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The impact of CAP subsidies on the agricultural enterprise's production structure

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Abstract

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The effect of implementing the Common Agricultural Policy (CAP) is a constantly discussed issue among society, politicians, academicians, practitioners and others. The aim of this paper is to test the mathematical model to examine the impact of CAP subsidies on the structure of production in the Bulgarian agricultural enterprise operating in a mountain region. In order to optimize the production structure, complex factors and dependencies are considered. Mathematical model does not allow taking into account informal relationships that do not have quantitative dimensions (habits, traditions, preferences). The results show that CAP subsidies have no impact on the structure of production, but only increase in gross margin and profit. The resulting optimization did not prove the successful applicability of the model in the CAP study. The model is applicable in optimizing production structure, animal feed ration, etc., but must be applied separately. It is not appropriate to apply to study the influence of CAP subsidies on production structure, livestock breeding, labor, plant growing, food ration. The article presents one case from which no conclusions can be drawn about the effects of the CAP subsidies on farms. This is due to the fact that the more criteria from different groups (land, plant, livestock, labor, food rations) are included in the optimization, the more the model strikes for a balance between the created organizational conditions, which is often a prerequisite for compromise solutions to the task significant discrepancies of expectations.

Keywords: CAP; agricultural enterprises; production structure; gross margin; mathematical model

Introduction

The effect of CAP subsidies is a constantly discussed issue among the public, politicians, academicians, practitioners, and others. The analysts try to assess the effects of agricultural policies on sector level on the one hand, and on the farm level, on the other. For this purpose, a number of known methods, approaches and shared experience are applied in the field.

In regard to analyzes concerning CAP subsidies and productivity of the EU farms, some studies use a structural semi-parametric estimation algorithm (Rizov et al., 2013), questionnaire survey (Svobodová and Věžník, 2012; Bachev, 2013), FADN Dataset (Galluzzo, 2016). There have been studies, which analyze the effect of CAP subsidies according to the econometric model (Arovuori and Yrjölä, 2015). Some studies analyse marginal returns and level of subsidizing through stochastic models (Ivanov, 2016). Other (Křístková and Habrychová, 2011) analyze direct payments to agriculture by applying Computable General Equilibrium (CGE) models. Ciliberti and Frascarelli (2015) analyze a critical assessment of the implementation of CAP 2014-2020 direct payments. Kaneva et al. (2005) analyzes the efficiency of production structures in Bulgarian agriculture using the DEA model.

We have accepted the challenge to test the mathematical model to study the impact of CAP subsidies on linear optimizing the structure of production in a Bulgarian agricultural enterprise operating in a mountainous region. A detailed description of the model is available in Dantzig (1987), Nikolov et al. (1994), Fletcher (2013), Vanderbei (2015), Piryonesi and Tavakolan (2017).

Some of the first publications in Bulgaria related to economics models are in the area of domestic trade planning, also known as internal trade. Later there are researches on production planning (Georgiev, 1973), forecasting and planning the national economy (Vladimirova, 1981), trade (Mladenov, 1984), (Aleksandrov, 1986), linear optimization models (Avramov and Grozev, 1991), agriculture (Nikolov et al., 1994; Nikolov, 1998). The more recent publications on this topic are: Abramova (2003), Ivanov and Dobreva (2007), Pushkarova (2010), Dobreva (2011), Milkova and Michaylov (2016).

The aim of this study is to test the mathematical model to examine the impact of CAP subsidies on optimizing the structure of production in a Bulgarian agricultural enterprise operating in a mountain region. Additionally, we want to check the level of applicability of linear optimization in studying the impact of the CAP subsidies. It should be stressed that only the effect of subsidies on the production structure of the farm is studied, not entirely from the CAP, which has many other mechanisms of impact on farms.

Materials and Methods

For the creation of the model, the study is based on researches of Nikolov et al. (1994). Solving a particular economic problem with mathematical methods means creating an economically-mathematical task. Economic modeling is a mathematical task, which reflects with satisfactory precision the most important relations and characteristics of the economic problem. These tasks are constructed in a system of linear dependencies. They should reflect the conditions to be taken into account when solving the task. The objective function expresses the optimality criteria (min, max):

$$\begin{aligned} &A_{11}X_1 + A_{12}X_2 + \dots + A_{1n}X_n \le B_1 \\ &A_{21}X_1 + A_{22}X_2 + \dots + A_{2n}X_n \ge B_2 \\ &\vdots \\ &A_{m1}X_1 + A_{m2}X_2 + \dots + A_{mn}X_n = B_1 \\ \hline &F = C_1X_1 + C_2X_2 + \dots + C_nX_n \rightarrow \max\ (\min) \end{aligned} \tag{1}$$

where:

X_j indicates the size (magnitude) of the activities or metrics,

A_{ij} and Cj indicate the activities that will be done,

B_i means the amount of available resources or the amount of activities (restrictions).

The objective function *F* gives the optimality criteria.

The solution of the model will answer the following questions:

1. Establishing the optimum production structure according to the constrains and the optimality criteria;
2. Establishing the impact of the CAP subsidies on efficiency and production structure, depending on the chosen optimal criteria.

In order to establish the production structure of the selected agricultural holding, it is necessary to determine: crops area, number of animals, feed balance, labor resources and other activities. When developing the model, the optimality criteria will be max gross margin. Additionally, we will set another criterion for optimality – max profit.

The argument for choosing the farm is based on the fact that experts and researchers in agri-economic science find that farms in mountain areas have a mixed specialization – plant growing and dairy farmer.

Description of the farm

The necessary information was gathered with the assistance of specialists from the studied farm.

The farm is a legal entity registered under the Commercial Law as a sole limited liability company. Its activities are in a mountainous area on a territory of Sofia region. The soil type is *Cambisoles*, the area falls in the group of infertile lands in the bonity rating 0-20 ball,10th category. Climate conditions create prerequisites for growing wheat, rye, vineyards, fruit trees, late vegetables.

The management is located in lands of the former cooperative union. At the beginning of the 1990s, an agricultural cooperative for production and services was set up, but after 2010 it ceased agricultural activity.

The farm pays to the cooperative a rent, which is used for storage of grain – BGN 650 per year. The farm is equipped with modern equipment – John Deere tractors and harvesters.

There is a mixed plant breeding specialization of its production activity. The farm does not own land. It rents 2000 decares (da). It pays a rent of BGN 24/da. In addition, 1500 da of pastures/meadows are rented from the municipality for the feeding of the animals. They are used both for animal grazing (green food) and for hay. The land is distributed as follows: 500 da municipal land and 1000 da white spots. The municipality pays municipal rent of BGN 8 per decar per year. There is no additional opportunity for hiring land in the area because it is too organized as a production resource. There are no irrigation facilities built on the land.

Cultivated crops on the rented land are as follows: wheat – 700 da; barley – 300 da; sunflower – 700 da; corn for silage – 300 da. Wheat, barley and sunflower are also grown for commodity crops, except for animal feed. Wheat could be sold at BGN 0.27/kg, barley – 0.26 BGN/kg, sunflower – 0.65 BGN/kg. For the purpose of the model we assume that the products can be purchased at the same price. Wheat yield is 400 kg/da; barley yield is 500 kg/da; sunflower yield is 200 kg/da. According to the studies, the amount of straw is about 40% of the yield. We assume an average amount of straw of 180 kg/da. We do not apply the sunflower rotation requirement (1/6 of the area). The yield of silage corn is 1 tonne/da.

The farm has the potential to grow about 100 cows. At the moment there are 75 dairy cows with an average of 10 liters of milk per day or about 3600 liters per year. The breeds are „Bulgarian Rhodope Govedo" and "Iskar Govedo". Due to the commitment because of the subsidy received, the farm is obliged to grow a minimum of 20 animals of every breed. Every day the produced milk is bought from a processing plant at a price of 0.70 BGN/liter. At this stage, cows are fed on a level of 4000 liters milk per year. The necessary food for animal feeding is farms own production. Additionally for the ration of the animals concentrated fodder can be bought at the price of 0.65 BGN/kg. On the farm, cows are fed according to a ration determined by the zootechnics, in agreement with the farm manager.

The required Net Energy Intake (NEI) per year for one cow will be determined according to the technical and economic standards. According to zootechnical requirements, we assume (according to Nikolov et al., 1994; Nikolov, 1998) that the relative share of fodder to get the required NEI may vary within the following limits:

1. Concentrated feeds from 20 to 40% from the necessary NEI;
2. Silage – from 30 to 48% of NEI;
3. Hay – from 5 to 12% of NEI;
4. Green fodder – from 10 to 20% of NEI;
5. Straw – maximum 10%.

The bred cattle are 55 cows of the "Bulgarian Rhodope Govedo" and 20 cows of "Iskar Govedo" breed. The milk Bulgarian Rhodope Govedo breed is less in quantity, but due to commitments under Measure "Agroecology" of CAP and the subsidies taken, there is an obligation to select them for 5 years. There are 9 people permanently employed on the farm, distributed as follows: 3 mechanics with gross remuneration at 1100 BGN/month (13 200 BGN/year); 2 labourer with 1000 BGN/month (12 000 BGN/year); 2 dairy farmers with BGN 1100/month (BGN 13 200/year). These labor costs will be considered as variable costs because they depend on the amount of activity performed and may in practice vary. The salary costs of the administrative and managerial staff will be included in the column of permanent costs: 1 agronomist – 1000 BGN (12 000 BGN/year); 1 zootechnician – 1000 BGN (12 000 BGN/year); accountant (cashier and human resources) – BGN 1000 (BGN 12 000/year); manager – 15 000 BGN/year. Additionally, temporary support of 70 working days for common work and up to 90 working days for mechanized activities can be recruited on a monthly basis. Payments are 30 BGN per day for a labourer and 40 per day for a mechanic. Annually a single worker and mechanic can provide 240 working days, and one dairy farmer – 280 working days. The maximum number of permanent workers on the holding may not exceed 18 people. The months with the highest labor pressure are July, August and September. The number of days during which it is possible to carry out field work in the months with high labor tensions are respectively: July – 26 working days; August – 26; September – 24. When mechanics do not carry out mechanized activities, they can do a common job.

According to the technological requirements (Nikolov et al., 1994; Nikolov, 1998), the following restrictions must be observed:

1) Autumn crops under non-irrigating conditions occupy not less than 45% and not more than 55% of the crop rotation area;

2) The sunflower does not occupy more than 17% of the crop rotation area (1/6).

Since the aim is to assess the impact of the CAP subsidy on the efficiency and structure of production, information relevant to their application on this farm is needed.

The farm has received subsidies under Pillar 1 of the CAP for 2017 as follows:

- 41 BGN/da, distributed as follows – 19.50 BGN/da under Single Area Payment Scheme, 12.50 BGN/da green payments, 9.00 BGN/da for disadvantaged areas;
- 75 dairy cows (419 BGN/animal) under Scheme 11 for support for dairy cows under selection control.

Development of feeding normative is an important step in collecting information. For different crops, livestock and other activities a set of norms has been developed, depending on whether the activity is commodity or not. Commodities are the activities from which the final output is obtained, i.e. production for sale. These are wheat, barley, sunflower, cow's milk. Non commodity is the production that is used in the production cycle for producing milk, like: 1) fodder crops needed to feed the animals – wheat, barley, sunflower, silage corn; 2) animals for carrying out the reproduction process. For the different activities, norms are developed for 1 decar or 1 tonne of production. In addition, it is necessary to pay attention to the optimal feeding of ruminants. The optimal ration is the one that satisfies the maximum zootechnical feed requirements of the respective group of animals.

Setting the model

In order to determine the production structure of the selected mountain farm, it is necessary to determine the area of the crops, the number of animals and other activities to achieve maximum economic impact. During the developing of the model, the criterion is to achieve the maximum gross margin with the inclusion of CAP subsidies and without applying them. The solution of the problem will also answer the questions regarding the most cost-effective production processes for crop production (for feed and commodities) and for livestock breeding (cows, feeding with ration for 4000 l milk). On the other hand, the model provides the opportunity to quickly and easily develop different options for optimizing the production structure in case of a change of production or some of the limiting conditions. Additionally, the decision will present the impact of CAP subsidies on the production structure and, accordingly, on the economic outcome. The production structure in the case at hand depends on the specifics of natural conditions and limiting factors. On the chosen farm, the organizational conditions are as follows:

1. Quantity and quality of the land (impossibility to rent more land, low bonity estimated, non-irrigated conditions, etc.);
2. Amount of grazing meadows;
3. Quantity and quality of the main productions (breeds of selected animals, milking, presence of cowshed, warehouses, etc.);
4. Labor resources (number of permanently employed workers, field workers, livestock workers, mechanics, zootechnics, agronomist;
5. Agrotechnical crop rotation requirements (minimum/maximum limits in which they may vary, green/dry weight ratio);
6. Zootechnical conditions regarding the feeding of animals according to the milking;
7. Contracts to buy milk, sale of commodity crops;
8. Ability to purchase concentrated fodder;
9. Prices of marketed production and means of production.

Fot the purpose to optimize the objective function we use the SOLVER application in MS Excel. SOLVER is an application that can be used to find an optimal solution (minimum or maximum) of an equation that is subject to various constraints. The optimal solution should be located in one cell and to be the result of the mathematical calculation of the variables of the objective function.

Creating unknown variables and limitations

To determine the impact of CAP subsidies on the economic efficiency of the farm, we define the following unknown variables:

X_1 – wheat (da)
X_2 – barley (da)
X_3 – sunflower (da)
X_4 – corn for silage (da)
X_5 – pasture meadows (da)
X_6 – hay for feed, own production (t)
X_7 – purchased concentrated fodder for cows (t)
X_8 – own concentrated fodder for cows (t)
X_9 – green feed (m)
X_{10} – straw for feed, own production (t)
X_{11} – purchased hay for feed (t)
X_{12} – cows – 4 tons of milk (number)
X_{13} – rented land (da)
X_{14} – labourers, permanent workers (number)
X_{15} – mechanics, permanent workers (number)
X_{16} – livestock workers, permanent workers (number)
X_{17} – revenue (BGN, thousands)
X_{18} – variable costs (BGN, thousands)
X_{19} – labor costs (BGN, thousands)
X_{20} – fixed costs (BGN, thousands)
X_{21} – gross margin (BGN, thousands)
X_{22} – profit (BGN, thousands)
X_{23} – NEI (number)
X_{24} – administrative costs (BGN)
X_{30} – wheat, commodity (da)
X_{31} – barley, commodity (da)
X_{32} – sunflower, commodity (da)

After determining the unknown variables, we develop the necessary constraints expressing in a mathematical form the different conditions and requirements that we need to comply with in the optimal plan. The constraints are:

I. First group of constraints on land use requirements

1. Constraints on rented land (da)

$$X_{13} = 2000 \tag{2}$$

2. Relationship between agricultural crops and rented land

$$X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 = 2000 \tag{3}$$

3. Meadows constraints (da)

$$X_5 \leq 1500 \tag{4}$$

4. Autumn crops, at least 45% of the crop rotation area (da)

$$X_1 + X_2 + X_{30} + X_{31} \geq 900 \tag{5}$$

5. Autumn crops, max 55% of the crop rotation area (da)

$$X_1 + X_2 + X_{30} + X_{31} \leq 1100 \tag{6}$$

6. Sunflower, a maximum of 17% of the crop rotation area (da)

$$X_3 + X_{32} \leq 340 \tag{7}$$

II. Second group of constraints on the use of labor resources

7. Workers, maximum (number)

$$X_{14} + X_{15} + X_{16} \leq 18 \quad (8)$$

8. Workers, minimum (number)

$$X_{14} + X_{15} + X_{16} \geq 9 \quad (9)$$

9. Labourers, maximum (number)

$$X_{14} \leq 6 \quad (10)$$

10. Labourers, minimum (number)

$$X_{14} \geq 3 \quad (11)$$

11. Mechanics, maximum (number)

$$X_{15} \leq 6 \quad (12)$$

12. Mechanics, minimum (number)

$$X_{15} \geq 3 \quad (13)$$

13. Livestock workers, maximum (number)

$$X_{16} \leq 6 \quad (14)$$

14. Livestock workers, minimum (number)

$$X_{16} \geq 3 \quad (15)$$

III. Third group of constraints on animal feed

15. Balance of NEI needed to feed the cows (number)

$$489X_4 + 480X_6 + 1050X_7 + 1160X_8 + 170X_9 + + 280X_{10} + 480X_{11} \geq 7100X_{12} \quad (16)$$

16. Silage, min 30% from NEI (number)

$$489X_4 \geq 2130X_{12} \quad (17)$$

17. Silage, max 48% from NEI (number)

$$489X_4 \leq 3408X_{12} \quad (18)$$

18. Concentrated fodder, min 24% from NEI (number)

$$1050X_7 + 1160X_8 \geq 1704X_{12} \quad (19)$$

19. Concentrated fodder, max 40% from NEI (number)

$$1050X_7 + 1160X_8 \leq 2804X_{12} \quad (20)$$

20. Green fodder, min 10% from NEI (number)

$$170X_9 \geq 710X_{12} \quad (21)$$

21. Green fodder, max 20% from NEI (number)

$$170X_9 \leq 1420X_{12} \quad (22)$$

22. Straw, max 10% from NEI (number)

$$280X_{10} \leq 710X_{12} \quad (23)$$

23. Hay, min 5% from NEI

$$480X_6 + 480X_{11} \geq 355X_{12} \quad (24)$$

24. Hay, max 12% from NEI

$$480X_6 + 480X_{11} \leq 852X_{12} \quad (25)$$

25. Processed concentrated fodder which we feed the animals and the source from which we receive it (t)

$$0.4X_1 + 0.5X_2 + 0.2X_3 \leq X_8 \quad (26)$$

26. Relationship between straw and autumn crops

$$X_{10} \leq 0.16X_1 + 0.16X_2 \quad (27)$$

27. Balance between green fodder and hay that the farm can get from pasture meadows

$$4X_6 + X_9 \leq 2.2X_5 \quad (28)$$

28. Wheat, min 20% of concentrated fodder

$$0.4X_1 \geq 20\%X_3 \quad (29)$$

29. Barley, min 20% of concentrated fodder

$$0.5X_2 \geq 20\%X_3 \quad (30)$$

30. Sunflower, min 20% of concentrated fodder

$$0.2X_3 \geq 20\%X_8 \quad (31)$$

IV. Fourth set of limitations for the minimum and maximum limits between which the specified crops and animals may vary

31. Cows, minimum (number)

$$X_{12} \geq 40 \quad (32)$$

32. Cows, maximum (number)

$$X_{12} \leq 100 \quad (33)$$

V. Fifth group of constraints, auxiliary

33. Income (BGN)

$$X_{17} = 108X_{30} + 130X_{31} + 130X_{32} + 2800X_{12} + + 419X_{12} + 42X_{13} \quad (34)$$

Income (BGN) – 2^{-nd} option without subsidies

$$X_{17} = 108X_{30} + 130X_{31} + 130X_{32} + 2800X_{12} \quad (35)$$

34. Variable costs (BGN)

$$X_{18} = 70X_1 + 62X_2 + 54X_3 + 50X_4 + 70X_{30} + 62X_{31} + + 54X_{22} + 100X_6 + 650X_7 + 100X_{10} + 110X_{11} + + 50X_{12} + 12\,000X_{14} + 13\,200X_{15} + 13\,200X_{16} \quad (36)$$

35. Labor costs (BGN)

$$X_{19} = 12\,000X_{14} + 13\,200X_{15} + 13\,200X_{16} \quad (37)$$

36. Administrative expenditure (BGN)

$$X_{25} = 40\,800 \quad (38)$$

37. Fixed costs (BGN)

$$X_{20} = 24X_{12} + 8X_5 + X_{25} \quad (39)$$

38. Gross margin (BGN)

$$X_{21} = X_{17} - X_{18} - X_{19} \quad (40)$$

39. Profit (BGN)

$$X_{22} = X_{17} - X_{18} - X_{19} - X_{20} - X_{25} \quad (41)$$

40. NEI (number)

$$X_{24} = 489X_4 + 480X_6 + 1050X_7 + 1160X_8 + + 170X_9 + 280X_{10} + 480X_{11} \quad (42)$$

41. Minimum contribution of fodder crops (da)

$$X_1 \geq 20\%X_8 \quad (43)$$

42. Minimum contribution of fodder crops (da)

$$X_2 \geq 20\%X_8 \quad (44)$$

43. Minimum contribution of fodder crops (da)

$$X_3 \geq 20\%X_8 \quad (45)$$

In order to assess the impact of the subsidies implemented under the CAP, it is necessary to define the criterion of optimality. The gross margin will be used in this example. Additionally, the task will be solved with a maximum profit criterion.

$$F = 108X_{30} + 130X_{31} + 130X_{32} + 2800X_{12} + 419X_{12} + + 42X_{13} - 70X_1 - 62X_2 - 54X_3 - 50X_4 - 70X_{30} - 62X_{31} - 54X_{32} - 100X_6 - 650X_7 - 100X_{10} - 110X_{11} - 50X_{12} - 12\,000X_{14} - 13\,200X_{15} \rightarrow \text{MAX gross m}\varepsilon \quad (46)$$

The objective function is designed to affect the area of different crops used for feed or for sale, cows and subsidies (when using optimization subsidies), the area of grazing grassland used and hay production, purchased fodder and labor costs. The solution of the optimization equation is expected to result in the area of the land to be sown with a particular crop, the optimal number of cows to grow.

Solution of the task under different optimality criteria (gross margin/max profit, with and without subsidies)

The optimization was solved with the SOLVER software product.

Table 1. Parameters of the optimal solution for the gross margin/max profit target with/without subsidies

Unknown variables		Decares	Tonnes	Numbers	Thousand BGN
x_1	Wheat	31			
x_2	Barley	275			
x_3	Sunflower	31			
x_4	Corn for silage		697		
x_5	Pasture meadows	514			
x_6	Hay for feed, own production		674		
x_7	Purchased concentrated fodder for cows		0		
x_8	Own concentrated fodder for cows		156		
x_9	Green feed		835		
x_{10}	Straw for feed, own production		0		
x_{11}	Purchased hay for feed		11		
x_{12}	Cows – 4 tons of milk			100	
x_{13}	Rented land	2000			
x_{14}	Labourer, permanent workers			3	
x_{15}	Mechanics, permanent workers			3	
x_{16}	Livestock workers, permanent workers			3	
x_{17}	Revenue				531,364
x_{18}	Variable costs				127,9
x_{19}	Labor costs				115,2
x_{20}	Fixed cost				46627,34
x_{21}	**Gross margin with subsidies**				**288,262**
$x_{21`}$	**Gross margin without subsidies**				**162,32**
x_{22}	**Max profit with subsidies**				**190, 635**
$x_{22`}$	**Max profit without subsidies**				**64, 735**
x_{23}	NEI			710 000	
x_{24}	Administrative cost				51,00
x_{30}	Barley, commodity	0			
x_{31}	Sunflower, commodity	656			
x_{32}	Wheat	309			

Source: Own calculations

Results and Discussion

The results obtained from the optimization are shown in Table 1, in which the parameters of the optimal solution for the gross margin/max profit target with/without a subsidy included are presented.

In the management of the farm it is assumed that the rented land is 2000 decares and is used at its full capacity. In determining the optimal structure of the farm, the requirements for optimal ration of animals are taken into account by tracking the balance of the NEI.

The main effect on the results is the type of objective function, the constraints and the set price parameters. The type of the objective function is linear, as well as the constraints. Linearity influences the results in 2 ways:

1. It maximizes the quantities produced from crops with a good price, on the one hand;
2. It minimizes the crops with price disadvantage to the minimum, on the other hand.

That is why, the produced wheat for fodder is only 31 decares (the production costs of wheat are 72 BGN/da, while for barley and sunflower they are respectively 62 BGN/da and 54 BGN/da) and the commodity wheat is 0. The latter results from the lower sales price of wheat set in the model – 108 BGN/da (130 BGN/da for barley and sunflower).

The amount of land sown with sunflower fodder is also 31 decares. Although sunflower is financially profitable for cultivation at a cost of only 54 BGN per decare, its profitable market price is the reason for it to be sold as commodity (309 decares) and for this reason the minimum quantity is set as a fodder according to the limitations introduced.

The moderate production costs and the good market price of barley cause it to be the optimal crop, both for feed (275 decares) and for sale (656 decares).

In fact, the difference between market price and production costs is greater for sunflower, which is why it is also mainly produced as a commodity crop.

The quantity of silage corn (697 t) is determined primarily by its low price and restrictions on its use for food.

In terms of the number of breeding animals (X_{12}), the function is maximized by maximizing the number of cows – 100 within our study. As already mentioned, the linearity of the gross margin objective function implies such a result when gross margin is positive.

It is interesting to note whether the availability of CAP subsidies will change the results of optimization. The impact of the subsidies on the model is reflected by the animal subsidies of BGN 419 and the subsidies per unit area of BGN 42. The main result of the use of CAP subsidies is the increase in the gross margin from BGN **162.32** thousand up to BGN **288.26** thousand. Accordingly, max profit is from BGN **64.735** thousand up to BGN **190.635** thousand.

All other parameters of the model – with regard to the structure of the areas for cultivation of different crops, grazing meadows, labor costs remain unchanged, whether or not subsidies are used.

Conclusion

In this paper, we tested the impact of CAP subsidies on the production structure of an agricultural enterprise through a mathematical model. The main conclusion from the optimization model of the objective function of the gross margin/max profit is that the existence of CAP subsidies does not affect the production structure of the agricultural enterprise‘s with regard to the crop rotation and animals.

The resulting linear optimization did not prove the successful applicability of the model in the CAP study. Betting as optimal criteria in the gross margin/maximum profit goal optimizes costs in line with the limitations. The model is applicable in optimizing production structure, animal feed ration, etc., but must be applied separately. It is not appropriate to apply for studing the influence of CAP subsidies on production structure, livestock breeding, labor, plant growing, food ration.

At the same time, we also need to address some of the weaknesses we identified during the task development and after getting the possible solutions. The mathematical model is not able to take into account the influence of external factors (temperature, humidity, precipitation, atmospheric pollution, climate change), including current environmental, behavioral, social, etc. Also, the model can not foresee the possible future changes in the market environment, the behavior of competition, the change in consumer requirements. The task's condition does not include the behavioral characteristics of managers, employees and stakeholders. However, it is not possible in the mathematical model to take into account and include all factors influencing the production activity of the holding. The task also does not make it possible to take into account important factors for the operation of the enterprise, provided that it is in a situation of unfavorable position compared to competition. This greatly determines the possible optimal solutions, which does not, therefore, justify making a correct management decision.

The subjective approach in determining the minimum and maximum parameters of the participation of the different feed groups in the animals feeding leads to a narrowing of the possible iterations to ensure full biological nutrition. This is due to the fact that the more criteria from different groups (land, plant, livestock, labor, food rations) are included in the optimization, the more the model strikes for a balance between the created organizational conditions.

References

Abramova, G. (2003). Model for optimal functioning of the dairy cattle / economics-mathematical "simplex method". *Bulgarian Journal of Agricultural Economics and Management*, *48*(1), 54-58.

Arovuori, K., & Yrjölä, T. (2015, October). The impact of the CAP and its reforms on the productivity growth in agriculture. In *147th EAAE Seminar:"CAP Impact on Economic Growth and Sustainability of Agriculture and Rural Areas* (pp. 1-14).

Avramov, A., & Grozev, S. (1991). Mathematical modeling. Svishtov (Bg).

Alexandrov, Kr. (1986**).** Economic and mathematical methods and models in trade: Operations research. Sofia, Higher Economic Institute (Bg).

Bachev, H. (2013). Assessment of the impact of the EU CAP on agricultural cooperatives*. Bulgarian Journal of Agricultural Economics and Management , 58*(1), 22-36*.*

Ciliberti, S., & Frascarelli, A. (2015). A critical assessment of the implementation of CAP 2014-2020 direct payments in Italy. *Bio-based and Applied Economics*, *4*(3), 261-277.

Dantzig, G. B. (1987). Origins of the simplex method. Stanford Univ., CA, Systems Optimization Lab, Defence Technical Information Center, Tehcnical Report Sol. 87-5.

Dobreva, Yu. (2011). Optimization modeling in sustainable development survey. Sofia University "Sv. Kl. Ohridski", Dissertation (Bg).

Fletcher, R. (2013). *Practical methods of optimization*. John Wiley & Sons.

Galluzzo, N. (2016). Analysis of subsidies allocated by the Common Agricultural Policy and cropping specialization in Romanian farms using FADN dataset. *Scientific Papers: Management, Economic Engineering in Agriculture & Rural Development*, *16*(1), 157-164.

Georgiev, T. (1973). Economic and mathematical model and tasks for production planning in APK, TKZS, DZS. Sofia, Zemizdat (Bg).

Ivanov, B. (2016). Scenarios and effects on different probabilities of development of Bulgarian agriculture. In: *Proceeding from IIIrd Applied science forum* "Agricultural Development and Commodity Market Projection" (November 28-29, 2016, Sofia), pp. 22-33.

Ivanov, I., & Dobreva, J. (2007). Application of the optimization model and the Slutsky equation in the supply of public goods. In *Proceedings of International Conference of Rousse University* (Vol. 46, pp. 161-167).

Kaneva, K., Mladenova, M., Koteva, N., Bashev, H., Risina, M., Hadzhieva, V., & Mitova, D. (2005). Efficiency, sustainability and competitiveness of agricultural holdings. *Bulgarian Journal of Agricultural Economics and Management*, *50*(5), 44-54**.**

Křístková, Z., & Habrychova, A. (2011). Modelling direct payments to agriculture in a CGE Framework – analysis of the Czech Republic. *Agric. Econ.-Czech*, *57*(11), 517-528.

Milkova, T., & Mihaylov, D. (2016). Operations research. Varna, University of Economics (Bg).

Mladenov, H. (1984). Application of economic and mathematical methods and models in domestic trade. Sofia, Higher Economic Institute (Bg).

Nikolov, N. (1998). Designing the production structure of agricultural production. Sofia, Stopanstvo (Bg).

Nikolov, N., Ivanov, G., & Stefanov, L. (1994). Economic and mathematical modeling of agricultural production. Sofia, Zemizdat (Bg).

Piryonesi, S. M., & Tavakolan, M. (2017). A mathematical programming model for solving cost-safety optimization (CSO) problems in the maintenance of structures. *KSCE Journal of Civil Engineering*, *21*(6), 2226-2234.

Pushkarova, A. (2010). Mathematical models of economic tasks for decision making. In: Proceedings of the Scientific Conference, Veliko Tarnovo, pp. 451-455 (Bg).

Rizov, M., Pokrivcak, J., & Ciaian, P. (2013). CAP subsidies and productivity of the EU farms. *Journal of Agricultural Economics*, *64*(3), 537-557.

Svobodová, H., & Věžník, A. (2012). Impacts of the Common Agricultural Policy of the European Union in the Vysočina region (Czech Republic) by the view of the farmers. *Journal of Central European Agriculture*, *12*(4), 726-736.

Vanderbei, R. J. (2015). *Linear programming*. Heidelberg, Springer.

Vladimirova, K. (1981). Economic and mathematical methods and models for forecasting and planning of the national economy. Sofia, Higher Economic Institute (Bg).

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