The Use of Factor Analysis of the Cost When Justifying the Directions of Innovative Development of Crop Production (on the Example of the Grain Complex of the Pskov Region)

I P Voi ku1,4, V A Kuchuk2 and I S Sandu3

1Department of organization management and innovation management, Pskov State University, Lenin Square, 2, Pskov, 180000, Russia
2Software development department, LLC “Finace Software 2,” Yakubovich street, 24 letter A, Office 13n, Saint-Petersburg, 190000, Russia
3Department of economic problems of scientific and technical development of agriculture, FRC of land economy and social development of rural areas – All-Russian Agricultural Economics Research Institute, Khoroshevskoe road, 35, Building 2, Moscow, 123007, Russia
4Corresponding Author

E-mail: voiku-ivan@yandex.ru

Abstract. Situations of risk and uncertainty create conditions for the development of the modern economy. This increases interest in the method of factor analysis, which allows to clarify the trends of the analyzed indicator, to determine the influence of factors on its decline or increase, as well as to establish reserves for growth or reduction. Interest in the product competitiveness, caused by the level of production expenses, reduces the object of factor analysis to the cost. The results of factor analysis, obtained by a unified methodology, allow us to compare the influence of production expenses on the cost of production both in the scale of an enterprise and in the scale of the region and the sector. Crop production, as the most important sector of agriculture, is no exception in this regard. The presented results of the factor analysis of the production cost of the main crop of the Pskov region show the multifaceted influence of the volume of production and expenses on the cost of grain growing. The results of the assessment of the influence of changes in expenses and production volume on the change in the cost of grain crops cultivation, combined with the indicators of the relative change in the contingent cost of 1 ton of grain crops, allow us to divide the municipal districts of the Pskov region into four typological groups: extensive growth, recession, stagnation and intensive growth. The influence of changes in wages, expenses for seeds, fertilizers, maintenance of fixed assets and other expenses on the cost of grain crops cultivation in each of the four typological groups is illustrated. Since the expenses in crop production are the points of application of innovations, the identified reserves of cost reduction allow us to formulate the main directions of innovative development of regional crop production.

1. Introduction
There are four types of situations in which a modern manager makes management decisions: conditions of certainty, risk, uncertainty and conflict. Innovative development assumes decision-making in each of these types of situations [1].
In the conditions of certainty, we know the number of possible situations, the probability of each of which is equal to one, and their consequences. The difficulty of the decision-making is determined by the number of alternatives, as well as the need to choose the selection criterion. An example of such a situation for an agricultural enterprise is making the decision to purchase agricultural equipment on the basis of the estimate of production expenses [1].

In the conditions of risk, a probabilistic approach is used, which involves predicting the possible consequences and assigning them probabilities. An example of such a situation for an agricultural producer is making the decision on the introduction into the crop rotation of new varieties of agricultural crops [1].

The main difficulty of the uncertainty situation is the impossibility of estimating the probability of consequences. The maximization of the minimum profit, the minimization of the maximum profit and the maximization of the maximum profit can be used as the main criterion for making a management decision. Agricultural producers are confronted with situations of uncertainty more often than enterprises of other fields of activity. It is caused by a huge role which is played by natural and climatic conditions on parameters and outcomes of agricultural production [1].

In the conditions of conflict, unformalized methods are used [1].

The conditions of the developing market economy are formed, primarily, by situations of risk and uncertainty. This requires managers to focus not only on identifying risks, assessing their degree, magnitude and consequences, but also on risk management methods.

In this situation, the use of the method of factor analysis has a significant practical interest. It allows to identify the trends of the analyzed indicator, to determine the influence of factors on its decline or increase, as well as to establish reserves for growth or reduction.

The most important problem of modern agricultural production is a significant advance in the growth of prices for material expenses relative to the prices for finished products. Therefore, reducing the cost of agricultural products is currently a crucial condition for the effective development of production.

The cost of crop products is the value of natural resources used in the production process, raw materials, supplies, fuel, energy, fixed assets expended, labor resources, works, services, etc. [2].

The value of goods, works or services reflects all aspects of the operating activities of the enterprise, accumulates the results of the use of production resources. The financial results, the reproduction rate and financial stability of the enterprise depends on the level of the cost.

Since the modern conditions of economic development cause increasing interest in the study of product competitiveness due to the level of production expenses, the importance of factor analysis of the cost is difficult to overestimate [1]. It allows us to find out the trends in the cost, to determine the influence of each factor on its increase or decline and, on this basis, to establish reserves for reduction of particular production expenses. The use of factor analysis of the cost allows to identify reserves and determine ways to increase the final results of agricultural activities at any level of sectoral management.

2. Problem statement

In modern agricultural enterprises, management decisions are often made on the basis of profit, profitability and total cost. This can lead to a distorted evaluation of the profitability of the products. Therefore, an approach, when a management decision is made on the basis of the analysis of the expenses structure and the calculation of marginal profit, should be a priority [3].

The analysis of the expenses structure performed by the method of factor analysis involves the use of information about the expenses based on the data of the primary documentation. Hence, this method can be used only if the agricultural enterprise has separate accounting of data on variable and fixed expenses [3]. However, the study of agricultural production trends in 93 countries with developed and developing economies in 1980-2000 showed the inaccessibility of reliable information sources even for the evaluation of productivity indicators [4]. In all probability, the information need for detailed
information about the structure of production expenses is an obstacle to the development of the practice of widespread use of the method of factor analysis.

It is also significant that an information on the expenses of crop production is formed taking into account the continuity and irreversibility of biological processes of cultivation of one or another crop. Therefore, reserves of direct expenses for the period of sowing to harvest are often created in order to form accounting statements. This allows to provide operational analysis of the cost of crop products with the necessary information [5].

The information used by the method of factor analysis should be accurate and reliable, comparable and interrelated. Only in this case, the indicators calculated using the unified methodology will allow full comparability of the processed and received information on the production expenses both in the scale of an enterprise and in the scale of the region and the sector [1].

3. Research questions
The main attention of many researchers is focused on local criteria of effectiveness of agricultural producers: profit and profitability of their production. However, the profit of a particular agricultural producer includes only part of the added value. Since a significant share of the added value is redistributed to other areas, it does not seem advisable to use traditional effectiveness indicators [6].

The effectiveness of modern agricultural enterprises depends not only on the production potential and product competitiveness, but also on the level and structure of expenses [7].

Making management decisions based on preventive and operational identification of areas for optimization and reduction of production expenses provides an achievement of the planned indicators of profitability of production activities [7]. In this regard, it is production expenses in crop production that are the points of application of technical and technological innovations [7].

4. Purpose of the study
The purpose of the study – the development of the practice of the use of factor analysis for management decision-making in the conditions of developing economy. The study will determine the direction of innovative development of regional crop production on the basis of identifying reserves to reduce the cost of main agricultural products. The grouping of municipal districts, which characterizes the types of development of the enterprises of the Pskov region, will allow to formulate specific recommendations for the innovative development of limiting factors in crop production.

5. Research methods
In the Pskov region, the enterprises of all 24 districts are engaged in the cultivation of grain crops, potatoes – 15 districts, but vegetables of open ground and protected ground – only in the Velikoloukskij, Krasnogorodskij, Pskovskij and Sebezhskij districts. Since grain production is located everywhere in the region, factor analysis of the cost is carried out on the example of grain crops.

For the analysis, all indicators were taken from the form No 8-APK “Expenses for the main production” of the consolidated annual report of agricultural enterprises of the Pskov region (Table 1).

The study of the production cost involves the parallel use of two main lines of analysis: changes in the total amount of expenses and total volume of crop production. Factor analysis begins with the recalculation of the cost of grain production in the reporting year, Y, taking into account the prices of the previous year, X. Next, the influence of expenses (growth of prices for resources) is determined as the difference between the actual cost in the reporting period and the contingent cost.

The influence of changes in production volume is calculated as the difference between the contingent cost in the reporting period and the planned cost of gross grain harvest in the previous period.
Table 1. Initial data for factor analysis of the cost of grain crops of the Pskov region for X – Y [8].

| Municipal districts          | Gross grain harvest in weight after processing, tons | The production cost of 1 ton, RUB | The cost of gross harvest, thousand rubles |
|------------------------------|-----------------------------------------------------|-----------------------------------|------------------------------------------|
|                              | X          | Y         | X          | Y         | X          | Y         |
| Bezhanickij                  | 2487       | 360       | 6447       | 7425      | 16034      | 2673      |
| Velikoloukskij               | 769        | 4993      | 6836       | 9811      | 5257       | 48986     |
| Gdovskij                     | 205        | 392       | 3893       | 5238      | 798        | 2053      |
| Dedovichskij                 | 691        | 4006      | 8387       | 9812      | 5795       | 39307     |
| Dnovskij                     | 924        | 56        | 10238      | 18579     | 9460       | 1040      |
| Krasnogorodskij              | 256        | 277       | 11827      | 8000      | 3028       | 2216      |
| Kun'inskij                   | 31         |           | 6352       |           | 197        |           |
| Loknyanskiy                  | 450        | 2736      | 8314       | 13172     | 3741       | 36039     |
| Nevel'skij                   | 652        | 3681      | 7196       | 6333      | 4692       | 23312     |
| Novorozhevskevskij           | 834        | 111       | 6949       | 11374     | 5795       | 1263      |
| Novosokol'nicheskij          | 7712       | 535       | 4102       | 5075      | 31635      | 2715      |
| Opochechik                   | 1186       | 202       | 4896       | 6233      | 5807       | 1259      |
| Ostrovskij                   | 2667       | 1634      | 6929       | 5244      | 18480      | 8569      |
| Palkinskij                   | 258        | 42        | 21349      | 13107     | 5508       | 550       |
| Pechorskij                   | 694        |           | 7172       |           | 4977       |           |
| Porhovskij                   | 3116       | 4993      | 6158       | 6501      | 19188      | 32459     |
| Pskovskij                    | 3652       | 392       | 7844       | 7022      | 28646      | 2753      |
| Pustoshkinskiy               | 386        | 4006      | 4966       | 6874      | 1917       | 27537     |
| Pushkinogorskij              | 1130       | 56        | 4715       | 7919      | 5328       | 443       |
| Pytalovskij                  | 2076       | 277       | 5088       | 12784     | 10563      | 3541      |
| Sebezhovskij                 | 2306       |           | 5585       |           | 12879      |           |
| Strugo-Krasnenskij           | 68         | 2736      | 9591       | 8905      | 652        | 24364     |
| Usvyatskiy                   | 50         |           | 7550       |           | 378        |           |
| Total                        | 34609      | 33495     | –          | –         | 202763     | 263090    |

The total change in the cost of grain crops through changes in expenses and production volume in the districts of the Pskov region is presented in figure 1, which shows that in most districts the change in these factors has both negative and positive influence on the cost of the cultivation of grain crops.
Figure 1. Influence of changes in expenses and production volume on the level of the cost of cultivation of grain crops in the districts of the Pskov region, thousand rubles.

The relative deviation of the cost per 1 ton of grain is defined as the ratio of the difference of the actual cost for the reporting period to the contingent cost. In a large part of the districts of the Pskov region, the contingent cost per 1 ton of grain is increasing. The maximum growth indicators of the contingent cost are presented in Pytalovskij, Dnovskij, Pushkinogorskij, Novorzhevskij and Loknyanskij districts. The reduction of the contingent cost is presented only in Palkinskij, Krasnogorodskij, Ostrovskij, Nevel’skij and Strugo-Krasnenskij districts.

The influence of changes in expenses and production volume on the change in the cost of cultivation of grain crops in the districts of the Pskov region, combined with indicators of relative changes in the contingent cost per 1 ton of grain, allow to form four typological groups (Figure 2).

Figure 2. Grouping of administrative districts of the Pskov region by the main factors of changes in the cost of grain.
In the presented figure, factors such as “influence of expenses” and “influence of production volume” set the coordinate system, and the size of the contingent cost per 1 ton of grain crops determines the diameter of the “bubbles”. The color of the “bubbles” characterizes the growth (blue) or reduction (white) of the contingent cost of production.

Grouping characterizes different types of development of the Pskov region enterprises: extensive growth, recession, stagnation and intensive growth (Table 2).

**Table 2. Grouping matrix.**

| Group A. Stagnation                  | Group B. Extensive growth                       |
|-------------------------------------|-------------------------------------------------|
| Pytalovskij, Opocheckij, Dnovskij,  | Velikolukskij, Loknyanskij, Pustoshkinskij,     |
| Bezhanickij, Novorzevskij, Pushkinogorskiy and Novosokol'nicheskij | Dedovichskij, Porhovskij and Gdovskij          |
| Group C. Recession                  |                                                   |
| Ostrovskij, Palkinskij and Pskovskij|                                                   |
| Group D. Intensive growth           |                                                   |
| Nevel'skij, Krasnogorodskij and Strugo-Krasnenskij | |

There are the following districts in Group A (positive influence of expenses, negative influence of production volume): Pytalovskij, Opocheckij, Dnovskij, Bezhanickij, Novorzevskij, Pushkinogorskiy and Novosokol'nicheskij. They are characterized by the growth of the contingent cost per 1 ton of grain crops. There is maximum growth of the contingent cost per 1 ton of grain crops in most of the districts of this group (Opocheckij, Dnovskij, Novorzevskij and Novosokol'nicheskij).

At the same time, changes in production volumes have a more significant influence on this process than changes in expenses. Most likely, such highly negative trend is the result of the high share of other non-production expenses in the structure of the cost of grain crops (Figure 3).

There are the following districts in Group B (positive influence of expenses, positive influence of production volumes): Velikolukskij, Loknyanskij, Pustoshkinskij, Dedovichskij, Porhovskij and Gdovskij. They are also characterized by growth of the contingent cost per 1 ton of grain crops.

![Figure 3. Changes in the structure of the cost of grain for the main groups of municipal districts of the Pskov region.](image)

The contingent cost of the leaders of this group (Pustoshkinskij and Dedovichskij districts) increases in proportion to the expenses and the volume of grain production. Since there are no noticeable changes in the cost structure, the further increase in the volume of grain production will be accompanied by a proportional increase in expenses. One of the few positive moments in such a situation may become a fuller utilization of the available production capacity of enterprises in the
districts of the group under consideration.

Group C (negative influence of expenses, negative influence of production volumes) includes the following districts: Ostrovskij, Palkinskij and Pskovskij. These districts are characterized by a reduction of the contingent cost per 1 ton of grain crops. Ostrovskij district provides the maximum figure of reduction of the contingent cost due to the proportional reduction of expenses and production volumes in the group. Palkinskij and Pskovskij districts provide the reduction of the contingent cost by a decrease in the production volume of grain crops. Noteworthy is the fact that in reporting year, Y, in this group there was a reduction of the share of other expenses and labor expenses to the minimum values. This negative trend is most likely caused by the liquidation of some agricultural enterprises in the districts. The remaining enterprises are actively investing in the renewal of fixed assets and the purchase of seeds, which is also reflected in the cost structure in the districts of group C.

Group D (negative influence of expenses, positive influence of production volumes) includes the following districts: Nevel'skij, Krasnogorodskij and Strugo-Krasnenskij. These districts are characterized by a reduction of the contingent cost per 1 ton of grain crops. If Krasnogorodskij district provides a reduction in the contingent cost by reducing expenses with almost unchanged production volumes, the reduction of the contingent cost in the Strugo-Krasnenskij and Nevel'skij districts is achieved both by increasing the volume of grain production and reducing expenses. There is the most noticeable change in the structure of expenses in the districts of this group. The expenses for seeds and fertilizers has increased by more than two times, while other expenses have declined by more than four times. Consequently, the reduction of the contingent cost is provided by the effect of production scale with simultaneous reduction of non-production expenses. This is a highly positive trend, reflecting the experience of intensification of grain production in the scale of the several districts.

A comprehensive analysis of the cost of grain production involves the study of the degree of influence of changes in expenses as a whole and by expenses items, as well as the revelation of the causes of these changes. Figure 4 illustrates the influence of five factors (changes in labor expenses, expenses for seeds, fertilizers, maintenance of fixed assets and other expenses) on the cost of cultivation of grain crops in each of four analyzed groups of districts in the Pskov region.

![Figure 4](image)

**Figure 4.** Influence of expenses structure on the cost of grain crops by groups of administrative districts of the Pskov region, %.

In the group of the most efficient districts (Group D), changes in other expenses, expenses for fertilizers, wages and maintenance of fixed assets reduce the contingent cost per 1 ton of grain crops. The expenses for seeds, on the contrary, increase the contingent cost. In the districts, expenses for fuel and electricity, maintenance of agricultural machinery and equipment are reducing. At the same time,
wages are also reducing. This may indicate the active use of modern agricultural machinery. The increase in the expenses for seeds can be explained by both an increase in cultivated areas and an acquisition of better, and, hence, more expensive seeds.

In the group of least efficient districts (group A), all considered types of expenses increase the contingent cost. The wage growth while reducing cultivated areas indicates a decrease in the level of mechanization. The physical deterioration of the equipment used, the lack of modern agricultural machinery can lead to an increase in expenses for maintenance and seeds. The use of new agricultural technologies in the municipal districts of Group A is unlikely.

6. Findings

Parameters of gross harvest in crop production can be divided into two groups. The first group reflects the production factors: water and fertilizer content in the soil, the specific area of the soil, etc. The second group reflects the yield indicators of particular cultivated crops. It is these factors that are the limiting factors in crop production [9].

The first group of factors is individual elements of the cost, including the expenses for seed (planting) material and fertilizers, maintenance of fixed assets and payment of wages, as well as other significant expenses. The state of these factors is manageable. As a result, the development of production based on the implementation of innovative techniques and technologies not only improves the quality, but reduces the cost of agricultural products [10].

The situation, in which only 16% of the districts can be classified as effective according to the results of factor analysis, is a crisis. It is necessary to take urgent measures to reduce the production expenses in the majority of the municipal districts of the Pskov region, which was once one of the well-developed agricultural regions of Russia.

Since the main task of factor analysis of the production cost is the search for reserves to reduce the cost of production in order to increase the profitability and competitiveness of agricultural products, based on the results obtained earlier, it is possible to formulate the main directions of innovative development of crop production for the analyzed groups of districts:

1. Reduction of the resource intensity of production by agricultural producers in the districts of group A.

To do this, it is necessary to increase labor productivity, an important role in the growth of which, as well as the production efficiency in general, is played by the mechanization of production processes and production modernization.

Along with the increase in labor productivity, the basis for reducing the resource intensity of production is bringing to the standard level the consumption of fertilizers, seeds and fuels and lubricants. It is also advisable to minimize non-production expenses.

The formation of fertile and biologically active soil provides agricultural crops with the necessary nutrients sufficient for their optimal growth and development. Balanced application of organic fertilizers has a positive effect not only on the environment, but also creates favorable conditions for accelerating microbiological and physico-chemical processes in the soil, ensuring optimal crop growth [11].

However, the studies of crop production in Poland have shown that even with high yield, the increase in the intensity of cultivation of agricultural crops in the medium term leads to a reduction in the profitability of production. This is caused by the outstripping growth of production expenses over the growth of income level. Traditional high-intensity crop production technologies involve the widespread use of chemicals as fertilizers and crop protection products. It not only reduces indicators of ecological cleanness of products, and, consequently, its market value, but also requires expenses of an agricultural producer for elimination of negative consequences on the state of environment [12, 13].

This suggests that an organic farming should be the basis of agrotechnological innovation in crop production.

Large-scale implementation of organic farming technologies can change the cost structure of agricultural production. Studies conducted in a number of countries have addressed this issue. Thus,
according to the results of a study conducted in Ukraine, the cost of organic products is significantly different from products grown by traditional technologies. This is due to the content of the concept of organic farming, namely, the complete refusal of the use of chemical fertilizers, pesticides and genetically modified organisms. In addition, organic farming involves the adherence of crop rotation, the use of compost as a fertilizer, green manure crops, biological methods of crop protection [14]. Many years of experience of Ukrainian farmers shows that the production expenses for organic agriculture are lower than for traditional, especially for crop production [14].

The results of long-term studies in Switzerland also show the obvious advantages of crop production on organic technologies: the expenses for energy and fertilizer 50% lower, and the expenses for crop protection products 97% lower than on traditional technologies [14]. This effect can be maximized: the use of information technologies not only increases the efficiency of production process control, but also leads to an even more significant reduction in various types of expenses [15].

An innovatively active agricultural enterprise should have a highly mechanized production, the main technological operations of which are provided with technical means using limited and expensive energy resources [16].

In crop production all mechanical energy is provided by means of mechanization. In addition, most of the electrical energy is converted into mechanical energy and is also provided by means of mechanization. Consequently, energy-saving technologies in crop production are primarily innovations in the field of mechanization [17].

Energy saving is one of the main efficiency indicators of the use of multifunctional aggregates, which assume simultaneous performance in one pass of several technological operations, which provide complexity, continuity and flow of the performed works. The use of such aggregates in crop production radically changes the traditional technologies of cultivation of agricultural crops, and, consequently, gives impetus to agrotechnological innovations [18].

2. The introduction of promising varieties of main agricultural crops should be ensured, first of all, in the districts of groups C and D, i.e. where there is an increase in production volume.

Selection is an important direction of modern crop production. Therefore, the introduction of new promising varieties will increase the yield of main agricultural crops, and, consequently, reduce the expenses per unit of product.

3. Organization of current and perspective planning in the grain production.

Planning is an indispensable component of economic policy. The need for perspective long-term plans is caused by the fact that the implementation of most technological measures requires a long time (implementation of crop rotations, land reclamation, variety renewal). The use of digital technologies in various fields of crop production provides continuous monitoring and control of production processes, increases the profitability of production, ensures efficient use of production expenses [19, 20]. For example, the implementation of modern pressure irrigation systems reduces water consumption by an order of magnitude, and increases the yield of cultivated crops [21].

7. Conclusion

Situations of risk and uncertainty form the conditions for the development of the modern economy. This increases an interest in the practice of using the method of factor analysis for management decision-making. This method allows to identify the trends of the analyzed indicator, to determine the influence of factors on its decline or increase, as well as to establish reserves for growth or reduction. Interest in the competitiveness of products, caused by the level of production expenses, reduces the object of factor analysis to the cost.

The results of factor analysis, obtained by a unified method, allow us to compare the influence of production expenses on the cost of products both in the scale of an enterprise and in the scale of the region and the sector. In this regard, crop production, as the most important sector of agriculture, is no exception.

Factor analysis of the cost of the main crop of the Pskov region shows both negative and positive influence of production volume and expenses on the cost of cultivation of grain crops. The influence
of changes in expenses and production volume on the change in the cost of cultivation of grain crops, combined with indicators of the relative change in the contingent cost per 1 ton of grain crops allow to distribute the municipal districts of the Pskov region into four typological groups: extensive growth, recession, stagnation and intensive growth.

A comprehensive cost analysis illustrates the influence of five factors (changes in wages, expenses for seeds, fertilizers, maintenance of fixed assets and other expenses) on the level of the cost of cultivation of grain crops in each of four typological groups of the districts of the Pskov region.

Since the limiting factors in crop production are individual elements of the cost, the state of these factors is controlled and manageable. In this regard, expenses in crop production are the points of application of innovations aimed at reducing the cost of agricultural products.

The results of the study allow us to formulate specific recommendations for the development of limiting factors in crop production, to determine the direction of innovative development of regional crop production on the basis of identifying reserves to reduce the cost.

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