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# The use of stochastic model of supply and demand for the organization of planning and forecasting activities at the agricultural enterprise

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**Abstract**

In the article we give new approach of planning and organization of work on forward-looking enterprise agribusiness: a spectrum of relationships manufacturer and buyer, forming a system of supply and demand. This takes into account the stochastic nature of supply and demand indicators. We made the analysis of production and sales as an example of LLC "Kolos" (Kurgan region, Almenevsky area) using the proposed method.

**Keywords**

Planning, forecasting, stochastic system of supply and demand, supported and unsupported demand, utilized and unutilized supply, management of agricultural enterprises.

## Introduction

Planning and forecasting – one of the most important functions of the enterprise management, allowing objectively assess the prospects for the development of the company, to determine the way of development, reduce the risk of adverse outcomes of production and financial activities. However, ut is necessary in market conditions that a plan and forecast should be not formal documents, but expressing deep thought out strategy and tactics of industrial activity, helping in advancement into new markets and improving the social situation of workers.

Studies show that the overwhelming majority of agricultural enterprise still do not use the possibility of planning and forecasting its activities as a tool to improve the efficiency of production, which proved its priority over other management functions in developed countries.

Difficulty of planning and forecasting activities on farms caused mainly by complexity of the organization of planning and forecasting work, shortage of qualified personnel, unpredictability of economic situation, the lack of adequate methodological support. Planning and forecasting activities of most companies is based on intuition, knowledge and experience of employees by 70% and only by 30% – on calculations using computer technology and the use of special programs. For the time being the most common type of planning documents on farms in the region, in the best case – a business plan to substantiate the

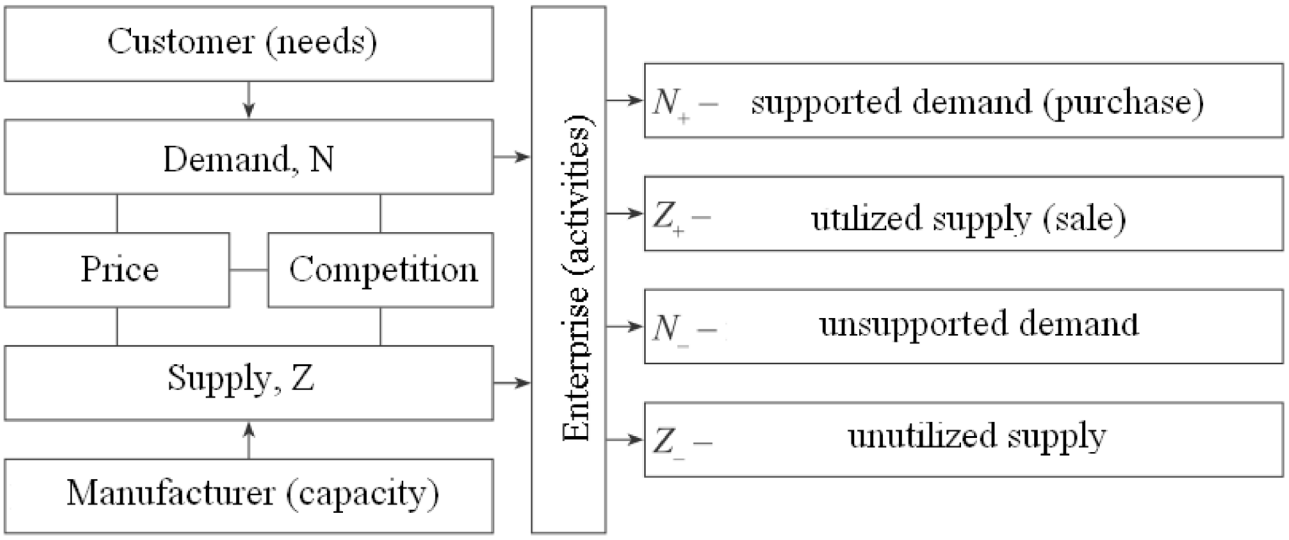


**Figure 1. Block diagram of the model of supply and demand**

involvement of additional financial resources for the development of production and to give an idea of promoting a product on the market, selling prices, anticipated financial and economic performance of the company. Another important planning document is the current activity plan and financial plan, which indicators are often used instead of feasible prediction calculations.

Most studies, reviewing the functioning of the agricultural enterprise and describing the model to improve its effectiveness, lay stress on minimizing costs or maximizing profits at constant conditions of its functioning. These models do not take into account the random nature of the studied indicators: output, demand for products. Moreover, the situation of overproduction and subsequent loss of profit from unsold products also not taken into account, and at the same time are not considered the amounts of lost income due to the fact that demand for the company's products exceeds supply.

This paper discusses the issues of planning and forecasting through the relationship of the manufacturer and the buyer, which forms the supply and demand model (Figure 1).

Further consideration of the provisions discussed are best carried out evidenced from a particular organization. For this purpose we use data on production and financial activity of LLC "Kolos" (Almenevsky District, Kurgan Region), reflecting the agricultural activities in conjunction with the demand for the products that it produces.

LLC "Kolos" is a crop enterprise. Basic statistics for barley derived from findings on enterprise activities, are

**Table 1. Manufacture and sale of barley**

| Products of LLC "Kolos" | Year | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
| Barley (amount in kind, centners) | 3118 | 105 | 311 | 4384 | 5862 | 5416 | 6436 |
| Barley (cost, ths. rub.) | 253 | 9 | 48 | 484 | 922 | 1343 | 1692 |
| Barley (realized, ths. rub.) | 310 | 19 | 43 | 860 | 1425 | 2012 | 3021 |

summarized in Table 1, the reference period – one year.

Input data of the model (2) is a supply, which is the production of barley. According to the data (Table 1), the supply – a random integer value.

In fact, the demand is also a random integer value, but to get the data on it is almost impossible. This is not only due to the situation in the world, country and region. Even though a necessity in a constant amount of barley for the needs of the region, district, the demand for the products will be random for any agricultural enterprise because of substantially different annual production volume at each farm (including farm bankruptcy). However, since all the annual output was purchased, then are known demand levels, which give an estimate of its minimum $n^*_{min}$ and maximum $n^*_{max}$ values.

For the practice of technical and economic planning may be sufficient the probability assignment method, which is used in network planning. Events that occur only once are determined by the survey of experts, each gives three duration estimates – optimistic, pessimistic and most probable. This approach can be used to monitor the demand for agricultural products; another way to get this information does not seem possible (too many factors). Although, it is almost impossible to find the distribution of targeted random value analytically, the model allows working with separate implementations of this value.

Output parameters of the model are supported demand $n_+$, utilized supply $z_+$ ($n_+ = z_+$), unsupported demand $n_-$, unutilized supply $z_-$ in real and value terms (Figure 1).

For estimates of $n^*_{min}$ and $n^*_{max}$ values of demand for intermediate values corresponding to the values of purchased products in different years, we obtain the values of the cost parameters of the utilized supply $S_{z_+}$ and its equal supported demand $S_{n_+}$, the cost of unsupported demand $S_{n_-}$ and unutilized supply $S_{z_-}$, as well as the cost

$$S = S_{n_+ = z_+} - S_{n_-} - S_{z_-} \quad (1)$$

which is equal to profit with the deduction of its unsupported demand and unutilized supply (Table 1).

**Table 2. Calculation of real and cost characteristics of demand and supply**

| Demand | Real characteristics | | | Cost characteristics | | | |
|---|---|---|---|---|---|---|---|
| 100,0 | 100,0 | 0,0 | 3561,7 | 24,3 | 0,0 | 660,2 | –635,9 |
| 1000,0 | 773,7 | 226,3 | 2888,0 | 187,8 | 54,9 | 535,3 | –402,5 |
| 2000,0 | 1488,0 | 512,0 | 2173,7 | 361,1 | 124,3 | 402,9 | –166,0 |
| 3000,0 | 2202,3 | 797,7 | 1459,4 | 534,5 | 193,6 | 270,5 | 70,4 |
| 3600,0 | 2562,0 | 1038,0 | 1099,7 | 621,8 | 251,9 | 203,8 | 166,0 |
| 4000,0 | 2790,6 | 1209,4 | 871,1 | 677,2 | 293,5 | 161,5 | 222,2 |
| 4500,0 | 3059,7 | 1440,3 | 602,0 | 742,5 | 349,5 | 111,6 | 281,4 |
| 5000,0 | 3274,0 | 1726,0 | 387,7 | 794,5 | 418,9 | 71,9 | 303,8 |
| 6000,0 | 3599,4 | 2400,6 | 62,3 | 873,5 | 582,6 | 11,5 | 279,4 |
| 6500,0 | 3661,7 | 2838,3 | 0,0 | 888,6 | 688,8 | 0,0 | 199,8 |

Calculations are made using the program "Forecasting and optimization of economic performance of the enterprise" and are shown in Table 2. In addition, it is taken into account that the market price of barley sales for this period averaged for the enterprise $S^1_{nz} = 0.30$ ths. rub. for centner, cost $S^1_z = 0.19$ ths. rub. for centner.

It is followed from the results of the calculations (Table 2) that the amount of unsupported demand reaches a minimum value at the minimum demand for barley $n_0 = 100$ centners. ("Sold as much as needed"). The value of direct losses is minimal, but in this case the value of the possible loss of profits $\bar{z}_- = 3561$ centners approaches the maximum. Under other values , the company can grow barley less or more ща the existed demand. In this case, along with the profits from sales, the direct loss may appear at the same time with lost profits, which value may be calculated from the model.

Based on the random nature both of the volume of products manufactured and its demand, the enterprise is facing the task of determining the rational volume of barley production to meet the demand (and receiving of profits), without burdening with overstocking and reserves at the same time. These calculations are presented in Figure 2.

The relevant costs are related with each of these functions:

$S_{n_+ = z_+}$, $S_{n_-}$, $S_{z_-}$

The total cost can be represented by the following relation (Eq. 1)

How does the company reach the level of production at which the profit margin is the maximum? It is clear that if production increases gross income is more than lost profit, the company should increase production. If additional production leads to an increase in income to a lesser extent than lost profit, the company, which aims to maximize

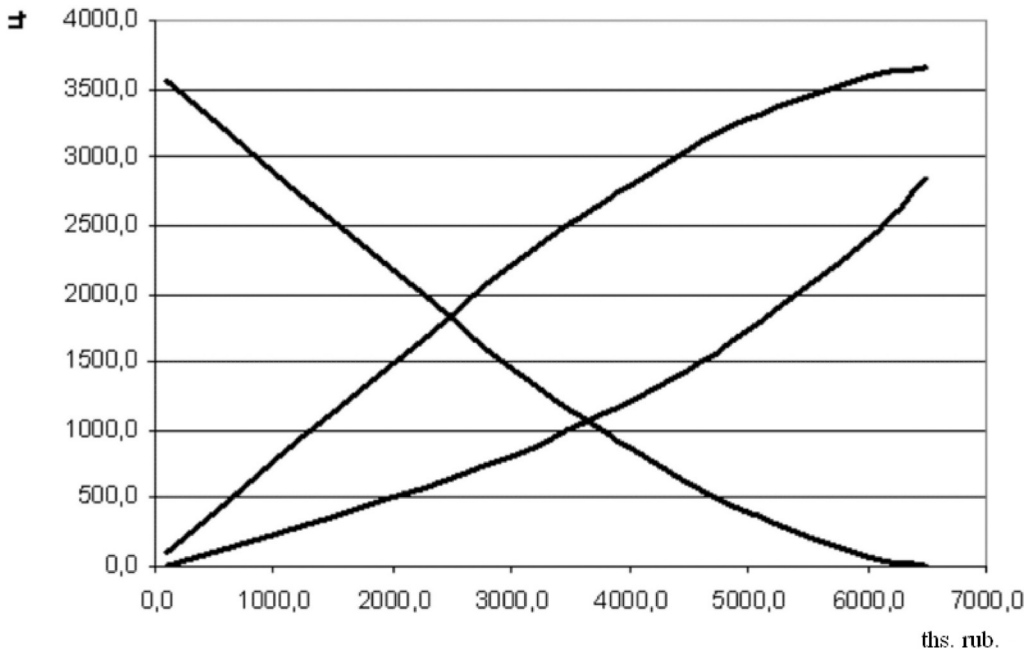


**Figure 2. Graph of the curves** $\overline{n}_+ = \overline{z}_+, \overline{n}_-, \overline{z}_-$

profits, should not increase production. Figure 3 helps to make these arguments more visible.

Thus, analyzing the graph of cost *S* (Formula 1), we can conclude that in the present moment for the company LLC "Kolos" a rational strategy will be the production of barley in volume from 4500 to 6000 centners. This interval in the proposed production volumes is conditioned by a reclined curve behavior near the maximum.

Consequently, analyzing the cost parameters of the supply and demand model, the head of agricultural enterprise can estimate the rational production volume under conditions of uncertainty, simultaneously calculating the proportion of unutilized supply, i.e., direct losses of the company and a share of unsupported demand – the lost profits.

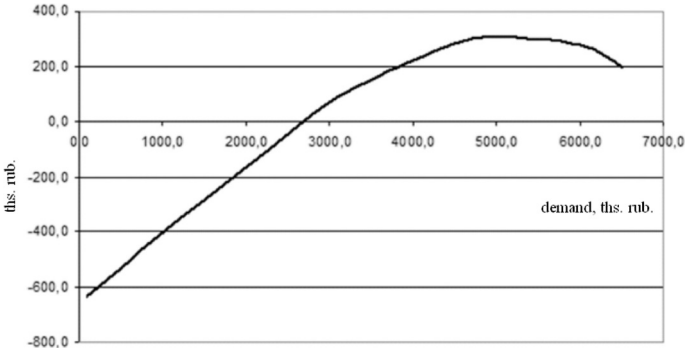


**Figure 3. Figure total value S(n)**

Thus, the proposed methodology consists of three blocks.

First block – economic monitoring of external and internal environment, the accumulation of information, which will subsequently be used as an original sample data for the supply and demand model. Initial data for calculation of parameters of the model, operating in the

time limit (reference period – one year), are the demand $N$ and supply $Z$, characterized by an arbitrary distribution function $C(n) = P(N \le n)$ and density function $c(n) = dC(n)/dn$.

It must be emphasized, since any decision is always based on the available information, the priority measures for the organization of planning and forecasting activities of the company is gathering information and implementation of information management systems.

Introduction and practical implementation of these activities do not require large investments. They may be implemented by:

– The introduction of automated information systems, in which basis will be the collected information about its own production, financial and other activities, such as 1C: Enterprise 8, which creates a common information space for the display of financial and economic activity of the enterprise.

– Global computer networks to provide timely exchange of information and search for information about the prices of products, sales market research and customer demand, etc. According to sociological surveys of rural manufacturers, the most relevant for them is the information about alternative opportunities of the demand of produced and sold products, forecasting crop yields, long-term and short-term forecasts of climatic conditions, new technologies in agricultural production, etc.

Second block – calculation of functional, numeric and cost characteristics provided of the supported demand $n_+$, utilized supply $z_+$ ($n_+ = z_+$), unsupported demand $n_-$, unutilized supply $z_-$ (Table 3).

For the calculations in the model, given net realizable value $s^1_{NZ}$ and cost (supply price) of the product $s^1_Z$ are used.

Based on the known $N$, $Z$, $s^1_{NZ}$ and $s^1_Z$ the following cost parameters are calculated:

– Demand price $s_N = s^1_{NZ} \cdot N$;

– Supply price $s_Z = s^1_Z \cdot Z$;

– Cost of sales $s_{NZ} = s^1_{NZ} \cdot NZ$ – income from the sale of products;

– The cost of unsupported demand $s_{N\_} = s^1_{NZ} \cdot N_-$, potential losses related to the fines, the loss of clients in the future, unrealized enterprise capabilities, i.e. this indicator may point on lost profits and, consequently, on the need for further development of production;

– The cost of unutilized supply $s_{Z\_} = s^1_{NZ} \cdot Z_-$, direct losses attributable to the value of unsold goods, the cost of storage – this value may indicate on the need to reduce the supply of this type of enterprise products and transfer funds to

**Table 3. Functional and numerical characteristics of indicators of supply and demand system**

| Indicator characteristics | Demand, $N$ | Supply, $Z$ |
|---|---|---|
| Distribution function | $A(n_i)=P\{N\le n_i\}=\frac{m_i}{M}$ | $C(z_i)=P\{Z\le z_i\}=\frac{m_i}{M}$ |
| Distribution density | $a(n)=dA(n)/dn$<br>$a(n_i)=\frac{A(n_i)-A(n_i-1)}{n_i-n_{i-1}}$ | $c(n)=dC(n)/dn$<br>$c(z_i)=\frac{C(z_i)-C(z_i-1)}{z_i-z_{i-1}}$ |
| Average value of the indicator | $\overline{n}=\sum_{z=0}^{\infty} n\cdot a(n)$ | $\overline{z}=\sum_{z=0}^{\infty} z\cdot c(z)$ |
| Cost | $\overline{s}_N=s^1_{NZ}\cdot\overline{n}$ | $\overline{s}_Z=s^1_Z\cdot\overline{z}$ |

*Table 3 (continued)*

| Indicator characteristics | Supported demand $N_+$, utilized supply $Z_+$ | Unsupported demand $N_-$ | Unutilized supply $Z_-$ |
|---|---|---|---|
| Distribution function | $H(n)=P\{NZ\le n\}$<br>$H(n)=$<br>$=1-[1-A(n)]\cdot[1-C(n)]$ | $Q(n)=P\{N_-\le n\}$<br>$Q(n)=$<br>$=\sum_{i=0}^{\infty} a(i)\cdot[1-C(i-1-n)]$ | $G(n)=P\{Z_-\le n\}$<br>$G(n)=$<br>$=\sum_{i=0}^{\infty} c(i)\cdot[1-A(1-i-n)]$ |
| Distribution density | $h(n)=dH(n)/dn$<br>$h(n)=H(n)-H(n-1)$ | $q(n)=dQ(n)/dn$<br>$q(n)=Q(n)-Q(n-1)$ | $g(n)=dG(n)/dn$<br>$g(n)=G(n)-G(n-1)$ |
| Average value of the indicator | $\overline{nz}=\overline{n}_+=\overline{z}_+=\sum_{n=0}^{\infty} n\cdot h(n)$ | $\overline{n}_-=\sum_{n=0}^{\infty} n\cdot q(n)$ | $\overline{z}_-=\sum_{n=0}^{\infty} n\cdot g(n)$ |
| Cost | $\overline{s}_{NZ}=s^1_{NZ}\cdot\overline{nz}$ | $\overline{s}_{N_-}=s^1_{NZ}\cdot\overline{n}_-$ | $\overline{s}_{Z_-}=s^1_{NZ}\cdot\overline{z}_-$ |

other products, i.e. this indicator may indicate on the possible loss of profits and, consequently, the need to develop measures to reduce it.

The third block is focused on a combination of strategic alternatives and entrepreneurial vision. The resulting graphs made on the basis of calculations in the second block, make it possible to determine the most optimal way of enterprise development for the given parameters, as shown in the example. But largely one product may not give the desired profit margin. In practice, one should pick up a few more types of goods for further calculations with the subsequent formation of the optimal composition of products.

## Conclusion

In summary, the methodology elaborated, for the first time allows forecasting and planning the economic performance of the enterprise on the basis of economic-mathematical model that takes into account a stochastic nature of demand and supply. The model includes new calculated indicators to make the system more reliable in terms of maxi-

mum profit to manufacturer, and to seller – the most complete satisfaction of the customer demands. The use of methodology admits to calculate a rational volume of production allowing managing the enterprise to the best advantage, excluding crisis (bankruptcy). The methodology should be used at initial stages of business planning in order to avoid erroneous development. Identified unsupported demand will indicate on possible lost profits and, consequently, on the need for further development of production, and unutilized supply – on actual lossed of income and, consequently, on the need to develop measures to reduce it.

To automate the calculations was developed the software "Forecasting and optimization of economic performance of the enterprise" in the VisualBasic 6.0, designed not only for use by agricultural specialists, but also for widespread use in other industries in the field of planning and forecasting activities of the enterprise.

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# Применение стохастической модели спроса и предложения для организации планово-прогнозных работ на предприятии АПК

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**Аннотация**

В статье рассматриваются новые подходы организации планово-прогнозных работ на предприятии АПК: через спектр взаимоотношений производителя и покупателя, образующих систему спроса и предложения. При этом учитывается стохастический характер показателей спроса и предложения. Проведен анализ производства и реализации продукции на примере ООО «Колос» (Курганская область, Альменевский район) с использованием предложенной методики.

**Ключевые слова**

Планирование, прогноз, стохастическая система спроса и предложения, обеспечиваемый и необеспечиваемый спрос, используемое и неиспользуемое предложение, управление сельхозпредприятием.

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