The grain sub-complex of the region: trends and development prospects when growing competition

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Abstract. The agro-industrial complex of Russia is developing in difficult socio-economic, political conditions; however, the grain sub-complex demonstrates the sustainable nature of its development, confirming this with an increase in production volumes. The key role in this has been played by the introduced organizational, economic, managerial, and structural changes that adapt the industry to work in new economic conditions and risks. As a result, Russia is a leading player in the global food market. In the agricultural sector of the economy, there are intensive and extensive factors of present and future development. The reorientation of production towards the priority of intensive factors is possible, based on such key areas as technical and technological renewal, modernization, digital transformation of the industry, which will provide it with significant competitive advantages in the face of high global risks. The current trends in the world market, aimed at increasing demand for grain, also cause a change in the structure of production in regions. Changes in the structure of production entail changes in production volumes. Extensive factors of growth in the scale of grain production can be used to a very limited extent, without prejudice to the economy and the regional market for agricultural products. The priority direction for further development of grain production in the region should include intensive production methods. In this case, the structure of agricultural land and sown areas does not undergo significant transformation and global structural changes, and the increase in production volumes is achieved due to the complex of applied intensive methods of agricultural production.

1. Introduction

The growth of the population and, in connection with this, the growing demand for food in the world require the production of agricultural products on an ever-increasing scale. Grain is in especially high demand on world trading floors, but it is not only a food product for humans, it is also a raw material for the feed industry. The dual purpose of this agricultural product ensures a stable demand for it both within the country and in the world food markets. The global grain market is characterized by stable production growth, so for the period 2017-2021 it grew by 3.6 %, i.e. the average annual growth was 0.72 %, the world wheat market for the specified period increased by 1.06 % with an average annual growth of 0.21 %. According to the Food and Agriculture Organization of the United Nations (FAO), Russia has a share of about 13-14 % in the world wheat market, but the average grain yield in Russia is 40 % lower than the world average one. Therefore, the potential for growth in production volumes lies in the yield increase, i.e. an intensive factor of production.
The agro-industrial complex of Russia is developing in difficult socio-economic and political conditions. The economic sanctions of the EU countries and the United States, the COVID-19 pandemic, systematic economic crises, and other negative political and socio-economic factors have a significant impact on its functioning. At the same time, it is impossible not to notice the positive changes that have taken place in the industry in recent years, in particular, in the grain product subcomplex of the country, which demonstrates the sustainable nature of its development, confirming this with an increase in production volumes [1, 2]. The key role here was played by timely implemented organizational, economic, managerial, structural changes that adapt the industry to work in new economic conditions and risks.

2. Materials and methods
In recent years, the country has been actively promoting its grain areas to more northern regions, due to the fact that modern breeding and seed production make it possible to develop not only drought-resistant, adapted to southern latitudes, but also frost-resistant varieties of crops that grow successfully in cold climatic conditions. As a result, Russia is a leading player in the global food market, receiving significant currency earnings from the sale of grain [3]. Considering the current global dynamics of demand for this type of product, it can be concluded that in the next decade, the demand for grain on world trading floors will increase at a higher rate than in previous years, which means that the country as a whole and its regions should expand grain crops, increase yields, actively promote products abroad in order to strengthen their positions, with the prospect of increasing their share in the global agricultural market. Otherwise, the vacated market niches, in the face of fierce competition and the steady growth in demand for grain that has developed in the world, will be occupied by other producing countries. The theory and practice of agricultural production distinguishes between two directions of development of the industry: extensive and intensive ones. In the first case, the growth of agricultural production is achieved by expanding the area of agricultural land and increasing the livestock, the second direction is realized through the growth of productivity per unit of land area and total productivity. If the first type of production has the property of being limited in space and time, the second type has a wider scope of its capabilities. One can judge the level of technical, technological, intellectual development of the industry by the prevailing type of production. The advantages of the intensive method of agricultural production have been convincingly proven in many scientific publications, for example, the historical aspect of intensification and its positive effect in the countries of Latin America - Chile, is presented [2], the need for intensification of agricultural production and its high competitive advantages in the Republics of Egypt and Iran are described [3, 4], maintaining the sustainability of Indian agriculture and increasing the yield due to intensive methods of agricultural production in the country are shown [5]. The emphasis on intensive methods in agriculture and the rationale for the need for intensive rice cultivation in Vietnam were studied by other authors [6]. The results of intensive methods of agricultural production can also be negative, such consequences should be predicted and taken into account when developing a strategy for the development of agricultural production, as evidenced by the research of scientists [7]. The need for harmonization of intensification processes, with the conservation of biodiversity and nature protection, is also shown [8].

Modern domestic agricultural production is focused on the second type, but significant volumes of products are obtained due to extensive factors. It is possible to reorient production towards the priority of intensive factors based on key areas of development of the agricultural sector of the national economy, such as technical and technological renewal, modernization and digital transformation of the industry, which will provide highly competitive advantages for the industry in the face of fierce competition and high global risks and challenges in the world food market [4]. An important component of the successful development of the grain sub-complex is the modernization, technical and technological renewal of all production processes [5, 6]. First of all, this concerns the equipment involved in production, which should be distinguished by a high level of reliability, be resource-saving and productive, reduce product losses to minimum, and create comfortable working conditions for all
participants in the production process. An equally important factor in the growth of labor productivity is the digital transformation of the sub-sector, the transfer of all technological processes to digital functioning [7]. Modern world standards of equipment and technologies produced for the grain sub-complex are distinguished by high productivity, quality and reliability. They are focused on digital technologies and innovations that allow many technological production processes to be carried out without the participation of workers. At the same time, they have a high cost [8]. Nevertheless, when focusing on this direction of development, one should approach their introduction into practice with a special degree of caution, since no matter how “smart” and “highly intelligent” the machines that carry out technological processes are, it is impossible to carry out technological processes and achieve a steady increase in the scale of grain production without highly qualified personnel in the sub-sector. Therefore, high-performance, highly intelligent equipment, technologies, supported by qualified personnel in the grain sub-complex are the main conditions and factors for increasing the efficiency of production that are in high demand today both in the domestic and foreign markets. These vectors of development are especially relevant at the present time, because high competition on world trading floors requires the offer on the market of such products that would differ for the better in many quantitative and qualitative parameters in comparison with those offered in the market. It should be noted that the development of the industry should take place sequentially in several stages. First of all, technical and technological re-equipment should be carried out in order to create a base and platform for the upcoming changes, then digitalization and digital transformation of the industry come. Such a logical sequence of transformations can give a new impetus to the work of the industry, resistance to risks, and bring it to a higher level of intellectual development. Thus, new equipment and technologies, digital transformation, can significantly increase production volumes, guarantee product quality, thus create the necessary conditions and prerequisites for its successful implementation in the market.

3. Results
When examining the dynamics of the livestock of agricultural animals, it should be noted that it has been declining in the country over the past years. So, it is quite possible to reduce the need for the production of concentrated feed for the livestock industry, which is obtained from grain. Therefore, in order to level the reduction in the need for grain products in the domestic market, such losses should be compensated by an increase in sales in the external market, which will provide an additional inflow of exchange earnings [9]. As practice shows, the growth of production volumes in modern conditions is impossible without the intensification of production aimed at increasing productivity. The increase in the yield of grain crops in the current conditions should be ensured by a complex of modern agrotechnical measures. An important place in this direction is given to chemicalization processes, i.e. organization of optimal application of synthetic fertilizers in combination with organic ones [10, 11]. If there is no problem with the production and supply of synthetic fertilizers to the industry in the country and its regions, then the analysis of the practice of applying organic fertilizers indicates the opposite, namely, in most regions of Russia, organic fertilizers are applied in very modest amounts and there is a tendency to reduce the share of their application by unit area in the future. This situation is primarily due to the constant reduction in the number of cattle, the presence of a closed production cycle at large dairy complexes and mega-farms [12]. Therefore, many regions of the country are experiencing and will experience in the future a constant lack of organic fertilizers for the crop industry [13, 14]. The current trends in the world market, aimed at increasing demand for grain, also cause a change in the structure of production in the regions. In the vast majority of regions of the Non-Black Earth Region, in the south of Russia, the structure of production is changing with an emphasis on the active expansion of sown areas under grain crops. Grain, as a strategic food product, both in the country and in the world, occupies the largest share in the structure of crops and it increases every year [15]. Given the natural and climatic features of the country, grain production today and in the foreseeable future will be one of the key areas for the development of the agricultural sector of the economy in most regions of Russia [16]. Ryazan region is a part of the Central Federal District and is
increasing the volume of production of this highly demanded product in the market. Table 1 shows the changing structure of agricultural production in the region for 2015-2019. For the purpose of a more objective assessment of the ongoing structural shifts, the calculation was made in actual current prices.

**Table 1.** The structure of agricultural production for 2015-2019 (in all categories of farms), %

| Parameters                              | 2015   | 2016   | 2017   | 2018   | 2019   |
|-----------------------------------------|--------|--------|--------|--------|--------|
| Agricultural products, total            | 100.0  | 100.0  | 100.0  | 100.0  | 100.0  |
| including, crop production             | 58.9   | 57.6   | 55.7   | 56.8   | 61.6   |
| livestock production                    | 41.1   | 42.4   | 44.3   | 43.2   | 38.9   |
| Deviation (crop production minus livestock production), % | +17.8  | +15.2  | +11.4  | +13.6  | +22.7  |

The processes of structural shifts indicate a steady growth trend in the structure of agricultural production of the share of crop production. For example, in 2019, the share of the crop production in total production increased by 22.7 %, which indicates that this trend will continue in the future with more accelerated pace of structural shifts towards the crop production. Changes in the structure of production entail changes in the volume and range of products. The scale and volume of grain production in the region in terms of its individual types in farms of all categories in dynamics over a number of years are presented in table 2.

**Table 2.** Gross yields of the main types of leguminous and grain crops for 2015-2019, thousand tons

| Parameters              | 2015    | 2016    | 2017    | 2018    | 2019    | Deviation, 2019/2015 |
|-------------------------|---------|---------|---------|---------|---------|----------------------|
| Spring and winter wheat | 850.7   | 977.0   | 1,291.2 | 1,016.5 | 1,229.6 | +378.9               |
| Change index            | 1.00    | 1.15    | 1.52    | 1.19    | 1.45    | +0.45                |
| Spring and winter rye   | 16.6    | 14.2    | 19.6    | 18.0    | 15.2    | -1.4                 |
| Change index            | 1.00    | 0.84    | 1.18    | 1.08    | 0.93    | -0.07                |
| Spring and winter barley| 468.8   | 295.4   | 471.6   | 404.1   | 541.2   | +72.4                |
| Change index            | 1.00    | 0.63    | 1.01    | 0.86    | 1.16    | +0.16                |
| Triticale               | 2.2     | 3.3     | 5.6     | 5.8     | 3.7     | +1.5                 |
| Change index            | 1.00    | 1.50    | 2.54    | 2.63    | 1.68    | +0.68                |
| Corn for grain          | 142.8   | 134.2   | 77.4    | 55.6    | 137.9   | -4.9                 |
| Change index            | 1.00    | 0.94    | 0.55    | 0.39    | 0.96    | -0.04                |
| Oats                    | 45.5    | 24.1    | 42.3    | 31.0    | 31.6    | -13.9                |
| Change index            | 1.00    | 0.53    | 0.93    | 0.68    | 0.69    | -0.31                |
| Buckwheat               | 1.4     | 1.9     | 4.9     | 1.7     | 1.3     | -0.1                 |
| Change index            | 1.00    | 1.35    | 3.5     | 1.21    | 0.93    | -0.07                |
| Legumes                 | 95.2    | 104.7   | 171.2   | 76.4    | 87.7    | -7.5                 |
| Change index            | 1.00    | 1.09    | 1.80    | 0.82    | 0.92    | -0.08                |

The data of table 2 confirm the fact of production restructuring in the agro-industrial complex of the region with a shift towards the expansion of grain production. For example, over a five-year period, the region has been steadily increasing the production of spring and winter wheat. So, 850.7 thousand tons was produced in 2015 and already 1,229.6 thousand tons was produced in 2019, i.e. by 378.9 thousand tons or 45 % more with 9 % average annual growth rate of the gross volume. Thus, the structure of production in the region over a 10-year period can change by 90 % in the direction of an increase in grain production. Some positive dynamics of growth in production volumes is observed for spring and winter barley, where the increase amounted to 72.4 thousand tons or 16 %. For other types of industry products, there are slight fluctuations in the direction of growth or decline. Thus, the key
types of products produced in the region are wheat and barley, and if the first type of product is intended mainly for food purposes, the second type is used primarily in the brewing industry and for animal feed. Significant volumes of spring and winter wheat obtained in the region are usually sold both in the domestic and foreign markets.

4. Discussion
The main task facing the agro-industrial complex of the region today is to increase the volume of grain production, which is ensured by a complex of key factors of both intensive and extensive nature. The key extensive growth factor is the expansion of areas under grain crops. Given that the land is spatially limited and its productivity is unlimited, it should be borne in mind that such expansion is possible, as a rule, mainly due to the reduction of areas occupied by other agricultural crops. Then, the expansion of areas occupied by grain, due to the curtailment of the production of other equally important agricultural crops, such as potatoes, vegetables, beets, etc. will lead to a reduction in their production, a shortage in the market, and as a result, an increase in prices for these types of products. Thus, the expansion of areas, i.e. the extensive factor of growth of the scale of production can be used in a very limited framework, without prejudice to the economy and the regional market for agricultural products. The priority and direction of development of grain production is intensive methods of agro-industrial production, which are based on the idea that the productivity of the land is unlimited, provided that it is properly handled, resulting in an increase in the productivity of agricultural land, which, first of all, manifests itself in an increase in productivity of crops. In this case, the structure of agricultural land and sown areas does not undergo significant transformation and global structural changes, and the increase in production volumes is achieved due to the complex of applied intensive production factors. To ensure the growth of the scale of grain production, the region should mainly apply intensive methods that contribute to the growth of production volumes, which should include the introduction of a modern system of agriculture and field crops, in particular, technical and technological renewal and modernization of the industry, a system for applying organic and synthetic fertilizers, digital transformation and digitalization of the sub-sector, as well as other areas of an intensive nature. There is an analytical study by the elimination method (factorial analysis) of grain production volumes, revealing the numerical influence of key factors of an extensive and intensive nature on the scale of production in the grain sub-complex of the region (table 3).

Table 3. Analytical study of the influence of key factors on the scale of wheat production in the region

| Parameters | 2015    | 2019    | Deviation for the period, (+/-) |
|------------|---------|---------|---------------------------------|
| Areas under crops, thousand ha | 288.4   | 372.1   | +83.7                           |
| Crop yield, dt/ha               | 29.5    | 33.0    | +3.5                            |
| Bulk yield, thousand tons       | 850.7   | 1,229.6 | +378.9                          |
| Conditional indicator "conditional bulk yield of wheat", thousand tons | 951.7   |         |                                 |
| Determination of the degree of influence of "crop yield" factor on production volumes, thousand tons (intensive factor) | | +101.0            |
| Determining the degree of influence of "sown area under crop" factor on production volumes, thousand tons (extensive factor) | | +277.9            |
| Deviation ID                     |         |         | +101.0 + 277.9 = 378.9; +379.9 = +378.9 (corresponds) |
It should be noted that the present increase in the volume of grain production of the regional agro-industrial complex occurs due to the complex influence of both factors, namely, intensive and extensive ones. So, due to the expansion of sown areas under grain crops (extensive factor), the degree of influence of the factor ensured an increase in gross production at the level of +277.9 thousand tons of grain and due to the growth in crop yields (intensive factor), the degree of influence of this factor ensured an increase in production in the amount of +101 thousand tons of grain. In order to find out the level and degree of significance of each factor in the total gross increase in grain production, it is necessary to determine the growth rate for each factor separately, as well as the growth structure. In this case, the total increase in grain production for the analyzed period amounted to +378.9 thousand tons, of which +277.9 thousand tons or 73.3% of the increase was due to the expansion of sown areas occupied by grain crops (extensive factor), +101.0 thousand tons of products or 26.7% was obtained due to the increase in the productivity of agricultural land (intensive factor). Thus, the regional increase in grain production is still achieved due to extensive growth factors, namely, due to the expansion or transformation of sown areas and agricultural land, which in market conditions is a direction with low development potential in the future. Based on analytical studies of current trends, regional authorities should be oriented towards the need to shift the focus to comprehensive support for the activation of intensive factors of production in the direction of the development of the industry. The high rates of transformation of the structure of sown areas and agricultural land in the region are associated with an increase in the share of grain area in their structure, which may lead in the foreseeable future to a shortage of production of other crops in the domestic market, but no less important for consumers. For a more objective assessment of the ongoing changes in the regional grain sub-complex, there is an analytical decomposition into intensive and extensive factors influencing the production volumes of key products of the sub-sector produced in the region, presenting the results of the study in the form of a matrix of analytical table 4.

Table 4. Matrix of analytical decomposition (deviations) of the influence of extensive and intensive factors on the increase in production volumes in the grain sub-complex of the region

| Crop Complex (cumulative) influence of factors, thousand tons | Intensive factor (crop yield) | Extensive factor (sown areas under crops) |
|-------------------------------------------------------------|-------------------------------|----------------------------------------|
| Winter and spring wheat                                     | +378.9                       | +101.0                                 | +277.9 |
| Winter and spring rye                                       | -1.4                         | -1.4                                   | 0.0    |
| Winter and spring barley                                    | +72.4                        | +212.2                                 | -139.8 |
| Corn for grain                                              | -4.9                         | +7.0                                   | -11.9  |
| Legumes                                                     | -7.5                         | -29.5                                  | +22.0  |

The presented calculations indicate multidirectional trends affecting the bulk grain production in the region. For example, the reduction in rye production was affected by a decrease in the yield of this crop with unchanged sowing areas. An important place in the region, along with spring and winter wheat, is given to spring barley, which occupies significant areas (more than 172 thousand hectares in 2019), the scale of production of which was significantly influenced by an intensive factor - the growth in the yield of this crop ensured an increase in bulk volume in the amount of 212.2 thousand tons, however, an extensive factor, namely, the reduction in the area under crops, led to a loss of yield in the amount of 139.8 thousand tons. The same multidirectional trends can be traced in the volumes of corn production, but here the extensive factor significantly overlapped the intensive one, as a result, the intensification process did not ensure the proper growth in production volumes, having received a decrease of 7.0 thousand tons. The same process, but with a diametrically opposite influence of
actors, is observed in the production of legumes, where the crop shortage in the amount of -7.5 thousand tons (22.0-29.5) occurred due to a significant decrease in the yield of legumes (the cumulative effect of the parameter minus 29.5 thousand tons), but at the same time expanding the area under crops (the total influence of the parameter plus 22.0 thousand tons). As a result, the degree of influence of the first factor (intensive) turned out to be stronger than the influence of the second one (extensive). As analytical studies show, the main factors in the growth of production volumes in the region should be considered intensive factors of production, namely, the growth of yields for all types of crops without exception. One of the key areas for increasing the productivity of agricultural land in the region is also the process of chemicalization of the industry and ensuring optimal organic nutrition for plants. These areas of intensification of agricultural production in Ryazan region have been very active recently. For example, mineral fertilizers were applied in the region (in terms of 100 % of nutrients) in 2019 by 95 %, or 34.8 thousand tons more than in 2014. There is an increase in the share of synthetic fertilizers applied per unit of land area occupied by grain crops. So, if in 2014, mineral fertilizers were applied in the amount of 55 kg (in terms of 100 % nutrients) per 1 hectare of the area occupied by grain and legumes (excluding corn), in 2019 this figure was 90 kg. Thus, the increase turned out to be more than 63 % in comparison with the base period. The region is experiencing great problems associated with a shortage of organic fertilizers [17]. The specific application rates of organic fertilizers turned out to be at a very low level, so for 1 ha of grain and legumes, the introduction of organic matter decreased by 22 %, from 0.9 t/ha in 2014 to 0.7 t/ha in 2019, which will negatively affect the yield. It is possible to solve problems with fertilizers, for example, based on the experience of European countries, which justifies the need to increase the production of leguminous crops as the main source of protein and soil provision with nitrogen [22].

5. Conclusion
Thus, the conducted studies allow to conclude that there is a significant impact on the volume of production of grain products of extensive factors in the region. This is especially pronounced in the production of wheat and barley. The regional agrarian policy in the field of grain production is focused on the complex impact of extensive and intensive methods of production, active introduction of synthetic fertilizers into the technology of growing grain. It is quite likely that in the future the increase in the volume of grain production will be carried out due to this important element of intensification, but it should be taken into account that the lack of organic nutrition may affect the reduction in grain quality and yield. The study shows that a significant increase in production volumes should be provided due to intensive factors, since this is a key and non-alternative direction for the future development of the grain sub-complex of the region, as well as the country as a whole.

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