Optimization Models of Agricultural Enterprises Activities under Stochastic Uncertainty Considering Institutional Factors

Victoria KYFYAK, *Lecturer Ph.D*
Economics Department,
Chernivtsi Yuriy Fed'kovich National University,
Ukraine
vikashkrobanets@mail.ru

Abstract

The uncertainty of the environment of agricultural enterprises functioning due to institutional factors was determined. The optimization model of activity of agricultural enterprises under stochastic uncertainty based on the institutional factors is proposed as well.

Keywords: *optimization model, stochastic uncertainty, institutional factors, institutional uncertainty, structure of agricultural production.*

Introduction

Research and development of regulation of agricultural enterprises (as the main subjects forming food security and competitive advantages of the country) requires a systematic approach to determine the structure of the agricultural sector in a dynamic changing environment. The accounting of institutional factors as the core product of uncertainty conditions of agricultural enterprises is particularly important at the new structure of the economic system. Therefore, one of the objectives of the strategy of development of modern agricultural management mechanism is modeling the optimal proportions of agricultural production.

Over the past decades were built and investigated dozens of mathematical economic models of agricultural enterprises. However, it should be noted that in most cases these models are deterministic, so with a high degree of idealization reflect the real situation. This fact does not reduce their importance for the study of the methodological problems of the agricultural sector, but they are unlikely to serve as an analytical tool for quantitative calculations and constructing accurate predictions of the relevant economic systems that operate in a changing environment.

The article aims at creating of efficient optimization model of agricultural enterprises in the face of uncertainty caused by institutional factors.

Paper Content

Uncertainty may be different, due to various reasons. So, we have to consider options that depend on the state of weather and climatic conditions, on the behavior of certain *subjects***,** from the expectations and projections for the future and so on. Consideration of real economic problems shows that such "uncertainty" is often typical. Hence there is a need to move from researching of idealized situations described by deterministic variables to taking into account the probabilistic nature of behavior of economic systems.[1]

Uncertainty is a rather broad concept that reflects the objective impossibility of obtaining absolute knowledge about internal and external operating conditions for socio-economic systems, the ambiguity of their parameters. Uncertainty is treated not only in the sense of lack of comprehensive knowledge, but also as a constant exchanging conditions, transformation, fast and flexible reorientation of production, the actions of competitors, changes in market conditions, etc.[2] Uncertainty mutates in shape and content.

In today clearly emerge the uncertainty of the domestic agricultural economy that among the many factors associated with institutional uncertainty, defined as imperfect institutional support.

American economist F. Knight in *Risk, uncertainty and profit* proves that the decisive role in the emergence of the phenomenon of entrepreneurship plays a special form of risk – uncertainty that can be insured.[3] The formal and informal institutions minimizing uncertainty in society. The institutions are rules that guide activities of entities in a particular direction.[4] Thus, in the modern economy institutions serve as a form of stabilization and reduction of uncertainty. In transformational economical system with imperfect institutions we may talk about the presence and significant impact of institutional uncertainty.

---

[1] S. A. Berezin and B. L. Lavrovsky, *Stochastic optimization model* (Novosibirsk University [NSU], Novosibirsk: Novosibirsk State University [NSU], 1980), 3.
[2] F. H. Knight, *Risk, Uncertainty, and Profit* (Cosimo, Inc., 2006), 31.
[3] Knight, *Risk, Uncertainty, and Profit*, 294.
[4] V. Vitlinskyy, *And risk in the economy and entrepreneurship:* [monograph], V.V. Vitlinskyy (H. I. Velykoivanenko - K.: MBK, 2004), 11.

In science, there is no attention to institutional uncertainty with in a changing environment is essential. We can identify the factors that give rise to this uncertainty:

1) dynamic – caused by scientific and technological progress, trends and effects of it are very difficult to predict;

2) subjective – due to psychological variability sentiments of people and their behavior;

3) factor of limited information;

4) limitations of research tools;

5) structural – caused by the order effect of economic mechanism: pricing - financial software – development of credit relations, etc.

Causes and types of uncertainty for economic and mathematical models associated with the characteristics of different nature. The economic literature describes and investigates a number of approaches to the classification of uncertainty. Accordingly, we can distinguish the following types of uncertainty:

- considering institutional factors;
- mental and psychological uncertainly (the dominant factor is the human);
- transactional uncertainly (this type of uncertainty is the imperfect reflection of institutional support for property rights);
- systematic and synergetic uncertainly (the basis of this type is the structure factor, which is based on a systems approach);
- transformation uncertainty (this kind of uncertainty is characteristic for all transition economies and systems);
- integration uncertainty (due to increasing trends of globalization of economic processes).

We will offer some stochastic optimization models for structures of agricultural enterprises of given region based on their features. We believe that the activity of agricultural enterprises is the uncertainty caused by institutional constraints, incompleteness institutional support.

One of the areas of solution of the optimization model is to determine the optimal structure of agricultural enterprises under the influence of institutional factors. Rightly about the above statement is V. Polterovich whose institutional trajectory is considered promising if it is coordinated with the resource, technological and institutional constraints and provides built-in mechanisms that induce changes in declared institutions and prevent the emergence of dysfunctions and institutional traps.[5] This effect is that the parameters of crop yields, product

[5] Vitlinskyy, *And risk in the economy and entrepreneurship.*

prices, the number of inputs and costs per unit of output should be characterized not only by their averages, but also variation.

We agree with V. Riabokon that synthesizing the overall economic and social effects on the functioning of the institutional mechanism should focus on such important attributes of his successful development of the sector as the output of production and sales in the market, the structure of sales from infrastructure sales channels, the level of prices; formation and development of agricultural producers, the level and structure of earnings by sector, productivity, cost and profitability, the level of equivalent exchange.[6] Enterprises should develop within existing production resources, rational use them to provide livestock feed at the optimal structure and the optimal quality, to meet contractual sells obligation. The optimality criterion is to maximize profits.

Stochastic analogue of the deterministic theoretical problem with stochastic parameters we built according to the chosen problem statement. The maximizing of the expectation of the objective function must be selected as optimality criterion. Theoretical terms should be replaced by probabilistic constraints require the relevant inequalities with probability at least predetermined.

The structure of optimization model for agrarian enterprise with optimizing cattle was taken as a basic mathematical model.[7] This is especially actual in reducing livestock in Ukraine, however, in our opinion, can be applied on a wider scale. Parameters of the model are random variables, replaced by their statistical characteristics (expectation and variance).

Need to find variables

$x_s\ (s \in S)$, $x_h\ (h \in H)$, $x_j\ (j \in J)$, $\overline{X}$ *and* $\underline{X}$,

to maximize function Z:

$$Z = \overline{X} - \underline{X} \rightarrow \max \qquad (1)$$

under the following conditions:

1) forming the sum of production costs:

$$\underline{X} = \sum_{s \in S} f_{1s} x_s + \sum_{h \in H} f_{1h} x_h \qquad (2)$$

[6] V. Polterovich, *Strategy of modernization, institution and coalition*, 11, http://www.institutiones.com/strategies/960-strategii-modernizacii0instituti-i-koalicii.html.
[7] V. P. Ryabokon, "Effeciency of operating developing of mechanisms of economic regulation of agricultural production," V. P. Ryabokon and A. P. Suprun, *Economics of agricultural sector*, 6 (2012): 6-12.

2) formating proceeds from the sale of marketable products:

$$\overline{X} = \sum_{s\in S} \overline{c}_q \overline{\nu}_{qs} x_s + \sum_{h\in H} c_h \nu_{qh} x_h \qquad (3)$$

3) limited productive resources:

$$\sum_{s\in S} \overline{f}_{is} x_s + \sum_{h\in H} f_{lh} x_h \le F_l \qquad (l \in L) \qquad (4)$$

4) the use in livestock by-products plant:

$$\sum_{s\in S} \overline{p}_{js} x_s \ge x_j \ , \quad (j \in J) \qquad (5)$$

5) manufacturing of the final product in an amount not less than specified, including:

a) plant:

$$\sum_{s\in S} \overline{\nu}_{qs} x_s \ge V_q \qquad (q \in Q_1, Q_1 \in Q) \qquad (6)$$

b) livestock:

$$\sum_{h\in H} \nu_{qh} x_h \ge V_q \qquad (q \in Q_2, Q_2 \in Q) \qquad (7)$$

5) the relationship of crops and livestock, including:

a) balance diets for animal:

$$\sum_{s\in S_k} a_{is} \overline{p}_s x_s + \sum_{j\in J} a_{ij} x_j \ge \sum_{h\in H} b_{ih} x_h \qquad (i \in I) \qquad (8)$$

b) the structure of food:

$$\sum_{h\in H} d_{kh}^{\min} x_h \le \sum_{s\in S_l} a_{is} \overline{p}_s x_s + \sum_{j\in J} a_{ij} x_j \le \sum_{h\in H} d_{kh}^{\max} x_h \qquad (k \in K) \qquad (9)$$

7) performance in livestock of technological requirements of structure of cattle herd:

a) the structure of the herd:

$$\sum_{h\in H} x_h = A \ , \qquad (10)$$

8) the limited size of crop industries:

$$\underline{n}_r \leq \sum_{s \in S} x_s \leq \overline{n}_r, \quad (r \in R) \qquad (11)$$

9) inherence variables:

$x_s \geq 0,$ $(s \in S)$, $x_h \geq 0,$ $(h \in H)$, $x_j \geq 0,$ $(j \in J)$, $\overline{X} > 0$ And $\underline{X} > 0$ (12)

Adopted notation:

H – species of animals;

K – sex- and agegroups of animals;

S – crop species;

L – types of resources;

I – types of nutrients;

J – food groups;

Q – types of commercial products;

Q1 – types of commodity crop production;

Q2 – types of commercial livestock production.

Applied indices:

h – type and k- sex- and agegroups group of animals;

s – crops;

l – type of resource;

1 – cash costs;

i – number of nutrients;

j – a group of feed;

q – kind of marketable products;

r – agricultural technology of crops.

Free members:

F_i – availability of resource i-th species;

V_q –amount of production q-th species under contractual obligations;

$\underline{n}_r$ and $\overline{n}_r$ - respectively the minimum and maximum possible area of crops r-th group.

Applied technical and economic factors:

f_{ls} – costs of l-th resource per unit area s-th culture;

f_{lh} – costs of l-th resource per unit of livestock h-th group of animals;

p_{js} – output per unit of area of s-th culture of j-th type of feed that are byproducts;

p_s – out of the main forage production per unit of area of s-th fodder crops;

a_{ij} – nutrient of i-th species per unit of j-th type of feed;

a_{is} – nutrient of i-th species per unit production of feed s-th crop;

$d_{kh}^{\min}$ – the minimum permissible standard size needs to feed the k-th group of livestock of h-th group of animals, which is expressed in feed units;

$d_{kh}^{\max}$ – the maximum permissible standard size needs to feed k-th group of livestock of h-th group of animals, which is expressed in feed units;

V_{qs} – output of marketable products of q-th species per unit area of culture s-th species;

V_{qh} – output of marketable production of q-th type of h-th group of animals;

C_s – the cost of 1 hectare of s-th culture;

C_h – the cost of a stock of h-th group of animals without the cost of feed;

C_q – the price of one quintal of q-th type of product.

variables:

x_s – the size of the area of s-th culture to be found;

x_h – the size of livestock of h-th group of animals to be found;

x_j – the amount of the j-th type of feed (by-products plant), which goes to feeding animals;

$\overline{X}$ – total income (loss) from sales;

$\underline{X}$ – production costs.

Consider a stochastic mathematical model of the problem with probabilistic constraints.

Need to find variables

$x_s (s \in S)$, $x_h (h \in H)$, $x_j (j \in J)$, $\overline{X}$ and $\underline{X}$,

to maximize function Z:

$Z = \overline{X} - \underline{X} \to \max$

under the following conditions:

1. Deterministic restrictions:

1.1) given size of age- and sexgroups of animals:

$x_h = E_h \quad (h \in H)$ (13)

1.2) limit the size of crop industries:

$\underline{n}_r \leq \sum_{s \in S} x_s \leq \bar{n}_r, \quad r \in R$ (14)

2. Probabilistic limits:

2.1) forming the sum of production finance costs:

$P(-\underline{X} + \sum_{s \in S} f_{1s} x_s + \sum_{h \in H} f_{1h} x_h = 0) \geq P_1$ (15)

2.2) the formation of the receipts from the sale of marketable products:

$P(-\underline{X} + \sum_{s \in S} \bar{C}_q \bar{\nu}_{qs} x_s + \sum_{h \in H} C_h \nu_{qh} x_h = 0) \geq P_c$ (16)

2.3) limits of productive resources:

$P(\sum_{s \in S} f_{ls} x_s + \sum_{h \in H} f_{lh} x_h \leq F_l) \geq P_l \quad (l \in L)$ (17)

2.4) application of by-products plant in animal:

$P(\sum_{s \in S} \bar{P}_{js} x_s - x_j \geq 0) \geq P_j \quad (j \in J)$ (18)

2.5) output of final crop production isn't less than determined:

$P(\sum_{s \in S} \bar{\nu}_{qs} x_s \geq V_q) \geq P_q \quad (q \in Q_1, Q_1 \in Q)$ (19)

2.6) to optimize the structure of crop and livestock, including:

a) balance the diet of animals:

$P(\sum_{s \in S_k} a_{is} \bar{p}_s x_s + \sum_{j \in J} a_{ij} x_j \geq \sum_{h \in H} b_{ih} x_h) \geq P_i, \quad (i \in I)$ (20)

b) the structure of the feed:

$P(\sum_{s \in S_k} a_{is} \bar{p}_s x_s + \sum_{j \in J} a_{ij} x_j \leq \sum_{h \in H} d_{kh}^{\max} x_h) \geq P_k, \quad (k \in K)$ (21)

$P(\sum_{s \in S_k} a_{is} \bar{p}_s x_s + \sum_{j \in J} a_{ij} x_j \geq \sum_{h \in H} d_{kh}^{\min} x_h) \geq P_k, \quad (k \in K)$ (22)

3) inherence variables:

$x_s \geq 0, \ (s \in S), \ x_h \geq 0, \ (h \in H), \ x_j > 0, (j \in J), \ \underline{X} > 0, \overline{X} > 0,$ (23)

Where

$P_1, P_c, P_l, P_j, P_q, P_к$ – equal probabilities of the relevant restrictions.

Deterministic analog of problem involves the objective function, constraints and deterministic problem without changes and probabilistic limits converted into identical determined by a mathematical apparatus which is shown above.

1. Deterministic analogue of probabilistic limits of the formation of financial expenses:

$$\sum_{s\in S}\bar{f}_{1s}\,x_s + t_{p1l}\sqrt{\sum_{s\in S}\sigma^2_{\upsilon c}x_s^2 + \sum_{h\in H}C_h v_{qh}x_h} - \bar{X} = 0 \qquad (24)$$

2. Deterministic analogue of probabilistic limits of the formation of the total revenue from the sale:

$$\sum_{s\in S}\bar{c}_q\,\bar{v}_{qs}\,x_s - t_{p_c}\sqrt{\sum_{s\in S}\sigma^2_{\upsilon c}x_s^2} + \sum_{h\in H}c_h v_{qh}x_h - \bar{X} = 0 \qquad (25)$$

3. Deterministic analogue of probabilistic limits on the use of productive resources:

$$\sum_{s\in S}\bar{f}_{1s}\,x_s + t_{pl}\sqrt{\sum_{s\in S}\sigma^2_{fls}x_s^2 + \sum_{h\in H}\bar{f}_{lh}\,x_h} \le \bar{F}_l, \quad (l\in L) \qquad (26)$$

4. Deterministic analogue of probabilistic limits of the use of animal by-products plant:

$$\sum_{s\in S}\bar{p}_{js}\,x_s - t_{pl}\sqrt{\sum_{s\in S}\sigma^2_{pj}x_s^2} - x_j \ge 0, \quad (j\in J) \qquad (27)$$

5. Deterministic analog of probabilistic limits 2.5 out of final crop output, at least for the set

$$\sum_{s\in S}\bar{v}_{js}\,x_s - t_{pl}\sqrt{\sum_{s\in S}\sigma^2_{pj}x_s^2} \ge V_{q,} \quad (q\in Q_{1,}Q_1\in Q) \qquad (28)$$

6. Deterministic analog of probabilistic limits engaged relationship with crop breeding, including:

a) balancing diet for animal:

$$\sum_{s\in S_k}a_{is}\,\bar{p}_s\,x_s - t_{ps}\sqrt{\sum_{s\in S_k}\sigma^2_{ps}x_s^2} + \sum_{j\in J}a_{ij}x_j - \sum_{h\in H}b_{ih}x_h \ge 0, \quad (i\in I); \qquad (29)$$

b) the structure of food:

$$\sum_{s\in S_k}a_{is}\,\bar{p}_s\,x_s - t_{ps}\sqrt{\sum_{s\in S_k}\sigma^2_{ps}x_s^2} + \sum_{j\in J}a_{ij}x_j - \sum_{h\in H}d^{\max}_{kh}x_h \le 0, \quad (k\in K); \qquad (30)$$

$$\sum_{s\in S_k}a_{is}\,\bar{p}_s\,x_s - t_{ps}\sqrt{\sum_{s\in S_k}\sigma^2_{ps}x_s^2} + \sum_{j\in J}a_{ij}x_j - \sum_{h\in H}d^{\min}_{kh}x_h \ge 0, \quad (k\in K); \qquad (31)$$

Where

$t_p = \Phi^{-1}(P_i)$.

The main difference between the deterministic equivalent of the stochastic model and the corresponding linear model is that it takes into account the size of the objective fluctuations of random variables (model parameters), i.e. it is a more accurate reflection of the real production situation.

According to the developed model we can schedule the development of National Agricultural passport. Perspective objective is to guarantee food security through control of sowing different crops in all regions of the country. Thus, agricultural planning passports define three levels according to the climatic zones of the agricultural market. At first, the plan will be formulate at nationwide structure of sown areas and will offer those crops that can most effectively grow in each area. Then in the region will be develop passport for city regions, based of the National passport. The last stage, to prove to each farmer.[8] It should be noted that such a declared control over production phases (planning) can district the market situation. So will be destroyed not only postulates of liberalization long time incarnated in practice management, but also the market itself.

Let us note the introduction of certification of agricultural production “from the top” may lead to institutional as well as to economic traps that are difficult to predict by mathematical programming. Therefore, we believe that our proposed model should be used according to the method of “bottom-up”, i.e. the formation of the structure of agricultural products from producers to a government authority that will best meet institutional (not just natural and climatic conditions) characteristics of the region.

Conclusions

The proposed version of the model of activities of agricultural enterprises allows considering the impact of institutional factors on their development. Stochastic model parameters provide a more adequate reflection of the uncertainty that is the prerequisite for a modern agricultural sector in comparison with classical models. The algorithm of transformation of model to separable deterministic mathematical programming problem allows to provide a solvability of the systems. It is important to achieve the dynamics of the transformation

[8] M. M. Kostrytsya, “Entrepreneurship as institutional factors of rural development,” *Scientific Bulletin NUBiP of Ukraine* 163 (2011): 213-220.

process, the momentum of development, not only structural, economic and institutional indicators identified by analogies different content.

Prospects for further research

We believe that further implementation of economic-mathematical modeling in the mechanism of development of agricultural enterprises should apply to the working out of scenarios of the future development.

Bibliography:

1. Berezin, S. A., and Lavrovsky, B. L. *Stochastic optimization model*. Novosibirsk University [NSU] Novosibirsk: Novosibirsk State University [NSU], 1980.
2. Knight, F. H. *Risk, Uncertainty, and Profit*. Cosimo, Inc. 2006.
3. Kostrytsya, M. M. “Entrepreneurship as institutional factors of rural development.” *Scientific Bulletin NUBiP of Ukraine* 163 (2011): 213-220.
4. Polterovich, V. *Strategy of modernization, institution and coalition*. http://www.institutiones.com/strategies/960-strategii-modernizacii0instituti-i-koalicii.html.
5. Ryabokon, V. P. “Effeciency of operating developing of mechanisms of economic regulation of agricultural production.” V. P. Ryabokon, and A. P. Suprun, *Economics of agricultural sector* 6 (2012): 6-12.
6. Tesla, I. “Agricultural passport introduce in Ukraine.” *Slobodskoy edge*, 89. From 26.07.2012. http://www.slk.kh.ua/news/agroprom/agrarnij-pasport-vvedut-v-ukrayini---zastupnik-ministra.html.
7. Vitlinskyy, V. *And risk in the economy and entrepreneurship:* [monograph]. V.V. Vitlinskyy, H. I. Velykoivanenko - K.: MBK, 2004.