Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 21, Issue 1, 2021
PRINT ISSN 2284-7995, E-ISSN 2285-3952

INCREASING ECONOMIC PERFORMANCES USING OPTIMIZATION

Daniela-Elena ȘURCĂ

University of Agronomic Sciences and Veterinary Medicine Bucharest of Bucharest, 59 Marași Boulevard, District 1, 011464, Bucharest, Romania. +40213182564, Fax:+40213182888, Email: surca.elena@yahoo.com

Corresponding author: surca.elena@yahoo.com

Abstract

The present paper aimed to evaluate an agricultural holding, based on technical and economic analyzes for the period 2015-2019, whose resources and activities related to the last year were optimized. The optimization led to the improvement of the overall economic performance by the rational allocation of resources and the establishment of the crop structure in order to obtain large yields. The optimization process was accomplished by using a mathematical model of linear programming consisting of variables, constants, constraints and objective function. The modelling and simulation of the real system, by using the simplex algorithm, led to the identification of suitable solutions and implicitly obtaining a maximum effect with a minimum effort (high incomes with minimal expenses).

Key words**:** *agriculture, economic efficiency, optimization, simplex*

INTRODUCTION

The optimization process represents the way in which the sorting or elaboration of possible solutions representative of a system is performed, the final goal being the choice of the optimal solution that meets the system requirement and falls within the limits as well as the conditions imposed by it at the beginning. optimization. Thus, the optimization process will lead to the most favorable use of the resources held by the system to achieve the objective [13].
Optimization can be briefly defined as the activity of selecting a solution from the multitude of solutions offered by the studied problem, a solution that is defined as the best in relation to a predefined criterion. Before performing the optimization, it is necessary to take into account what is subject to optimization, more precisely what is subject to optimization [8], so in any correctly formulated optimization problem a certain criterion will be taken into account that can be expressed. through a quality index; cost function; objective function etc. Thus, following the realization of the best system according to the adopted criterion, the realized system will be optimal only with reference to the chosen criterion.

In order to turn our attention to the approached topic, it is necessary to know what we want to achieve by optimizing, thus, in this case we want to optimize economic performance. However, in order to treat the subject accurately, it is necessary to describe the notion of economic efficiency. According to the American Casson Herbert through his work „Business", the term efficiency is understood in English as "the ability or ability to achieve greater results with a minimum of strength" [1]. Efficiency in general was defined by Novojilov V. as "the ratio between the useful effect (result) and the costs incurred to obtain it" [7]. Românu I. stated that in the most general sense efficiency represents the reverse of an action, of a thing or of a person to create the most favourable effects for the society; the second sense of efficiency compares the results of an action with the resources consumed to carry it out [10]. Encompassing all the definitions given over time to the notion of economic efficiency we conclude that it reflects the quality of actions, activities, economic and sometimes uneconomic processes to produce economic and financial effects with a positive, favourable and minimal effort.

The efficiency of economic activity in agricultural holdings depends largely on three important factors, namely: average yields per hectare, production costs and market prices (factor supply prices and product capitalization prices) [14]. In order to increase the efficiency/economic performance in agricultural holdings, the optimization method described in the "materials and methods" section of the paper can be used, which can be used in agricultural units for the optimal sizing of activities and economic performance. Thus, as the title of this paper suggests, the purpose of this study is to provide a model for optimizing economic performance on a farm, but also to exemplify that the chosen optimization model can provide managers with appropriate solutions and/or improvement of the results obtained in the main activity of the agricultural unit.

MATERIALS AND METHODS

The optimization of production structures in order to increase economic performance was achieved by using linear programming. This method is used in establishing the size and structure of crops in a farm, optimizing / forecasting and replacing the real system with a model of it provides for the researched problem an optimal mathematical and economic form. Briefly defined, the linear programming method tries to determine the optimum of a phenomenon or activity. The economic-mathematical model of linear programming has the role of establishing and ordering the crops in the sense of obtaining the largest productions with a maximum benefit (profit) and minimum effort (expenses) [9]. In this activity, which uses linear programming, three elements will be used: the real system, the model and the two modeling and simulation relations. In other words, the problem of optimizing the structure of crops in order to increase economic performance will lead to the ordering of crops in order to ensure, of course under given conditions, a rational succession of crops, which allows and favors obtaining higher yields in accordance with which disposes of the agricultural holding.

Establishing the areas occupied by each crop is a complex operation because the unknowns of the system will be chosen in the order of their value compared to the optimization criterion and in relation to dependence on other crops [5].

To use linear programming, the following requirements must be met: establishing the list of variables, identifying activities and resources, setting constraints, specifying the objective function (maximum or minimum), knowing the size of inputs and outputs by sensitivity analysis.

The structure of the general linear programming model is constituted first of all by the set of activities denoted thus {A1, A2, ... An} that compose the analyzed economic system but also the set of resources used {R1, R2, ... Rm} as well as through the technical-economic relations between them.

The connection between activities and resources is determined by the manufacturing technology corresponding to each activity Aj (j = 1, ..., n) and can be numerically characterized by the column vector a (j) of components (a1j, a2j, ... amj). The elements {aij, i = 1, ..., m; j = 1, ..., n} are called technical coefficients or specific consumption coefficients and show how much of the resource Ri is consumed to produce a unit of the product (service) Pj (as a result of the activity Aj). All manufacturing "technologies" defined by column vectors a (j) can be organized in an array A with m rows and n columns; each row refers to a resource Ri (i = 1, ..., m) and each column refers to an activity Aj (j = 1, ..., n) [3] [4].

The mathematical model for optimizing the production structure in a farm can be solved through several programs supported by a computer (PC - Excel), but behind the programs for solving linear programming problems will be the calculation algorithm Simplex. This method of solving linear programming problems can be used for three or more variables, essentially being a matrix-type method [12]. The simplex algorithm will search through the set of possible solutions for the optimal solution to achieve the proposed objective, being an iterative procedure for solving the linear programming problems

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 21, Issue 1, 2021
PRINT ISSN 2284-7995, E-ISSN 2285-3952

brought to the tabular form. The simplex method generates new basic feasible solutions that increase the value of the objective function (or leave it unchanged), by generating new tabular forms for the real system of equations [2].
According to specialized studies, the simplex method is the most important method in finding solutions to linear programming problems [11] [6].

RESULTS AND DISCUSSIONS

The agricultural holding taken as a case study, registered for the period 2015-2019 the following variation of the total number of hectares, which are between 847-959 hectares
The total areas were attributed to crops of: wheat, rapeseed, corn, sunflower, peas, barley and it can be seen how in the Table 1.

Table 1. Crop structure for the 5 years under analysis (hectares)

Crop / year	2015	2016	2017	2018	2019	2019/ 2015 %	2019/ 2018 %
Wheat	368.	372	313	375	398	8.15	6,13
Rapeseed	157	169	244	261	188	19.75	(-27.97)
Corn	150	150	179	197	254	69.33	28.93
Sunflower	52	74	52	27	65	25.00	140.74
Peas	64	66	77	79	54	(-15.6)	(-31.65)
Barley	56	58	59	0.0	0.0	-	-
Total area	847	889	924	939	959	13.22	2.13

Source: data provided by the farm under analysis.

Average yields per hectare varied, being influenced by the characteristic of the soil, climatic conditions and investments allocated to those crops. Thus, in the last two columns on the right it can be seen the differences in 2019 compared to the previous year, as well as compared to the base year 2015.

Table 2. Average productions (kg/ha)

Crop / year	2015	2016	2017	2018	2019	2019/ 2015 %	2019/ 2018 %
Wheat	6,500	6,800	6,900	6,700	6,800	4.6	1.5
Rapeseed	3,000	2,900	3,100	3,200	3,150	5.0	(-1.6)
Corn	7,200	7,000	7,100	7,300	7,200	0.0	(-1.4)
Sunflower	2,700	2,900	3,100	3,000	3,050	13.0	(1.7)
Peas	2,800	2,400	2,600	2,500	2,550	(-8.9)	2.0

Source: data provided by the farm under analysis.

The total technological expenses changed in accordance with the crop structure. According to Table 3 the largest increase is recorded in 2017 compared to the previous year, an increase of 7.88% is recorded of which the largest expenditure was made with wheat cultivation. This is due to the fact that 2017 was a dry year, without rain and snow, and the farmer had to allocate investments to irrigate the crop.

Table 3. Technological expenses (lei)

Expenses	2015	2016	2017	2018	2019
Wheat	1,030,400	1,004,400	907,700	1,012,500	1,114,400
Rapeseed	471,000	490,100	756,400	783,000	582,800
Corn	375,000	420,000	465,400	531,900	660,400
Sunflower	150,800	207,200	135,200	72,900	169,000
Peas	108,800	99,000	130,900	118,500	91,800
Total	2,136,000	2,220,700	2,395,600	2,518,800	2,618,400
Evolution with base in a chain %		3.97	7.88	5.14	3.95

Source: data provided by the farm under analysis.

The total expenditure of the holding is formed from the following: technological expenses, salary expenses, rental expenses and headquarters expenses. In the table no.4, it can be seen an upward trend of those, increasing from one year to another by about 5.54 %.

Table 4. Total expenses (lei)

	2015	2016	2017	2018	2019
Technological expenses	2,136,000	2,220,700	2,395,600	2,518,800	2,618,400
Salary expenses	265,680	252,480	288,720	362,400	404,928
Rental expenses	325,000	312,000	299,000	331,500	357,500
Headquarters expenses	3,800	4,100	4,000	4,200	4,000
Total expenses	2,730,480	2,789,280	2,987,320	3,216,900	3,384,828

Source: data provided by the farm under analysis.

According to Table 5, the value of production increases progressively from one year to another with an average of about 7% per year. In the analysis performed, the highest increase is recorded between 2016 and 2017, when the value of production increased by 11.86%, at the opposite pole, the smallest increase was recorded between 2015 and 2016.
The factors that influence this economic growth are the technical factors such as: the surface, which increases from one year to another, the productions that also grow in a

slow but safe rhythm, and economic factors that have in their center the price of capitalization of production. Thus, the value of total production recorded in 2016 was influenced by the low price offered by grain traders.

Table 5. Gross income /production value (lei)

Production value	2015	2016	2017	2018	2019
Wheat	1,650,480	1,897,200	1,662,969	1,809,000	2,029,800
Rapeseed	795,990	710,645	1,270,752	1,302,912	929,754
Corn	658,800	703,500	787,958	934,765	1,280,160
Sunflower	171,288	244,644	228,904	122,688	276,413
Peas	173,,24	145,728	190,190	177,750	137,700
Total	3,450,382	3,701,717	4,140,773	4,347,115	4,653,827
Evolution with base in a chain %		7.28	11.86	4.98	7.06

Source: data provided by the farm under analysis.

Economic efficiency, translated by the result of the year (profit/loss), profit rate, production expenses per 1,000 lei income, material expenses per 1,000 lei income. Thus, the result of the exercise, for the unit under analysis, as well as for the entire analysed period can be seen in Table 6.

Table 6. The economic panel of the farm

	Total gross income (without subsidies;) (main production + secondary production)	Total expenditure	Gross profit	Profit rate %
2015	3,450,382	2,730,480	719,902	26.37
2016	3,701,717	2,789,280	912,437	32.71
2017	4,140,773	2,987,520	1,153,253	38.60
2018	4,347,115	3,216,700	1,130,415	35.14
2019	4,653,827	3,385,028	1,268,799	37.48

Source: data provided by the farm under analysis.

The profit results from the difference made between the gross income and the expenses of the farm. In all the years analyzed, the agricultural holding registers profit, and its value increases from one year to another.

The highest value registered is reached when the farm reaches the maximum cultivated area to 595 hectares. The value of the profit being higher by 12.24% in 2019 compared to the previous year. The optimization was performed with Solver from Excel program, by establishing the mathematical model, which includes the objective function, the matrix of technical and economic coefficients, variables, constants, constraints and limits of the linear programming model.

The mathematical model was written in the form of equations with non-negative variables and the optimal objective function according to the requirement (maximum or minimum), later transposed in the form of a table to allow the program to read and provide solutions according to the requirements and restrictions imposed.

The initial problem, the one that starts from solving the linear programming model, is known as the primary problem, from which will later derive another problem known as the dual problem. In addition to the above, the literature recalls that the primary solution is the structure of activities and consumption of each established restriction, while the dual solution will present the resources that are consumed in full.

Table 7. Matrix of coefficients and technical-economic restrictions

Crops	Corn	Sunflower	Peas	Wheat	Rapeseed	Sign	Boundaries/ resources
Restrictions	x1	x2	x2	x4	x5		
Corn Max.	1	0	0	0	0	≤	287
Sunflower Max.	0	1	0	0	0	≤	95
Peas Max,	0	0	1	0	0	≤	172
Wheat Max.	0	0	0	1	0	≤	380
Rapeseed Max.	0	0	0	0	1	≤	90
Diesel (litrs)	100	90	80	100	110	≤	93,000
Weed control	9	117	80	48	244	≤	66,000 (lei)
Pest control	195	61	0	68	388	≤	12,000 (lei)
Fighting disease	113	199	2	228	187	≤	14,600 (lei)
Chemical fertilizers (NPK))	100	180	0	150	200	≤	11,500 (kg)
Total area	1	1	1	1	1	≤	959,00
Corn Min.	1	0	0	0	0	≥	258
Sunflower Min.	0	1	0	0	0	≥	67
Peas Min.	0	0	1	0	0	≥	134
Wheat Min.	0	0	0	1	0	≥	326
Rapeseed Min.	0	0	0	0	1	≥	76
Gross income per hectare	6,349	5,391	3,679	6,349	5,075	MAX	
Total expenses per hectarer	4,506	3,024	2,132	4,391	4,549	MIN	

Source: Own calculations based on data provided by the agricultural holding.

Following the running of the simplex algorithm in order to minimize expenses and maximize income, optimal solutions resulted in the structure of the crops presented in Tables 8 and 9.

Table 8 Solving and interpreting the primary and dual solution in the context of minimizing the expenses

Optimal solution PRIMAL	Optimal solution DUAL
Own primal variable (VPP) ***Cultivated areas*** **X1** = 258 ha of corn; **X2** = 95 ha of sunflower; **X3** = 172 ha of peas; **X4** = 358 ha of wheat; **X5** = 76 ha of rapeseed;	Dual equalization variables (VDE) Deficit of lei/ha culture expenditures **ye1**=0 lei deficit to spend/ha of corn; **ye2**=0 lei deficits to spend / ha sunflower; **ye3**=0 lei deficits to spend / ha peas; **ye4**=0 lei deficit to spend / ha of wheat; **ye5**=0 lei deficit to be spent/ha of rape
Equalization primal variables (VDE) Differences between resources consumed and limits imposed **xe1** = 29 ha corn deficit; **xe2** = 0 ha deficit sunflower; **xe3** = 0 ha deficit peas; **xe4** = 22 ha wheat deficit; **xe5** = 14 ha rape deficit; **xe6** = 730 litters of diesel not consumed; **xe7** = 3154 lei not spent - weed control; **xe8** = 991 unspent lei - pest control; **xe9** = 1901 lei not spent on fighting diseases; **xe10** = 3200 kg NPK not consumed; **xe1**1 = 0 ha of uncultivated land; **xe12** = 0 ha corn surplus; **xe13** = 28 ha surplus sunflower; **xe14** = 38 ha of surplus peas; **xe15** = 32 ha surplus wheat; **xe16** = 0 ha of rapeseed surplus;	Own dual variables (VDP) Marginal expenses **y1** = 0 lei increase of the others / 288th ha of corn; **y2** = (-1367) lei increase cost for the 96 th ha of sunflower; **y3** = (-2259) lei increase in expenditure / 173 ha of peas; **y4** = 0 lei increase in expenditure / 381 th of wheat; **y5** =0 lei increase in expenditure / 91 th ha of rapeseed flower; **y6** = 0 lei increase in expenditure, / + 1 litter of diesel; **y7** = 0 lei increase in expenditure, / +1 lei in expenditure, weeds; **y8** = 0 lei increase in expenditure, / + 1 lei in expenditure, pests; **y9** = 0 lei increase in expenditure, / + 1 lei in expenditure, diseases; **y10** = 0 lei increase in expenditure, / + 1 kg NPK; **y11** = 4391 lei increase in expenditure / + 1 ha of land; **y12** = 114.5 increase in expenditure / 259 ha of maize; **y13** = 0 lei increase celt, / 68 th ha fl, sun; **y14** = 0 lei increase in expenditure, / 135 th ha of peas; **y15** = 0 lei increase in expenditure, / 327 th ha of wheat; **y16** = 154 increase in expenditure, / 77 th ha rapeseed;
F minim 3,734,707 lei (787,049 euro)	

Source: Simplex LP (Solver/Excel) algorithm results.

For the optimal solutions, obtained in Table 8, the following optimal values will be corresponding: average income = 5,441,943 lei (1,145,672 euros); expenditures = 3,734,707 lei (787,049 euros); profit = 1,707,236 lei (359,414 euros); profit rate = 0.46 lei profit per 1 lei spent. Marginal expenses (y1-y16) represent extra expenses if the farmer decides to increase one of the established activities, for example: increasing the area by one hectare will bring an additional cost of 4,391 lei (about 900 euro), while the establishment of another hectare of corn (minimum ha of corn initially established 258 +1), will bring an additional cost of 114.5 lei (23.6 euro). As can be seen in table no.8 surplus resources do not influence expenditure. Using the same calculation formula and the same technical and economic coordinates income was maximized (Table 9).

Table 9. Solving and interpreting the primary and dual solution in the context of maximizing the income

Optimal solution PRIMAL	Optimal solution DUAL
Own primal variable (VPP) ***Cultivated areas*** **X1** = 287 ha of corn **X2** = 67 ha of sunflower **X3** = 152.1 ha of peas **X4** = 374.9 ha of wheat **X5** = 78 ha of rapeseed	Dual equalization variables (VDE) Surplus income lei / ha culture **ye1** = 0 lei surplus of income / ha of corn; **ye2** = 0 lei excess income / ha sunflower; **ye3** = 0 lei surplus of income / ha of peas; **ye4** = 0 lei surplus of income / ha of wheat; **ye5** = 0 lei income surplus / ha of rapeseed;
Equalization primal variables (VDE) Differences between resources consumed and limits imposed **xe1** = 0 ha corn deficit; **xe2** = 28 ha deficit sunflower; **xe3** = 19.8 ha deficit peas; **xe4** = 5.11 ha deficit wheat; **xe5** = 12 ha rapeseed deficit; **xe6** = 32.2 liter of unconsumed diesel; **xe7** = 6459 unspent lei – weeds; **xe8** = 4119.93 lei not spent with pests; **xe9** = 0 lei not spent on fighting diseases; **xe10** = 2407 kg NPK not consumed; **xe11** = 0 ha of uncultivated land; **xe12** = 29 ha corn surplus / surplus; **xe13** = 0 ha surplus sunflower; **xe14** = 18 ha of surplus peas; **xe15** = 49 ha surplus wheat; **xe16** = 2 ha of rapeseed surplus;	Own dual variable (VDP) Marginal income **y1** = 1535.4 lei income increase / 288th ha of corn; **y2** = 0 lei income increase / 96th ha sunflower; **y3** = 0 increase in income / 173 ha of peas; **y4** = 0 lei income increase / 381 th ha of wheat; **y5** = 0 lei income increase / 91 th ha rapeseed; **y6** = 0 lei increase in income / + 1 liter of diesel; **y7** = 0 lei income increase / + 1 lei spent, weeds; **y8** = 0 lei increase in income / + 1 lei spent, pests; **y9** = 11.8 lei income increase / +1 lei expenditure, diseases; **y10** = 0 lei income increase / + 1 kg NPK; **y11** = 3661.1 lei income increase / + 1 ha of land; **y12** = 0 lei increase in income / 288th ha of corn; **y13** = (-616.8) lei income increase / 96th ha sunflower; **y14** = 0 lei increase income / 173 th ha of peas; **y15** = 0 lei income increase / 381 ha of wheat; **y16** = 0 lei income increase / 91 ha of rapeseed;
F maxim= 5.519.308 lei (1.697.743 euro)	

Source: Simplex LP (Solver / Excel) algorithm results.

For the optimal solutions, obtained in Table 9, the following optimal values will be corresponding: average income = 5,519,308 lei (1,1697,743 euros); expenditures = 3,821,566 lei (805,353 euros); profit = 1,697,959 lei (357,419 euros); profit rate = 0.44 lei profit per 1 lei spent.

Marginal income (y1-y16) is extra income if the farmer decides to increase one of the established activities, for example: increasing the area of corn by one hectare will bring an additional income of 1,534.4 lei (314 euro), while an expense of + 1 lei for fighting diseases will bring an income of 11.8 lei (2.46 euro). As can be seen, the surplus resources do not influence the incomes.

The modelling and simulation resulted in data close to the real ones (Table 10), the areas used for the cultivation of the five crops did not have major oscillations compared to the real ones. This indicates that the farmer took into account the rotation restrictions of the plants and, also, the economic benefit of each crop.

Table 10. Comparative analysis regarding the real situation of the technical and economic elements vs their modelled situation

TEHNIC	real	modelling and simulation	
		min. costs	max. income
ha			
Corn	254	258	287
Sunflower	65	95	67
Peas	54	172	152
Wheat	398	358	374
Rapeseed	188	76	78
ECONOMIC	real	modelling and simulation	
		min. costs	max. income
euro			
Income	979,753	1,1456,672	1,161,959
Expenditure	712,593	787,049	805,353
Profit	267,158	359,418	357,419

Source: Own calculations.

It can be notes that depending on what option is chosen for optimization (maximum income -minimum expenses) the technical indicator (area) will influence the economic part. From an economic point of view, the real profit obtained by the agricultural holding is approximately 30% below the two profit variants obtained after modelling and simulating the same system and the same thing can be observed in the case of income and expenses. It should be noted that in the modelled and simulated situation no restrictions about unforeseen situations were placed in the mathematical model, which, in most of the case, involve additional costs.

CONCLUSIONS

It is necessary that all the activities carried out within the agricultural holdings to be optimally dimensioned in order to ensure a maximum profit in conditions of increased economic efficiency, which implies a better use of the resources available to the company.

This type of optimization provides to the manager rigorous information of the actions taken by him and the various or multiple ways of correlating them with the resources available, whether if it is material or financial resources. Correlations of the resources with what they want to obtain, is made in a such way as to meet the requirements of the objective set for a period of time, giving them the opportunity to make the best decision without distorting reality in any way.

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