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# Optimal Allocation of Investment Resources for Agricultural Holding Modernization Using the Linear Programming

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**Abstract.** Realizing a favorable environment for achieving the sustainable development and a functional market economy, in context of actual economics restrictions, requires massive investments in productive capacities. Investments represent an important vector in promoting economic growth for any emerging country as Republic of Serbia and Romania are. In this context, for achieving best results for each investment well-designed projects are required. Nevertheless, a project needs programming for fulfillment its goals. This papers aims is to present such an investment project carried on with a mix model of financing, both with own and borrowed finances. Using linear programming it was, also developed, an investment scenario for a sheep farm, taking into account financing restrictions imposed by the financiers like BIRD and SAPARD programs.

**Keywords**: investments, project, financial allotment, linear programming, investment model, efficiency

## INTRODUCTION

In the actual period of time, the economic competition records levels, forms and implications in a continuous growth and diversification in all spheres of human activity (Done (2009) driven especially by the globalization process and in particular by the further integration of national economies in different economic areas. So, in agriculture, in particular, despite the relative immobility of the natural factor of production (nature), more and more ways to attract and recovery of resources and combination of different factors of production are multiplies.

In the literature as Bruinshoofd and Letterie (2004), Cicea *et al*. (2008) and Chivu *et al*. (2003) the aspects regarding the investment decision are multiple. Many authors including Subic (2007), Ionita and Blidaru (1999) and Done (2009) analyzing investments consider proper a model of capital investment when the capital it is costly and provides a theoretical discuss regarding connections between liquidation, finance, and investment, reaching at the conclusion that the investment equation is associated with a lower sensitivity of corporate investment to financial variables Bruinshoofd and Letterie, (2004). On the other side other authors as Fazzar and Petersen (1993), considering the investments in working capital concludes that is very important for a firm to invest in fixed capital accumulation that later may become signals for investor in relevance of financing constraints.

With the three largest contemporary core crisis: energy, food and human having a dramatic tendency to integrate into organic functionality, the main goal of restoring and maintaining balance involves the appropriate allocation of investment resources to all those

areas and industries capable of legitimate general multiplier effect on the economy and therefore a value added.

Such investments (Vasilescu *et al*. 2010, Cicea *et al*. 2008) improve the competitiveness of the economy by exploiting both the economic potential, as well human and financial one, by shifting the capital, own or attracted to a superior value in use.

Diversity investments plans involves a large variety of decision Ionita and Blidaru (1999), which hast to be taken and it must have a well-founded economic support. It should however keep in mind that not all investments projects can be considered investments, namely, those that contribute to the growth and diversification of production capacity by exploiting the resources raised in conditions of high competitiveness could be considered investments.

Mobilization of the financial resources necessary to carry out investment projects is done both by using the classical mechanism (Cicea *et al.* 2008) of own financial resources mobilization from depreciation fund, by using parts of earning profit or by using the capital market instruments as stock or bond issue and last but not least the attracted investments funds. Using this the investor is able to mobilize enough funds as external sources such as BIRD loans or PHARE, which provides significant financial support and partially granted money oriented to develop investment in production facilities.

In this study, we propose to establish an econometric model of allocating investment resources starting from the existence of a private agricultural company, which will use this process both own resources and attract finances.

## MATERIALS AND METHODS

In this paper we use linear programming in determining a resource allocation plan for investment in a sheep farm. Despite linear programming is a relative easy statistic method, in this case it was considered proper. The restriction criteria imposed by the financiers are well achieved in this context, and the influence factors can have a good representation in this model. For solving a linear model with rational expectations in literature were used models as those described by Blanchard and Kahn (1980) and Sims (2002). Also, the optimization procedures in maximization of profit and revenues taking into account the cost restriction by establishing actions criteria as Brekke and Moxnes (2003) says is a mandatory step in understanding investment process.

The main objective of this study it is the investment decision of the 'PKB' – OPOVO agricultural holding manager (South Banat - Yugoslavia) to undertake a project to develop and modernize the sheep farm. For this activity he has planned to use a particular investment fund worth 45,000 € (EURO) composed as follows:

- 20% of own sources, respectively 9,000 € (derived from the income from animal sales);
- the remaining 80% from renewable resources with non-refundable character: 25% of the sources of the BIRD (International Bank for Reconstruction and Development), totaling 11.250 €, and 55% capital received from SAPARD program (financial tool of the European Union, designed to assist candidate countries to address structural reform in agriculture and in other areas related to rural development), meaning 24.750 €.

Within the farm there are three sheep sections, namely:

- sheep up to 3 months of age (lambs);
- sheep aged between 3 and 12 months (sheep);
- sheep aged over 12 months (ewes and rams).

It is intended that through the allocated funds to be achieved a maximum income from the three sections mentioned, specifying that getting the amount financed from external sources is subjected to fulfilling some requirements imposed by the donor units, namely:

- BIRD requires the maximum 20% (2,250 €) of the amount allocated to be used for the arrangement of space and some elements of infrastructure (access roads, water supply), and the remaining 80% (9,000 €) being intended to purchasing equipment and fixed assets;

- the SAPARD program requires that maximum 30% (7.425 €) to be intended for the arrangement of the production space and some maintenance work of the court, roads, stables, feed storage facilities, then maximum 60% (14.850 €) for purchasing fixed assets and the rest of 10% (2.475 €) for personnel costs for development-redevelopment work (under providing services system). The information known, about the purchase prices of equipment, the funds required for arranging the court and for paying the personnel providing services, are presented in table 1.

Tab. 1

Technical-economic information on the sheep farm modernization

| Notations | Specification | Price |
|---|---|---|
| Elements of fixed capital for all three sections (lambs, ewes, respectively sheep and rams) | | |
| $e_1$ | Aggregate (tractor and various equipment) | 10.500 € |
| $e_2$ | buildings constructed as warehouses-storehouses | 2.150 € |
| $e_3$ | sprinkle-desinfestation pump | 700 € |
| $e_4$ | Blender for preparing solid food | 11.100 € |
| $e_5$ | Scale | 475 € |
| $e_6$ | veterinary equipment | 800 € |
| $e_7$ | small inventory | 200 € |
| Specialized fixed capital items (for ewes sections, respectively sheep and rams) | | |
| $e_{s1}$ | Hay and feed preparation equipment | 4.450 € |
| $e_{s2}$ | bathing pools | 300 € |
| $e_{s3}$ | shearing equipment | 2.400 € |
| Arranging the interior and production space | | |
| $a_1$ | yard (land leveling works, construction, repairs, etc.). | 8.400 € |
| $a_2$ | arranging access roads (leveling, paving, asphalt, etc.). | 4.500 € |
| $a_3$ | interior space (planting trees, painting, etc.). | 1.400 € |
| $a_4$ | painting, disinfection, etc. | 650 € |
| Providing services (for equipment installation, arranging the yard and stables, stalls etc.). | | |
| $p_{s1}, p_{s2}, p_{s3}$ | Paying the personnel for the lambs, ewes, respectively sheep and rams department | overall 2.475 € |

Source: author's data determination

The sheep farm is characterized by technical-economic indicators which are presented in the following table (Tab.2).

Tab. 2

Technical-economic indicators characterizing the three sections of sheep

| Section | Symbol | Sheep number | | Medium quantity (Kg/animal) | Unit price (Euro/Kg) | Production capacity designed for sale | | Sales revenues at 1 Eur fixed capital |
|---|---|---|---|---|---|---|---|---|
| | | existent | For sale | | | Physical (Kg) | value (Euro) | |
| lambs | $X_1$ | 175 | 85 | 12 | 2.8 | 1.020 | 2.856 | 0.88 |
| ewes | $X_2$ | 130 | 20 | 40 | 4.2 | 800.0 | 3.360 | 0.29 |
| Sheep and rams | $X_3$ | 560 | 95 | 68 | 2.5 | 6.460 | 16.150 | 0.89 |

Source: authors own determinations

**Model variables**

For describing, the investment model it was first established the working variables which are to be included later in the calculus. Thus, it was determined the following expression, for the pointers, in which:

$x_1$ - the investment fund allocated to lambs section;

$x_2$ - the investment fund allocated to ewes section;

$x_3$ - the investment fund allocated to sheep and rams section.

$e_1, e_2, e_3, e_4, e_5, e_6, e_7$ - binary variable designating purchasing the respective equipment (if it is 1, purchasing it is recommended, otherwise it will not be bought);

$e_{s1}, e_{s2}, e_{s3}$ - binary variable designating purchasing the specialized equipment (if it is 1, purchasing it is recommended, otherwise it will not be bought);

$a_1, a_2, a_3, a_4$ - the amounts for the improvements of the interior courtyard (on different categories of works, presented in table 1);

$p_{s1}, p_{s2}, p_{s3}$ - amounts allocated to the payment of spatial works, installation of equipment (according to the contracts of providing services), for the three sections (lambs $p_{s1}$, ewes $p_{s2}$ respectively for ewes and rams $p_{s3}$).

**Writing the model**

For writing, the investment model it was taking into account all the restriction variables previous described. For this, the admission restrictions in the available investment fund are:

$$x_1 + x_2 + x_3 \leq F$$

in which $F$ is the maximum available investment fund. Volume restriction in using the total available fund:

$$(C_1)\ x_1 + x_2 + x_3 \leq 45.000\ €$$

Structure restrictions in using the fund:

$$\frac{x_2 + x_3}{x_1 + x_2 + x_3} \geq 0,7$$

Expressing the condition that at least 70% of the total amount to be used for ewes and sheep sections) will be written equivalently:

$$(C_2)\ -7x_1 + 3x_2 + 3x_3 \geq 0$$

Then, $\frac{x_1}{x_1 + x_2 + x_3} \geq 0,2$

Or equivalently:

$(C_{12})\ 8x_1 - 2x_2 - 2x_3 \geq 0$

▪ Restrictions on fulfilling the conditions imposed by the BIRD and SAPARD:

$(C_3)\ 10.500e_1 + 2.150e_2 + 700e_3 + 11.100e_4 + 475e_5 + 800e_6 + 200e_7 \geq 23.850$

Condition $C_3$ is for using the full amount designed for purchasing / constructing fixed capital items derived from renewable resources). It is estimated that the most important equipment are those represented by $e_1, e_2, e_3, e_4, e_6$, that is why the following conditioned is imposed:

$(C_{11})\ e_1 + e_2 + e_3 + e_4 + e_6 \geq 5$

$(C_4)\ 4.450es_1 + 300es_2 + 2.400es_3 \leq 14.925$

Condition $C_4$ is for purchasing specialized equipment for which the amount of $14.925 = \frac{23.850}{2} + 30\% \times 9.000$ cannot be exceeded). It is estimated that the importance of specialized equipment can be ordered as follows: $e_{s3}, e_{s1}, e_{s2}$ and then the condition considering this hierarchy of buying preference is written:

$(C_{22})\ 2es_1 + es_2 + 3es_3 \geq 5$

▪ Restrictions regarding funding allocations for improvement:

$(C_5)\ a_1 + a_2 + a_3 + a_4 \leq 10.425,$

So, there will not be allocated for this category of spending more than $10.425 = 7.425 + 30\% \times 9.000$, but not less than 7425,

Thus:

$(C_{13})\ a_1 + a_2 + a_3 + a_4 \geq 7.425$

Among the four types of work the allocations will be made after the following structure:

- for the courtyard (land leveling works, construction-repair of fences) not more than half the amount designed for this purpose, namely:

$(C_{17})\ a_1 \leq \frac{a_1 + a_2 + a_3 + a_4}{2}$

- for arranging access roads, less than 25%, thus:

$(C_{18})\ a_2 \leq \frac{a_1 + a_2 + a_3 + a_4}{4}$

- interior space (planting trees, painting, etc..), less than a quarter of the designed amount:

$(C_{19})\ a_3 \leq \frac{a_1 + a_2 + a_3 + a_4}{4}$

- to pay civil conventions (spatial works and equipment installation):

$(C_6)\ ps_1 + ps_2 + ps_3 \leq 5.475,$

So we are not allowed to spend a sum of money greater than $5.475 = 2.475 + 30\% \times 9.000$,

$(C_{14})\ ps_1 + ps_2 + ps_3 \geq 2.475$

These funds, distributed on the three sections of sheep, will comply with the structure :

$$(C_7)\ \frac{ps_3}{ps_1+ps_2+ps_3}\geq 0{,}4$$

$$(C_8)\ \frac{ps_3}{ps_1+ps_2+ps_3}\leq 0{,}6$$

As the payment for providing services at the lambs department does not exceed 10% of the cost of works/equipment, we will write:

$$(C_{20})\ ps_1\leq \frac{10.500e_1+2.150e_2+700e_3+11.100e_4+475e_5+800e_6+200e_7}{10}+$$
$$+\frac{4.450e_{s1}+300e_{s2}+2.400e_{s3}}{10}$$

For ewes respectively sheep and rams sections, the amounts allocated must cover the purchase price of the specialized equipment and payment through civil conventions, as follows:

$$(C_9)\ x_2+x_3\geq 2400es_1+4450es_2+300es_3+ps_2+ps_3$$

For sheep and rams station, the amount allocated shall not exceed one third of the cost of entire farming equipment, namely:

$$(C_{10})$$

$$x_3\geq \frac{10.500e_1+2.150e_2+700e_3+11.100e_4+475e_5+800e_6+200e_7}{3}+\frac{a_1+a_2+a_3+a_4}{3}$$

Specifying the objective function:

$\max F(x)=c_1x_1+c_2x_2+c_3x_3$ in which:

$c_1, c_2, c_3$ - sales revenue drawn for 1 € fixed capital on each sheep section.

Substituting the known data (table no. 2) the objective function will be written as follows:

$$\max F(x)=0.88x_1+0.29x_2+0.89x_3$$

## RESULTS AND DISCUSSION

The solution obtained in computing the investment allocation leads to the following results described in table 3. According to the calculus the lambs department will be allocated the sum of 9,000 €, then 16,538.33 € to the ewes section, and respectively 19,461.67 € to the sheep and rams section (overall the full amount of 45,000 €).

Typically, resources are not restricted in the shape of „≥”only in the shape of „≤”, this is a special case to respect the requirements imposed by the irredeemable financial sources (BIRD and SAPARD).

According to these allocations we will obtain an increase of income from animal sales of 30.037 €. Of the equipment designed for all sections purchasing a complex aggregate is recommended (tractor and various equipment) worth 10,500 €, a sprinkle- disinfestations pump (700 €), a blender for preparing solid food (11.100 €), veterinary equipment (800 €) and warehouse-storehouse building (the building value is 2.150 €).

For purchasing specialized equipment 6.850 € will be allocated, as follows: 4.450 € for hay and feed preparation equipment and 2.400 € for shearing equipment. For work arrangements only 7.425 € will be spent (the amount required by BIRD and SAPARD), meaning: 2.475 € for the courtyard (land leveling works, construction-repair of fences), 1.856

€ each for access roads, respectively the interior space, the rest of 1.237 € will be used for painting, disinfecting, pest control. For payment of services 5.475 € will be allocated, as follows: 1.325 € for lambs section, 1.960 € for ewes section, and 2.190 € for sheep and rams section.

Tab. 3

The optimal version of the static scheduling problem

| Nr. | Decision Variable | Solution Value | Unit Cost or Profit c(j) | Total Contribution | Reduced Cost | Basis Status |
|---|---|---|---|---|---|---|
| 1 | X1 | 9.000,00 | 0,88 | 7.920,00 | 0 | basic |
| 2 | X2 | 16.538,33 | 0,29 | 4.796,12 | 0 | basic |
| 3 | X3 | 19.461,67 | 0,89 | 17.320,88 | 0 | basic |
| 4 | e1 | 1,00 | 0 | 0 | 0 | basic |
| 5 | e2 | 1,00 | 0 | 0 | 0 | basic |
| 6 | e3 | 1,00 | 0 | 0 | 0 | basic |
| 7 | e4 | 1,00 | 0 | 0 | 0 | basic |
| 8 | e5 | 0 | 0 | 0 | -118,50 | at bound |
| 9 | e6 | 1,00 | 0 | 0 | 0 | basic |
| 10 | e7 | 0 | 0 | 0 | -52,00 | at bound |
| 11 | es1 | 1,00 | 0 | 0 | 0 | at bound |
| 12 | es2 | 0 | 0 | 0 | -108,00 | at bound |
| 13 | es3 | 1,00 | 0 | 0 | 0 | at bound |
| 14 | a1 | 2.475,00 | 0 | 0 | 0 | basic |
| 15 | a2 | 1.856,25 | 0 | 0 | 0 | basic |
| 16 | a3 | 1.856,25 | 0 | 0 | 0 | basic |
| 17 | a4 | 1.237,50 | 0 | 0 | 0 | basic |
| 18 | ps1 | 1.325,00 | 0 | 0 | 0 | basic |
| 19 | ps2 | 1.960,00 | 0 | 0 | 0 | basic |
| 20 | ps3 | 2.190,00 | 0 | 0 | 0 | basic |
| Objective Function (Max.) = 30.037,00 | | | | | | |
| Nr. | Constraint | Left Hand Side | Direction | Right Hand Side | Slack or Surplus | Shadow Price |
| 1 | C1 | 45.000,00 | <= | 45.000,00 | 0 | 0,89 |
| 2 | C2 | 45.000,00 | >= | 0 | 45.000,00 | 0 |
| 3 | C3 | 25.250,00 | >= | 23.850,00 | 3.250,00 | 0 |
| 4 | C4 | 6.850,00 | <= | 14.925,00 | 8.075,00 | 0 |
| 5 | C5 | 7.425,00 | <= | 10.425,00 | 3.000,00 | 0 |
| 6 | C6 | 5.475,00 | <= | 5.475,00 | 0 | 0 |
| 7 | C7 | -0,00 | <= | 0 | 0 | 0 |
| 8 | C8 | -1.095,00 | <= | 0 | 1.095,00 | 0 |
| 9 | C9 | 29.150,00 | >= | 0 | 29.150,00 | 0 |
| 10 | C10 | 22.535,00 | >= | 0 | 22.535,00 | 0 |
| 11 | C11 | 5,00 | >= | 5,00 | 0 | -2.888,00 |
| 12 | C12 | 0 | >= | 0 | 0 | -0,00 |
| 13 | C13 | 7.425,00 | >= | 7.425,00 | 0 | -0,20 |
| 14 | C14 | 5.475,00 | >= | 2.475,00 | 3.000,00 | 0 |
| 15 | C15 | 0 | >= | 0 | 0 | -0,10 |
| 16 | C16 | 4.844,17 | >= | 0 | 4.844,17 | 0 |
| 17 | C17 | 0 | <= | 0 | 0 | 0 |
| 18 | C18 | 0 | <= | 0 | 0 | 0 |
| 19 | C19 | 0 | <= | 0 | 0 | 0 |
| 20 | C20 | 0 | >= | 0 | 0 | -0,60 |
| 21 | C21 | 6.850,00 | >= | 3.000,00 | 3.850,00 | 0 |
| 22 | C22 | 5,00 | >= | 5,00 | 0 | 0 |

Source: authors own computation

## CONCLUSIONS

In terms of market, restrictions imposed the economic efficiency goals, any investment project in modernization and development of a animal farm in our case, lambs and sheep, may be a good investment opportunity, with considerable chances of success, considering the risks associated with a free market economy with such investments are considerable.

Evidence increasingly shows that the success of optimal allocation of investments project is a subject to a multidisciplinary approach, particularly in use of econometric tools, due to harmonize the various interests involved in this process. In this context, we were more interested about the size and nature of investments financing sources and processes about both goals and allocation categories of capital and not the least by the nature and size of the financial and economic results.

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