are in place, regardless of their nature. And these cases are the predominant part of IF.

In our opinion, **sound investment decisions, taking into account in the best possible way the specific character of the agricultural units** (the links and functional relationships between the individual investment alternatives, between them and other production, and the conditions in which the farm is operating) **can be made using solutions of linear economic – mathematical problems (EMP) for determining the directions of development of IF**. They allow taking into account the complex impact of all factors, conditions and correlations and, on this basis, to make sound and efficient decisions on many questions, including that of the efficient choice between investment alternatives.

The linear EMP for determining IF's trends of development can produce practically applicable and efficient solutions to many important problems, including those related to investment, but only **in case they adequately reflect reality**. In the economic-mathematical models for PS of IF optimization with a view to the future developed and proposed by the known economic literature **the most serious criticism can be directed towards the way of reflecting conditions related to solving the issue of investment choice**.

[1] When speaking about optimization of PS of a given IF for the future it means most often to determine the directions of its development.

The problem of determining the directions of development of IF (and, in parallel, of the question of efficient choice between investment alternatives), can be solved using **static** or **linear-dynamic** EMP.

Weaknesses related to the inadequate explanation of the investment problem in **static EMM** are described in the Journal of Economics and Management of Agriculture, No 6/2005, where a way of they overcoming is proposed. In the present paper, we will try to do the same, but with respect to the **linear-dynamic EMM** of determining PS of IF with a view to the future.

The purpose of the present paper is to propose a way of adequate accounting of conditions, related to the use of capital assets and investment funds in a linear-dynamic economic-mathematical model for determining the production structure of an individual farm.

The issue

The problem of making a *complex assessment* of all conditions and interrelations when making a decision on the question of using investments can be successfully solved as a linear-dynamic economic – mathematical problem of determining PS of IF, including in an appropriate way the requirements of investment theory.

The development of the discussed problem, related to modeling of the investment process in agricultural units requires that the core principles of the classical investment theory be known and applied.

In general, the process of capital budgeting goes through the following stages: 1) Determining the cost-related money flows towards the project; 2) Forecasting the expected money flows from the project; 3) Forecasting the value of the assets created at the end of the period; 4) Determining the net money flows (NMF) based on the exploitation of the investment unit; 5) Determining the percentage discount rate; and 6) Evaluation of the investment project. The work on the linear-dynamic problem of determining PS of IF with a view to the future goes also through these stages.

As the principles, determining operations at each stage, are widely known and as the purpose of the present paper is different, they will not be analyzed in detail. It is necessary to mention that one of the most difficult tasks with investment projects in an individual farm is **determining the discount rate**. In this paper, **the method of the average weighted price of capital** has been adopted, as it is appropriate for use in dynamic environment, where companies employ different sources of long-term funding. [4]

Dynamic methods of evaluation of investment projects using a development problem for PS of IF have been applied. These are the method of net present value (NPV) and the method of annuited NPV, which provides for the comparability between money flows in different time periods. **Their advantages consist in the fact that the financial effect in absolute value is analyzed and the length of the project period is accounted for; they are easy to use and precise enough to ensure the optimization of the investment solutions.**

As it has been already mentioned, **in many cases the solution to the investment problem through the choice of investment projects turns out to be inappropriate for the individual farm, especially for farms, where specialization is broader**. In the individual farm, where annual crops are grown, usually there is a need for capital assets, such as land for the crops, machinery for the performance of all technological operations, buildings for the storage of produce, etc. *In most cases it is*

possible to grow more than two types of crops in this farm, using several possible technologies. Therefore it is necessary to determine the costs incurred for the respective output and the revenues generated from sales, so that the economic efficiency of this production is specified. Therefore, in order to make an evaluation of the specific investment, the specific IF's production structure has to be known, since the capital asset is utilized to obtain several products. And, as mentioned above, PS is yet unknown: it to be determined at a later stage, taking also account of investment opportunities. In the beginning of this process, there is available information on: 1) the possible income per unit of area under the respective crops, but not the size and technology of production; and 2) the costs involved in purchasing capital assets.

For instance, the possibility to grow wheat, barley, seed-corn, sugar cane, and others in IF, the potential revenues to be generated from the sales of the respective per decare output, and the tangible and labor costs for its production are known. Another known fact is the possibility to buy additional land, to construct an irrigation system on part of the available land and the costs of these investments. What remains unknown, however, is which of the mentioned crops will be included in PS, in what amount and whether they will be grown in conditions of irrigation or not. **It will be possible to determine in advance the cash inflows of mentioned investments only if there is an answer to the questions of what, how much, and how.**

Most researchers in the field of investments in real assets and the development of investment projects *do not pay due attention to this aspect* of the problem. [1, 4, 6, 12]

One of the few exceptions in this respect is S. Prodanov's study [9], where the optimal investment portfolio presents the set of investments with the maximum possible contribution to the achievement of organizational goals in view of the given limits. "A realistic interpretation of the problem of combining financial and investment solutions is achieved by applying linear optimization models." [9, p. 93]

We share S. Prodanov's opinion that using linear optimization models is justifiable only under specific circumstances. A similar model can be used in case of limited resources and/or in case of interdependence between investment projects. Our main arguments in this respect are mentioned above, namely that factors related to IF should be considered in their internal relation and dependence. This can best be achieved if the linear programming method is preferred to the traditional method of ranking investment projects in terms of their contribution to the company goals with limited resources.

In our opinion, the problem of using investment funds to create or purchase different capital assets must be solved in parallel with solving the problem of determining the future PS of a given IF. On the other hand, **it is not possible to find a working practical solution to the problem of determining the directions of development of the given IF, unless the most efficient possible way of investing in capital assets is found, as well as the efficient use of the already existing ones**. This is the way to account for **the complex character and the interrelations between the factors and conditions**, on which making management decisions aimed at the **improvement of the efficiency of the activity of an IF as a whole** depends.

Solving the investment problem by linear-dynamic EMP

The linear-dynamic (multiperiodic – in English language literature) programming provides an opportunity to determine the optimal strategy

for growth of the farm, and the obtained solution shows the size of investments, the type of created (acquired) capital assets, as well as the "path" towards reaching the defined goals.

Production undergoes several stages in an individual farm, just like the process of building and acquiring capital assets. The main features of multi-stage production processes is that operations are performed in a number of successive stages and the size of each operation is closely dependent on the other in sub-periods. Thus, the types of operations during successive production stages are mutually dependent. [7]

A main problem of the application of linear programming in making sound decisions, related to the investment activity of every IF, is **how to express the dynamic character of production, of financial processes, the change in the size and type of resources for a long period of time in developing EMP**. It is necessary to present adequately and objectively the related successive production stages, which should be taken into account in the solution of EMP to determine PS of IF in perspective. In EMP, it is necessary to look for an adequate way to present factors and conditions, so that the size of operations is determined in the course of several successive production periods, taking into account changing conditions and factors of production, in order to ensure balances of the intermediary products and account for the sequence of production of the intermediary products and their consumption to a maximum economic effect. [7] On the other hand, including balances in the linear-dynamic problem allows maximally satisfying the needs of future development, taking into account the available production conditions in the beginning and the ones created subsequently.

The dynamic LP, in its turn, allows making decisions for the optimal management of processes that change in time. They allow drafting plans for each year of the planned period, so as to maintain the optimal resource distribution between the operations performed in the farm, etc.

The solution to the linear-dynamic model describes the direction and amount of changes, which occur at the initial state, as well as the timing of these changes. **Not only does it provide answers to the questions of 'what', 'how much', and 'how', but also answers the question 'when', i.e. it reflects the development of production. The solution to the linear-dynamic economic-mathematical problem shows the investments to be made, in what fields and the final result expected to take place for the whole considered period, if the production program is completed.** It is also possible that the sources of accumulation and the period of creation of new production funds are specified.

The linear-dynamic model has a block structure, where each one of the blocks corresponds to a specific stage of the considered period. Each block must reflect the conditions and requirements that the pursued solution must satisfy during that period. Each block reflects the link between the output, produced during the respective, preceding and following period. In addition to the block for each subperiod, one block is included to account for the result of operations during each one of the subperiods, on the basis of which the target function is formed.

We believe that the problem of the successful investment process modeling can be solved by applying the linear-dynamic model, provided the latter encompasses an appropriately integrated module, which will allow solving the problem of directing investments and using capital assets.

The module we suggest (the system of unknown variables and constraints and a part of the target function for registering conditions where the solution to the investment problem is necessary)

includes two groups of unknown variables, referred to as:

First group – defining the amount of capital assets to be created or acquired during the respective year of the planned period.

Second group – defining the amount of own capital and loans to be invested during the respective year of the planned period – each of the capital assets is included in EMP with two unknown variables – the first shows the part of this asset that will be created (acquired) by own capital, the second – the part by loans.

Thus, the limitations of the proposed module can also be separated into two groups:

First group – they determine the maximum possible size of capital assets that are being created (acquired) for the respective planned period. They are formulated as follows:

$$\Sigma x_{ij} \leq B_i, \quad (1)$$

where:
x_{ij} – the size of the i-th type of capital assets, created (acquired) by funds from the j-th source
B_i – the maximum possible size of the i-th capital assets, created (acquired) during the first year of the planned period

Second group – the constraints of these groups determine:

a) the maximum possible size of investments during the respective year of the planned period for each type of capital source:

$$x_j \leq B_j, \quad (2)$$

where:
x_j – the size of the invested capital from the j-th financial source during the respective year of the planned period
B_j – the maximum size of the j-th financial source provided during the respective year of the planned period

b) the ratio between own capital and loan in investments during the respective year of the planned period:

$$a_{ic} * x_{ic} \leq x_{ik}, \quad (3)$$

where:
x_{ic} – the amount of own capital that can be invested during the respective year of the planned period
x_{ik} – the amount of loan capital that can be invested during the respective year of the planned period
a_{ic} – denotes the coefficient, used to introduce the desirable ratio or the one determined from practice

c) there is a requirement to limit the amount of created (acquired) capital assets for the respective period according to the available capital :

$$\Sigma a_{ij} x_{ij} \leq x_i, \quad (4)$$

where:
x_{ij} – the amount of the j-th capital asset created (acquired) during the respective year of the planned period with the money from the i-th source of capital
a_{ij} – the price of unit of the j-th capital assets, created (acquired) during the respective year of the planned period by funds, provided by the i-th source of capital
x_i – the amount of the i-th financial source during the respective year of the planned period

d) limitations ruling out the possibility that capital assets started (created) during a previous year will not to be completed (used):

$$x_{i(t-1)} = B_i, \quad (5)$$

where:
$x_{i(t-1)}$ – denotes capital assets of the i-th type, created during the previous period of the considered planned period
B_i – denotes the amount of created (acquired) capital assets of the i-th type during the previous period of the considered planned period

The following target coefficients are written in the target function with optimality criteria "maximum the annuited net present value of profit" in front of the different groups of unknown variables:

- in front of commodity crops – annuited net present value of the result (income money flows minus material costs);
- in front of animals – annuited net present value of the result (income money flows minus material costs);
- in front of unknown variables, denoting the number of employees – annuited net present value of salary costs wit the sign "-";
- in front of unknown variables, denoting newly acquired (newly created) capital assets – annuited net present value of the result (initial investment cost with the sign "-",income money flows with the sign " + ", material costs with the sign "-");
- in front of unknown variables, related to investments target coefficients are not written;

The linear-dynamic model allows to:
- give an answer to the question which investments are to be made and in what fields, the stage at which their creation and/ or acquisition should start, and the total final result, obtained throughout considered period;
- show the sources of capital, the time of its accumulation, the capacity to pay off the debt;
- take account of the time necessary for the realization of a particular investment
- take account of the possible changes in the conditions, which the sought solution is to match during specific subperiods; several versions of the activities can be developed quickly and easily depending on expectations
- different possibilities of obtaining a loan can be examined, its maximum amount, the conditions to be granted the loan, the state of the farm, etc. It is easy to check, what would happen, if ... ?
- as two unknown variables for each possible investment are included to account for the price of capital (own capital and loans), the price of capital is reflected adequately, according its source.
- to make investments using a combination of own and loan funds, as it is neither possible nor economically rational to use capital only from one source.

The weaknesses of the use of linear-dynamic modeling are the following:
- the linear-dynamic modeling is significant in size and its development is time-consuming;
- there is much higher probability of making technical mistakes.

In the process of realization of its current and investment activity, every IF faces limited resources – land, labor, capital, as well as the interrelation between investment projects. There are indisputable advantages in applying linear-dynamic modeling, as the most efficient combination of investment projects can be selected. The proposed approach is adapted to market conditions, in which farms operate, and allows making an evaluation and choice of investment direction or directions, at the same time accounting for both other output in IF and opportunities to use loans and the conditions for this. Different versions of action can be developed using this approach; the changes in external and internal environment can be registered; it is possible to evaluate to what an extent taking a loan would be beneficial, at what price, etc.

Conclusions

1. Using investment projects as a means to solve problems, related to the choice of investment solutions in IF in many cases does not lend satisfactory results, as **interrelations between the investment projects themselves, on one hand, and between them and the existing or possible new production – on the other, are not taken into account**. This problem can be resolved much better using linear programming and, in particular, linear-dynamic EMP to determine the directions of development of an individual farm.

2. The problem of directing investments in IF can **be successfully addressed also by applying a linear-dynamic model, provided that the model developed by us is also inserted in it in the way proposed by us, related to the solution to the investment problem**.

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