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ECONOMIC AND MATHEMATICAL MODEL FOR FORECASTING DIRECTIONS OF DEVELOPMENT OF HUNTING ENTERPRISES

Abstract. The article summarizes arguments and counterarguments within the scientific discussion on the development of the hunting enterprises. The aim of the article is to construct an economic and mathematical model for determining the number of wild hunting animals, in which the production and economic activity of the enterprises of the hunting economy will be able to operate on the basis of self-sustainability and self-financing. The actuality of solving of this scientific problem is in the necessity of reformation of the hunting economy in Ukraine, which provides formation of the national conception of its organization and development, which would base on the effective economic, ecological and social instruments; and which, at the same time, would take into account national management traditions. In order to construct an economic and mathematical model for predicting the directions of development of the hunting enterprises, the research was conducted in the following logical sequence: analyzed by what components are formed the total costs and total revenues from hunting economy; the boundary between the unprofitable and break-even level of hunting activity; according to the objective function, the theoretical principles of the economic and mathematical model were formulated, which allow to define the break-even quantity of hunting animals; four directions of development of the hunting enterprises are considered.

The methodical basis of the study were the methods of analysis, synthesis, economic and mathematical modeling, statistical method; the period of research – 2016-2017 years. The hunting facility of the Lviv region (Ukraine) was chosen as the object of the research as it gave us the opportunity to carry out additional calculations taking into account more optimistic directions of hunting economy development.

The research empirically confirms and theoretically proves that the hunting economy can function on the principles of self-sustainability and self-financing without going beyond the established and legally established norms.

Key words: economic and mathematical model, enterprises, hunting economy, wild hunting animals, break-even number of wild animals, capacity of hunting grounds.

Introduction. Ukraine is one of the largest countries in Europe and is characterized by extremely favourable territorial conditions, various environmental and climatic conditions, fertile lands, rich plant and animal world, and so on. Despite this situation, Ukraine is not without its problems. This is proved by the fact that the percentage of woodiness in the country is one of the lowest in Europe (15.9%) [1,2]. Another problem is the rather high anthropogenic pressure on the environment and the contamination of large areas of the country with radioactive substances, which leads to a decrease in the biodiversity of the animal and plant world. In particular, for the last few decades, the following animals and plants have been classified as rare or endangered: brown bear, lynx, otter, buzzard, eagle, yellow tortillas, and others [3].

The industrial and economic activity directed at the use, protection and reproduction of wildlife resources, which is engaged in specialized state forest, hunting and forestry farms, hunting associations and enterprises of other forms of ownership, is important in the structure of the national economy.

The objective necessity of reforming the hunting economy in Ukraine involves the formation of a national concept of its organization and development, based on effective economic, environmental and social instruments taking into account national traditions of management. One of the main reasons for the ecological and economic inefficiency of hunting-and-economic activities in Ukraine is the rather low number of wild hunting animals, which is why the cost of hunting is almost twice the amount of income. Analysis of the experience of hunting in the developed countries of the world proves that the production and economic activity of enterprises of the hunting economy can be profitable and operate on the principles of a market economy in accordance with the principles of sustainable ecologically balanced development.

The process of reforming the hunting economy is expensive and should be implemented gradually. The process of implementing an effective ecological and economic direction of the development of the hunting economy, which is aimed at achieving the optimal number of hunting animals in hunting grounds, acquires the longest time of establishment. Thus, the problem of economic stimulation of efficient reproduction and using of hunting resources is one of the key problems in modern science and it needs immediate resolution.

The organizational aspects of reforming and development of hunting economy in Ukraine are highlighted in the scientific works of such scientists as Bondarenko [4], Vovchenko [5], Delehan [6], Cherniavskyi [7], Dynka [6], Koval [9], Muraviov [10], Novikov [11], Protsiv [12], Siniakevych [13], Tunytsia [14], Khoietskyi [15], Sheihas [16] greatly contributed to solving the issues of the economic evaluation of the resources of the hunting economy, the ecological and economic stimulation of the using and protection of forest and fauna resources, as well as the state regulation of hunting and hunting in their scientific works.

The economic and mathematical modeling of the using of nature and its optimization as a scientific problem is considered in the works of many domestic and foreign scientists. However, despite the accumulated experience and the results obtained, the problem of economic and mathematical modeling and forecasting of the directions of development of hunting enterprises in the current conditions of reforming the economy of Ukraine deserves further study and becomes of special urgency.

The aim of the article: to construct an economic and mathematical model for determining the number of wild hunting animals, in which the production and economic activity of the enterprises of the hunting economy will be able to operate on the basis of self-sustainability and self-financing.

Methods. The theoretical basis of this research are the fundamental provisions of tourism science, economics of hunting, tourism and nature management, ecological economics, the theory of sustainable development, normative and legal support of activities in the field of hunting tourism. The methodical basis of the study were the methods of analysis, synthesis, economic and mathematical modeling, statistical method; the period of research – 2016-2017 years. The hunting facility of the Lviv region (Ukraine) was chosen as the object of the research as it gave us the opportunity to carry out additional calculations taking into account more optimistic directions of hunting economy development.

Results. The organized hunting and economic activities in Ukraine are conducted on the area of 38 340.6 thousand hectares, including the area covered by hunting regulation of 37 722.7 thousand hectares [17]. The largest part of the structure of Ukrainian hunting grounds is occupied by field lands – 28 334.2 thousand hectares (73.9%), and forest and wetlands – 7 857.5 thousand hectares (20.5%), 1 774.6 thousand hectares (4.6%) respectively [17]. In general, there are 1 113 legal entities on the territory of Ukraine engaged in organized hunting, 783 000 hunters were registered and 6 300 hunters and regular hunters were involved [2].

The payback of hunting economy of Ukraine constitutes about 46.9%. Total expenses on hunting are 284 018.2 thousand UAH with revenues 133 203.0 thousand UAH [17]. The average cost of hunting in Ukraine is 7 408 UAH per 1 thousand hectares, including the cost of protection and reproduction of hunting animals 3 266 UAH on 1 thousand hectares of hunting grounds [17].

The main condition for increasing the economic efficiency of the production and economic activities of hunting enterprises is not the reduction of the total costs of hunting, but rather the reduction of the number of game animals to their break-even level. For the last decade, Ukraine has seen a decrease in the number of ungulates, which are the basis for effective hunting farms. The density of wild animals in

hunting grounds is much lower than scientifically based indicators of their optimal capacity. This tendency makes it possible to argue about the ineffectiveness of the using of potential opportunities for hunting grounds that are not even capable of simply reproducing wildlife and the neediness to move to a new hunting economy based on the principles of a market economy.

In order to construct an economic and mathematical model, it is necessary to analyze what constituents generates the total costs and total revenues from the management of the hunting economy.

Total revenues from hunting economy are formed at the expense of [18]:

– implementation of licenses in accordance with the limit for hunting animals and additional licenses that are implemented in case of non-use of this limit;

– realization of shooting cards for fur animals and game birds;

– sales of hunting products (meat, skins, fat and trophies of wild hunting animals);

– provision of services to hunters in the hunting process (hunting services, trapping services, the use of enterprise transport (car or carriage), the development of carcasses of hunting animals, housing, clothing, weapons, documents, etc.);

– sponsorship.

The amount of revenues does not include entry fees and membership fees paid by hunters. In accordance with the constituent documents of public hunting organizations, funds received from entrance fees and membership fees are directed towards the reproduction of wild hunting animals.

Total costs for hunting are formed at the expense of wage costs of workers employed in hunting, the cost of guarding, reproduction and recording of wild hunting animals, the ordering of hunting grounds and other expenses related to the management of the hunting economy.

Other costs related to the management of the hunting economy include [18]:

– costs for the maintenance of hunting houses and hunting bases, office premises and production facilities, namely, the cost of their heating, lighting, maintenance;

– costs for the transport maintenance, hunting roads and their corresponding depreciation deductions;

– costs for the maintenance of hunting dogs, slaughter and hunting birds, horses, etc.;

– costs for the purchase and repair of hunting weapons, low-value inventory, stationery, etc.;

– other costs for business events.

The basis of forecasting the directions of development of hunting enterprises is laid the economic and mathematical model of break-even. Target function, which characterizes the level of break-even hunting activity, is described below:

$$F(X(Q),Y(Q)) = f_2(Y(Q)) - f_1(X(Q)) \rightarrow \min, \quad [0; -\infty] \tag{1}$$

$$f_1(X(Q)) = \sum_{i=1}^{n} X_i(Q), \quad n = 3, \tag{2}$$

$$f_2(Y(Q)) = \sum_{j=1}^{m} Y_j(Q), \quad m = 3, \tag{3}$$

where $f_1(X(Q))$ – is a function that describes the total revenues from hunting; $f_2(Y(Q))$ – a function that describes the total cost of hunting; n – the number of components that form the total revenues from hunting, m – the number of components that form the total costs of hunting.

The boundary between the unprofitable and break-even level of hunting activity will be such number of wild hunting animals, in which, in accordance with the established standards of extraction (shooting), the difference between total costs and total revenues will be equal to zero. In addition, there is a probability that the break-even number of wild hunting animals may exceed the maximum capacity of hunting grounds. In this case, hunting is economically and environmentally inappropriate as the proceeds from extraction of an additional animal will be significantly lower than the costs associated with an increase in their number, in which the hunting enterprise will receive the costs for compensation of environmental and economic losses caused by hunting animals to forest, and water facilities.

In accordance with the objective function, the authors have formulated the theoretical principles of the economic and mathematical model, which can be expressed using the system of equations:

$$L(Q) = \sum_{u=1}^{d} PL_u \cdot Q_u \cdot \frac{q_u}{100} \cdot S \cdot K_u \tag{4}$$

$$P(Q) = \sum_{u=1}^{d} \sum_{e=1}^{b} Pp_{ue} \cdot N_{ue} \cdot Q_u \cdot \frac{q_u}{100} \cdot S \tag{5}$$

$$R(Q) = \sum_{u=1}^{d} Ps_u \cdot Q_u \cdot \frac{q_u}{100} \cdot S + \sum_{v=1}^{l} Ps_v \cdot T_v \tag{6}$$

$$Z(Q) = \left(\frac{0{,}1 \cdot L(Q)}{\sum_{u=1}^{d} PL_u \cdot Q_u \cdot \frac{q_u}{100} \cdot K_u} \cdot (1 + \frac{r}{100}) \right) \cdot OJ + OM \tag{7}$$

$$W(Q) = 2{,}0 \cdot \sum_{u=1}^{d} \sum_{k=1}^{z} H_{uk} \cdot T_{uk} \cdot PF_k \cdot Q_u \cdot S \tag{8}$$

$$O(Q) = 0{,}2 \cdot (Z(Q) + W(Q)) \tag{9}$$

where $L(Q)$ – revenues from the sale of licenses (shooting cards) for the extraction of game animals, UAH; $P(Q)$ – income from the sale of hunting products, UAH; $R(Q)$ – revenues from rendering services to hunters, UAH; $Z(Q)$ – costs on the employees' wages, UAH; $W(Q)$ – costs for protection, reproduction, registration of hunting animals and the ordering of hunting grounds, UAH; $O(Q)$ – other costs related to the management of the hunting economy, UAH; PL_u – the cost for a license (shooting card) for obtaining the u-type of a hunting animal, UAH/animal; Q_u – optimal density of hunting animals of the u-species for 1000 hectares of hunting grounds, animals; q_u – allowable rate of using (shooting) of hunting animals of the u-species with a minimum (maximum) permissible density, %; S – area of hunting grounds, thousands hectares; K_u – coefficient, taking into account the number of additional licenses (shooting cards), which are realized in case of non-use of the permissible norm of obtaining u-type hunting animal; d – the number of species of hunting animals; Pp_{ue} – sales value of e-products from u-type hunting animal, UAH/kg, unit; N_{ue} – normative output of e-products from one hunting animal of the u-species, kg, unit/animal; b – number of types of hunting products; Ps_u – the cost of providing a service for the development of one carcass u-type hunting animal, UAH/animal; Ps_v – cost of providing v-th service to hunters, UAH/person-day, horse-day, machine-change; T_v – the general period of providing v-th service to hunters, man-days, horse-days, machine-change; l – the number of types of services provided to hunters; r – percentage of forest hunting grounds in the total area,%; OJ – annual wage fund for one hunter engaged in hunting, UAH; OM – annual wage fund of a hunter engaged in hunting, UAH; H_{uk} – daily norm of k-th type of forage per one individual for the u-species of a hunting animal, tons, kg, pc/day; T_{uk} – the average period of feeding the u species of hunting animal k-th type of feed, days; PF_k – cost of the k-th type of feed for the feeding of hunting animals, UAH/ on, kg, pieces; z – the number of feed types required for feeding hunting animals.

Thus, we take into account certain specific conditions for the reproduction and usage of hunting fauna resources restrictions for the target function of the model appear as follows in this form:

$$Q_{min} \le Q_{br} \le Q_{max} \tag{10}$$

$$q(Q_{min}) \le q(Q_{br}) \le q(Q_{max}) \tag{11}$$

where $q(Q_{br})$ – the norm of usage (shooting) of the quarry at their break-even number, %; $q(Q_{min})$ – the permissible limits of using (shooting) hunting animals at the minimum allowable number, %; $q(Q_{max})$ – the norm of usage (shooting) of hunting animals at their maximum permissible number, %.

The authors have tested the constructed economic and mathematical model on the example of the activity of the hunting enterprises based in the Lviv region (Ukraine). In order to determine the break-even number of hunting animals, the authors have considered four directions of development of hunting economy, in particular:

1. determination of the break-even number of the hunting animals, based on the actual indicators of the production and economic activities of the hunting enterprises;

2. determination of the break-even number of the hunting animals at their minimum allowable density and the minimum permissible norm of use (shooting);

3. determination of the break-even number of the hunting animals at their maximum permissible density and the minimum allowable rate of use (shooting);

4. determination of the break-even number of the hunting animals at their maximum permissible density and the maximum permissible norm of use (shooting).

Summary calculations in the context of the particular areas of the hunting economy are presented in table 1.
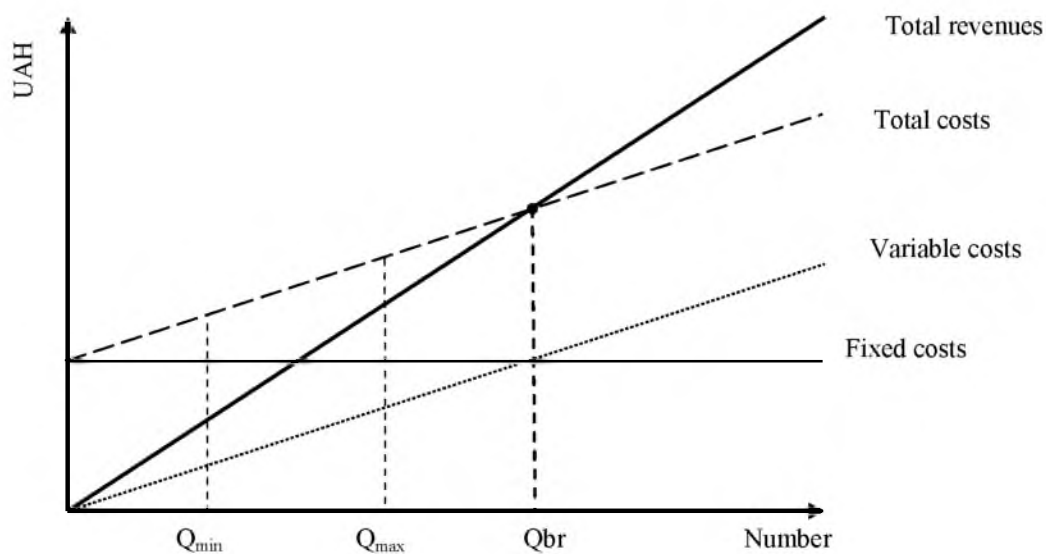
The analysis of the production and economic activities of the hunting enterprises in the Lviv region has showed that none of them meets the established norms of the minimum number of wild hunting animals, at which they are allowed to be produced (shooting, catching) [19].

The calculations, presented in table, confirm that the achievement of the break-even level of the hunting activity, with using actual financial indicators of reproduction and using of the hunting fauna resources, is only possible if the number of wild hunting animals significantly exceeds the maximum possible capacity of the hunting grounds (figure).

Thus, the current situation in the hunting grounds in the Lviv region (Ukraine) gives us an opportunity to carry out additional calculations taking into account more optimistic directions of hunting economy development. These directions are based on the assumption that the number of the main species of wild hunting animals in the hunting grounds in the Lviv region (Ukraine) corresponds to the established norms and are in the range between the minimum (at which they are allowed to be extracted) and their maximum allowable capacity.

Summary results obtained by determining the break-even number of the hunting animals in the Lviv region (Ukraine)

Indexes	Direction 1				Direction 2			
	Deer	Roe	Boar	Hare	Deer	Roe	Boar	Hare
Total costs, UAH	17 252 900				58 688 499.2			
Costs per 1000 hectares of the hunting grounds, UAH	10 470.3				35 616.3			
Variable costs, UAH / animal	730.8	221.1	252.4	7.4	927.5	532.2	1286.0	44.3
Total income, UAH	6 088 400				36 798 506.5			
Income from one produced animal, UAH / animal	–	–	–	–	16623.9	5539.70	10424.2	71.5
Revenue per animal, UAH	996.5	200.9	268.0	4.1	1676.7	555.2	2088.1	10.7
Q_{br}	5500	40493	13194	128782	10126	49777	8148	90461
Indexes	Direction 3				Direction 4			
	Deer	Roe	Boar	Hare	Deer	Roe	Boar	Hare
Total costs, UAH	100 082 360.2				100 082 360.2			
Costs per 1000 hectares of the hunting grounds, UAH	60 736.96				60 736.96			
Variable costs, UAH / animal	969.9	577.7	1326.9	47.6	969.9	577.7	1326.9	47.6
Total income, UAH	75 681 872.0				103 299 920.0			
Income from one produced animal, UAH / animal	16598.06	5528.31	10415.6	71.5	16596.29	5527.04	10407.55	71.5
Revenue per animal, UAH	1661.8	552.9	2079.5	10.7	2130.6	736.2	3127.5	17.9
Q_{br}	13281	49777	10198	90461	9133	42330	7183	90461
Normative indicators of the number of the hunting animals:	Q_{min}		8021	19907	5726	31833
	Q_{max}		16101	49777	9827	90461

The number of the main hunting animals species, which is calculated based
on the actual indicators of production and economic activities of the hunting enterprises

In order to determine the break-even number of the wild hunting animals in these areas, the authors have calculated the total revenues and total costs on hunting in accordance with the established norms of the output of hunting products and provided services, which are offered to hunters in the hunting process, the expenses on the animals' feed and the real prices of the products, services and feeds that have been formed to date in Ukraine. In addition, in order to determine the minimum and maximum permissible numbers of the wild hunting animals, the norms of their usage (shooting), the authors have used the indicators that are theoretically substantiated and approved [19].

The calculations presented in Table 1 show that, in order to achieve the level of break-even level of the hunting economy, with a minimum allowable number of wild hunting animals, it is necessary to keep roe and hare whose number is slightly higher than the maximum capacity of hunting grounds. The number of deer and wild boars, however, doesn't reach the minimum capacity of hunting grounds. This can be explained by the fact that costs on the usage (shooting) of deer and boars significantly exceed the variable costs of their reproduction, protection and accounting. It also should be noted that the revenues from the extraction of hares don't cover the variable costs of their maintenance. Taking into account everything mentioned above, it can be concluded that the breeding population of roe and hare is their maximum number, which allows full using of the capacity of hunting grounds. In addition, a part of the fixed and variable costs associated with the reproduction, protection and accounting of roe and hare can be attributed to the costs associated with the reproduction, protection and accounting of deer and wild boars, in case of increase in the number under which it will be possible to cover these costs.

Discussion. After considering four directions of the development of hunting enterprises, the authors claim that the fourth direction is the most favorable for the Lviv region; this direction is aimed to increase the number of hunting animals to their maximum permissible density in the hunting grounds in case of the maximum permissible norm of their use. The calculation of the break-even number of the wild hunting animals on the basis of actual financial indicators of the production and economic activity of the hunting enterprises in the Lviv region has confirmed the complete inefficiency of hunting, but this doesn't mean that this and all other areas, that can be used for preliminary analysis of ecological and economic projects and environmental programs, aimed to increase the population of the main species of the wild hunting animals.

Besides that, it has been established that not all hunting enterprises can be profitable, in particular, such enterprises which include the area of hunting grounds which is less than 10 000 hectares, which is associated with significant costs for wages payment to the employees in the hunting industry. To increase their economic efficiency, the authors propose to increase the area of hunting grounds due to hunting grounds of other enterprises.

Conclusions. The calculations which were made to determine the break-even number of the main species of the wild hunting animals, have shown that the hunting economy can operate on the basis of self-sustainment and self-financing without going beyond legally established norms. The obtained results are not final because there is a possibility of adjusting the number of hunting animals within the minimum and maximum capacity of hunting grounds.

The prospects for the further investigations are in the formation of a system of environmental policy instruments in the field of reproduction and using of hunting fauna resources, which will increase the efficiency of hunting management and make managerial decisions on the development of hunting economy, both at the state and regional levels.

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АҢШЫЛЫҚ ШАРУАШЫЛЫГЫНЫҢ ДАМУ БАГЫТТАРЫН БОЛЖАУДЫҢ ЭКОНОМИКАЛЫҚ-МАТЕМАТИКАЛЫҚ ҮЛГІСІ

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ЭКОНОМИКО-МАТЕМАТИЧЕСКАЯ МОДЕЛЬ ДЛЯ ПРОГНОЗИРОВАНИЯ НАПРАВЛЕНИЙ РАЗВИТИЯ ПРЕДПРИЯТИЙ ОХОТНИЧЬЕГО ХОЗЯЙСТВА

Аннотация. Статья обобщает аргументы и контраргументы в научной дискуссии по вопросам развития предприятий охотничьего хозяйства. Целью статьи является построение экономико-математической модели для определения численности диких охотничьих животных, при которой производственно-хозяйственная деятельность предприятий охотничьего хозяйства будет функционировать на принципах самоокупаемости и самофинансирования. Актуальность решения данной научной проблемы заключается в том, что появилась объективная необходимость реформирования охотничьего хозяйства в Украине, которая предусматривает формирование национальной концепции его организации и развития, что должна ориентироваться на эффективные экономические, экологические и социальные инструменты с учетом национальных традиций менеджмента. Для построения экономико-математической модели прогнозирования направлений развития предприятия охотничьего хозяйства исследование проведено в следующей логической 1последовательности: проанализировано, за счет каких составляющих формируются общие расходы и общие поступления от ведения охотничьего хозяйства; установлена граница между убыточным и безубыточным уровнем охотничье-хозяйственной деятельности; в соответствии с целевой функцией сформулированы теоретические основы экономико-математической модели, которые позволяют определить безубыточную численность охотничьих животных; рассмотрены четыре направления развития охотничьего хозяйства.

Методическим инструментарием проведенного исследования стали методы анализа, синтеза, экономико-математического моделирования и статистический метод, периодом исследования избраны 2016-2017 годы. Объектом исследования избрано охотничье хозяйство Львовской области (Украина), поскольку именно оно дало нам возможность для проведения дополнительных расчетов с учетом более оптимистических направлений развития охотничьего хозяйства.

Исследование эмпирически подтверждает и теоретически доказывает, что охотничье хозяйство может функционировать на основе самоокупаемости и самофинансирования, не выходя за пределы установленных и законодательно закрепленных нормативов.

Ключевые слова: экономически математическая модель, предприятия, охотничье хозяйство, дикие охотничьи животные, безубыточность численность диких животных, емкость охотничьих угодий.

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