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**APPLICATION OF MATHEMATICAL STATISTICS FOR ANALYSIS OF FUNCTIONING OF REGIONAL GRAIN MARKETS IN RUSSIAN EMPIRE IN THE SECOND HALF OF THE XVIII – EARLY XX CENTURY.**

**Summary.** The article is dedicated to an analysis of the dynamics of formation and functioning of regional grain markets in Russian Empire, that were prerequisite of formation of All-Russian agrarian market. The research was provided with methods of mathematical statistics – analysis of correlation and analysis of variance – and original method of analysis of «unstable» decades.

**Keywords:** mathematical statistics, correlation analysis, analysis of variance, bread market.

The study is aimed to consider method of use of analysis of correlation and analysis of variance to investigate development of regional grain markets in Russian Empire in the second half of the XVIII – early XX century according to datum of the dynamics of bread prices (by the example of rye prices – the most commonly used bread in the country). Special attention is paid to analysis of variance that was not used to solve the problem earlier. After description of method an analysis of formation regional grain markets and their development will be considered.

Method of research

Possibility of use of the dynamics of interaction of regional bread prices as indicator of formation of All-Russian agro-commodity market is based on such bases: in case unified market is existed it possible to observe approximately equal levels and fluctuations in price movements on all its territory, on this basis there is a conclusion that influence of common factors on prices dominated in this territory. In case there is no unified market (it means here different areas are bounded weakly with one another), influence of local factors is dominates, that happens in significant variety in levels and price movements in different areas. To clear up which factors (common or local) dominated in price movements, a new method of mathematical statistics for this assignment - dispersion analysis is proposed to use.

Analysis of variance is a statistical method of analyze of results, that depend on action of quantitative and qualitative factors. Analysis of variance can be used to identify common influence of economical factors that cannot be measured with quantitative measurement in index that is studied. The method consists in the fact that the total variation of the final figure is divided into parts corresponding to the separate and combined effect of various qualitative factors, and the final variation, which accumulates the effect of all unaccounted factors. Statistical study of these parts allows to make conclusions about whether influence is detected on the resulting rate of any factor. This section will consider the use of analysis of variance. In this case the presence or absence of effects on the resulting sign of one qualitative factor [1] is explored.

Applied to our problem, the above means the following: all area-based series of prices - indicators of development of market [2] are considered as a single complex, which is prices of rye for the entire territory of the Russian Empire during the period. This large array of prices is characterized, in particular, by its average value with some variation that expressed in our example of meanings of variance.

Then we imagine this single complex of prices is dissected into parts (which coincide with the area-based arrays of prices) on the basis of so-called factorial sign (attribute, whose influence on prices being studied). Each of these parts (a total of thirteen - the number of major economic and geographic areas that stand out in the Russian Empire) is characterized with its specific average value (the arithmetic mean) and several deviations of it. The variation of average values ​​can be explained with two types of reasons: 1) reasons related to the division of the complex by factor variable are therefore express the influence of this factor on the price and 2) causes beyond the control of this division (apparently are common to all complex arrays).

Obviously [3] that intergroup (factorial) variation depends largely on the actions of the factor based on which the division is made, and intra-group - from the effects of all other factors. To assess the significance of differences between group means, the variations of intergroup and intra-group should be measured. If intergroup (factorial) variation significantly (statistically significant) exceeds intra-group (final), the factor showed effects on resultant variable, significantly changing the value of group averages [4].

This factor, on the basis of which we share a complex of prices for area-based arrays, at first approximation can be called a sign of local predictors of pricing.With this division into arrays of area-based pricing, we test whether there was a significant effect on prices in each area of purelylocal factors of pricing (it is characterized by inter-group variation ), or whether it was immaterial and then other - common to all areas - factors (characterized by their impact intra-group dispersion) more influenced on pricing. Respectively, the movement of prices was then approved. In the first case, a single market has not yet formed, and in the second case - we can talk about the formation of a single market of rye for respective areas (and then distribute this finding to the entire agricultural market ).

Note that in our approach an indicator of market formation is also the coordination of prices (I.D.Kovalchenko L.V.Milovim B.M.Mironov [5] relied on the provision out of this situation and with). However, there is a difference in approaches to analysis*.* According to above authors' judgments about the superiority of the common pricing factors (and, consequently, the coordination of market mechanisms in general) can be just after (and from) estimation consistency of price movements (as well as other indicators - and above all price levels – at I. D.Kovalchenko and L.V.Milova).

In our analysis almost directly the degree of preference of local or systemic factors and pricing are taken into consideration and after its evaluation, optional conclusions about the consistency or inconsistency of price movements are made – that is optional and repeated indicator.

Thus, in our approach to a chain of logical assessment of market - "price movement" - "consistency of prices" - "advantage of the common factors of pricing" - "single market" – one intermediate unity falls ("consistency prices"). This obviously improves the accuracy of the conclusions on the problem that the accuracy of the conclusions of any investigation ceteris paribus the higher the smaller units (stages) between a process under study and the material, on the basis of which analysis, conclusions about the process are made.

Therefore, it would be better to talk on only the relationship between general and local factors in pricing, but we still often talk about the coordination of prices (primarily common factors relevant pricing) or about their inconsistency with the aim to adhere to the already established and accepted terminology (in many ways it has developed under the influence of the works of these three authors) of problems of market building, for brevity and simplicity in comparison results.

By the above, the factor we are considering obviously could be called as a sign (factor) of greater or lesser degree of development of market linkages and mechanisms, or a sign of formation of a single market - all three definitions have certain advantages and certain disadvantages, but truly reflect the essence of the approach .

Technology of analysis of variance complexes [6] can be reduced, mainly for calculation of indicators of varying, which are the sum of squares of deviations above (deviaty D), and for calculating the average and the total group of arithmetic average .

A scheme for single-factor analysis of variance complexes, which we stuck to, is given in Appendix 1.

Now we turn to our method of processing data on prices. We have taken 169 years (1746-1914 biennium) complex homogeneous retail price of rye in thirteen districts of the Russian Empire (these areas were identified by B.M.Mironovim [7] on the basis of the distribution of different *levels on bread* prices in the provinces and completely coincide with adopted in Russian and Soviet literature of Economic division into districts). Composition of districts is represented in Table 1.

Table 1

List of economic and geographic areas of the Russian Empire and the province that are part of them.

|  |  |
| --- | --- |
| Areas | Provinces |
| I (x1) north | Arkhangelsk Oblast , Vologda Oblast (since 1861.), Novgorod Oblast, Olonetsk Oblast, Pskov Oblast, St. Petersburg Oblast. |
| II (x2) East | Vyatka Oblast, Perm Oblast, Samara Oblast, Orenburg Oblast, Ufa Oblast. |
| III (x3) Southeast | Astrakhan Oblast, Don Oblast, Stavropol Oblast (up to 1847. - Caucasian). |
| IV (x4) Volzhskiy | Kazanskaya Oblast, Saratov Oblast, Penza Oblast, Simbirskaya Oblast (until 1861.), Nizhny Novgorod Oblast (since 1861). |
| V (x5) Central Chernozem | Voronez'ka Oblast, Kursk Oblast, Orel Oblast, Ryazan Oblast, Penza Oblast (since 1861.), Saratov Oblast (since 1861.), Tambov Oblast, Tula Oblast, Kharkov Oblast. |
| VI (x6) Central nonchernozem | Vladimirskaya Oblast, Vologda Oblast (up to 1861), Kaluga Oblast, Kostroma Oblast, Moscow Oblast, Smolensk Oblast, Tver Oblast, Yaroslavl Oblast. |
| VII (x7) Baltic | Courland Oblast, Livonia Oblast, Estland Oblast. |
| VIII (x13) West | Vilna Oblast, Vitebsk Oblast, Grodno Oblast, Kovel Oblast, Minsk Oblast, Mogilev Oblast. |
| IX (x8) Left-Bank Ukrainian | Poltava Oblast, Chernihiv Oblast. |
| X (x9) South-West | Volynska Oblast, Kiev Oblast, Podolia Oblast. |
| XI (x10) Steppe | Ekaterinoslavskaya, Tauris, Kherson and Bessarabian region |
| XII (x11) West Siberian | Tobolsk Oblast, Tomsk Oblast. |
| XIII (x12) East Siberian | Yenisei Oblast, Transbaikalia Oblast, Irkutsk Oblast. |

Each row of regional prices was divided into 10-year segments with an offset of 5 years (ie: 1746-55, 1751-60, 1756-65, ..., 1896-1905, 1901-1910, and a nine-year interval 1906 - 1914).Thus, 33 series (in general amounting 33 arrays of prices in the Russian Empire) and each of them lasts 10 years (except the last one) were obtained for a range of prices of each region. Further processing was carried out of the 10-year series by analysis of variance, ie the significance of the influence of local or general factors on prices was tested (and, therefore, coordination or incoordination of prices) in different areas (and in different groups of districts) in each of the 33 decades.

In addition to analyzing price movements in these 13 areas, the motion prices of provinces was considered in three southern regions of the Russian Empire – Left-bank Ukrainian, South-West and Steppe- which included (according to the administrative division of XIX - early XX century) Chernihiv province, Poltava province, Kiev province, Podolsky province, Volyn province, Tauride Yecaterinoslav province, Kherson province and region of Bessarabia. Here the purpose of the analysis was the same - to find out the impact of local materiality (on a scale of provinces, of course, most likely not strictly within them) factors on prices in the area.

Time of creation of market of appropriate areas (or entering the next area to any regional market) was established on the basis of the following criteria:

1. The first decade is established when influence of local factors of pricing was negligible, ie common factors of pricing dominated (or*,* using terms which were established to describe the problem, when the differences in price levels and their variability were insignificant).

2. This trend is confirmed in the next decade.

3. Installed trend is confirmed by the analysis of related five years taken from each decade.

Period of twenty years, in which the conditions were fulfilled of all three criteria, was taken during the formation on a particular area of the single market. I.D.Kovalchenko and L.V.Milov think 10 years is the optimal period for the criterium time of formation market [8], B.M.Myronov takes longer periods (different for various, a priori separated eras in the history of the Russian Empire)[9 ]. Accordingly we have adopted the first method of data analysis of criteria proposed by us, in fact, not contrary to the terms of the first two authors (and the duration of the period approaching to B.M.Myronova). In our view, they are different in their "cruelness"and complexity and it is conceived as optimal.

In addition to analysis of variance - the main in this paper - we conducted an analysis of price movements using correlation analysis. You must determine that correlation and variance analysis are types of mathematical and statistical methods that analyze source statistical material in planes that are not quite the same.

While analysis of variance is designed to detect certain materiality of impact of factor (in our case - a quality factor) for a certain number of groups that are taken in their entirety, correlation analysis considers the materiality of relationships within pairs of groups (there are multiple correlation analysis, but in our case, where it turns out the connection between a priori independent of each other grounds, it is not applicable) without regard to the factors that could affect or not affect the statistical materiality of the communication.

Proceeding from the above, we are based more on the first method in our analysis.We identify the main advantage of analysis of variance to correlation analysis: the first allows to take into account both the price level and synchrony of oscillations, while the second considers only the synchronization of oscillations (and therefore I.D.Kovalchenko and L.V.Milov were forced to consider the price levels using another, quite laborious type of analysis [10]).

Method of preparing for the correlation analysis of our data for prices is similar to already described analysis of variance. For each decade, then, matrixes of correlation of coefficients were calculated. Then significant coefficients of correlation were chosen from them at the chosen level of materiality  = 0.05. The above mentioned authors stopped in the analysis at this line, but it is known from mathematical statistics [11 ] that the presence of a considerable correlation between the variables X and y (rxy> 0.5) the sampling distribution of the coefficient of correlation for a large number of small samples that are taken from the general population that normally distribute, deviates significantly from the normal curve.

Thus, the sample coefficient of correlation is not an accurate assessment of the general parameter if it is calculated on the sample, although not numerous, and its absolute value greater than 0.5 (and market researchers are interested in just the coefficients of correlation greater 0.71) [12]. Due to this fact, R.Fisher found accurate means of assessing general parameter r by the value of the sample r. This means confined to the replacement value of r transformed z, which is related to the empirical correlation coefficient as follows:



The distribution of z is almost constant in the form because it almost not depends on volume selection and the value of r in the general population. We have made significant transformation of the coefficients of correlation in the value of z on a special table. And after that we evaluated statistical materiality of each indicator calculating the value of tz:



And also we compare tz with tst

In case it is inequality:

tz > tst ,

where tst is a Student test [13] at the adopted level of materiality a = 0.05 and k = n-2, which is determined by the tables, and the sample coefficient of correlation correctly reflects the general setting and it is statistically significant. Proved [14] that the use of z-transform allows more certainty to assess materiality statistical sampling r. So we worked with the z-transformed coefficients of correlation which are significant.

Criteria of time for the establishment of market of appropriate areas at analysis of correlation are almost the same as at the analysis of variance:

1. The first decade is established, when z - transform coefficients of correlations are significant for all pair combinations of these areas (each with each).

2. Statistically significant preservation of all bonds in the next decade is confirmed.

3. Installed trend is confirmed by the analysis of related Five-Year Plans which were taken from each decade.

«Approximations» of the boundaries of balance and imbalance of prices should be noted. This «approximations» is that a gradual shift at the analysis is 5 years, and also, most importantly, that the market could not appear "suddenly" and, apparently, still remained some during his final debugging mechanisms ( the same happens in stages imbalance , only with the opposite " sign" ), and hence identify the chronological framework quite accurately at this stage is not possible.

Thus, we examined research of methods of rye prices as indicators of forming a single territorial agricultural market. Now the results of the analysis are considered.

***Analysis of the formation of regional markets***

It would be logical to assume that the formation of all- agricultural market, the beginning of which probably should be dated to the middle of the XVIII century (internal customs were abolished in 1754), passed through the formation and subsequent merger of some regional markets[15]. These regions should obviously differ from one another with natural geographic and economic conditions. Based on this assumption , we have theoretically highlighted three such possible regions - conditionally - " south ", " north " and " Siberian ". By taken as a basis ( starting point ) Left-Bank Ukrainian ( in the southern region ), Central non-black ( in the northern region ) and West Siberian ( in the Siberian region), the other bordering with them and with each other consistently " joined ", areas to the extent of the coherence fluctuations and price levels in the vicinity of them. Each new set of districts in each region is subject to the following ( after the formation of the market) analysis.

Results of the analysis are shown in Table 2 , which reflects the formation of regional markets.

Table 2

Sequence of entry of areas to regional markets according to analysis of variance

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Region | Basic area | Spread of the base region (district) | The area that is part of the market | Time of entry of area to the regional market. |
| South | IX | IX | X | 1746 - 1765 |
|  |  | IX,X | XI | 1746 - 1765 |
|  |  | IX,X,XI | V | 1756 - 1775 |
|  |  | IX,X,XI,V | III | 1756 - 1775 |
|  |  | IX,X,XI,V,III | II | 1756 - 1775 |
|  |  | ***IX,X,XI,V,III,II*** | ***IV*** | ***1761 - 1780*** |
| North | VI | VI | VIII | 1801 - 1820 |
|  |  | VI,VIII | VII | 1816 - 1835 |
|  |  | ***VI,VIII,VII*** | ***I*** | ***1821 - 1840*** |
| Siberian | XII | ***XII*** | ***XIII*** | ***1756 - 1775*** |

We can start considering this process from the southern region as it has a large number of areas and it is interesting from this point of view. The period from 1746 till 1765 is the first twenty years in which the coordinated movement of prices was being observed in the Left-bank Ukrainian and in some other areas. Prices were balanced (i.e., hang on common pricing factors) in this period on the left bank Ukrainian, West and Steppe regions. In all other Russian areas the harmonization of prices was not observed since the beginning of this period. According to the existing data for this period in the provinces of these three areas (namely, Poltava, Chernihiv, Kyiv and Ekaterinoslav provinces) at this lower level the link between prices was also significant. All this allows us to distinguish this group of areas (at the level of provinces which constitute them) as a special region of the sustainable market linkages. We can call it the South-Russian sub-regional market \* (because of its obvious existence in a bigger region of coordinated price movements). Beginning around 1756 there were converging of levels and synchronization of price fluctuations in these three areas as well as in the Central Black Earth, South-Eastern and Eastern regions. According to our criteria, these six areas were united in a common agricultural market in 1756 – 1775 years. By 1780 the formation of the Southern regional market \*\* was basically completed by the annexation of the Volga region into it. Sometime West area and Central Nonchernozem areas were members of this region, but they were also likely to be integral parts of the Northern regional market. \*\*\*

In such a way, Southern RR formed such areas like Left-bank Ukrainian, Southwest, Steppe, Central Black Earth, South-East, East and Volzhsky areas.

The second regional market (PP) in European Russia was, by our assumption, North RR, whose territory is partially united in the market also in the XVIII century. Prices in the Northern and Central regions ranged Nonchernozem agreed already in 1761-80 years, but after that the market was being unbalanced for a long time and in the beginning of XIX century prices in any of the neighboring Central Nonchernozem (base) area were not consistent with its prices. According to our data, the next long enough (by the analysis of variance) period between statistically insignificant difference in prices in the regions of Northern RR is in 1801-1820 years, when there were not significant local factors in the base pricing and Western areas. Since 1816 much cozies is the price movement in these two areas and the Baltic. Thus, by 1835 Northern RR was included in these three areas. Almost in 1840 the creation of a single North RR was completed by the accession of the Northern area (after half a century in its relations with neighboring areas). Perhaps, it seems at first glance that a long stage of Northern region’s isolation from other areas of this market has been driven more by the significant differences of conditions and means of production and consumption of bread in the area.

So, North RR was formed following areas which are Central Nonchernozem, Western, Northern and Baltic.

The comparison of the localization’s results of regional markets in European Russia with the outcomes of I.D.Kovalchenko and L.V.Milova’s works, shows that highlighted our Southern RR generally coincides with localized them "Black-Ural", but it have been existing for a longer time. For the other regions, which are allocated by these authors, there are considerable differences, which are apparently explained by the fact that there are used less complete chronological coverage data in the I.D.Kovalchenko and L.V.Milova’s works. At the same time, in many cases, these authors used the large volume of data that represented each of the areas that offset, to some extent, lack of a continuous series of prices.

We can consider the formation of the Siberian regional market. \*\*\*\* It consisted of two large areas (covered and the actual and price data from Tobolsk to Petropavlovsk-Kamchatsky) which are the West Siberian and East Siberian and the prices of which were already agreed almost constantly since 1756-75.

Thus, we performed an analysis of the results obtained using the analysis of variance. Correlation analysis of paired bonds prices showed that during considering only the coherence of oscillations different picture of the market and, in particular, the creation of regional markets. According to this analysis, Southern RR was formed mainly at the beginning of the XIX century without the South-West region (but with the participation of the West Siberian region). At the same time, the first area tended to price fluctuations to the Baltic and Western regions. Left-bank Ukrainian region is also approached to them in some periods. This is easily explained by the attraction of these areas, such as manufacturers of bread, the Riga port during the second half of the XVIII century. [18].However, these associations were observed only in some years and so they could be quite random. North PP has not yet emerged in the 40s of the XIX century completely. It happened according to the correlation analysis in the last decade of the XIX century. Then, according to this analysis, Siberian RR was formed, and before that the consistency of price fluctuations observed in it in the 20-30s of the XIX century.

In such a manner, the conclusions about the formation of regional markets were obtained by correlation analysis differ too much from those given previously, and probably to a lesser extent reflect of the real situation, as it is less complete than the analysis of variance, consider the characteristics of the movement of prices and do not consider qualitative factors, which was mentioned above.

We have thus considered the dynamics of the regional price of life during half centuries and traced the process of establishing regional agricultural markets in the Russian Empire, as it appears according to the analysis of variance. In the greater part the regional markets were formed before the end of the XVIII century - Siberian until 1756-75, South - in the years 1761-80, this is almost immediately after the elimination of internal customs in 1754 (in some regions of the empire they were kept before 1758, particularly, in the South-Western part of the empire), which indicates a fairly high level of development of regional ties in the first half of the XVIII century, or high potential establishing such links that are "accumulated" in the first half of the XVIII century and realized in the second half of the XVIII.

It would be interesting to consider further the dynamics of the identified regional markets, which is also likely to be reflected in the price movement.

***The analysis of the functioning of regional markets***

The complex process of functioning of regional markets shows in general terms, in Figure 1, where for easy comparison there are the results of the variance and the correlation analysis of the three regional markets (for all 169 years in the areas existing at the time of creation of the regional market, according to the main analysis). In general, we will analyze the process using analysis of variance, except where noted.

Once again, we begin our analysis with the Southern RR (note immediately that the prices in RDP long period in 1845 were constantly balanced).Hardly having time to be formed, he survived years of partial imbalances in 1776-85. As seen in the diagram the significant fluctuations in bond price levels and generally were absent in the decade, but at the same time, it is seen that this period of price movement relationship existed in some years, which is confirmed in this regard, the imposition of periods (1771 -80 and 1781-90). Perhaps the problem is the movement of prices and therefore in the normal flow of goods movements associated with the end of the Russian-Turkish war of 1766-74 and, as a consequence, with the need for a certain restructuring of the supply of goods and, in particular, the bread on the market and the state. It is also possible that it could affect government activity to change local governance structures, in particular, the introduction of "Institution for management of provinces" in 1775.

Afterwards, there comes a stage of full harmonization of prices in the Southern RR, in other words, its full recovery in 1786-95. And it is necessary to determine that this was the "background" of two wars, partly the Russian-Turkish war in 1787-91 and the Russian-Swedish war in 1788-90. But, unlike the previous stage, they did not cause imbalance in market analysis. It is obviously that the major role was played here by the formation in 1786 of the State Bank debt although a penny of his money has not gone to the needs of trade. At the same time its huge capital has been spent on the needs of the military department [19] and, thus, to a lesser extent was violated resource trade adjustment. The inflation charge of huge sums of emissions to the bank hit the trade later, and this was reflected in the partial collapse of the Southern RR in 1796-1805 years (again, only partial, because, as in 1776 – 85 in the imposition of decades there significant association of prices and, consequently, can again assume the existence of the 10-year period some years when prices were balanced). It is seen that this period can be explained by partial imbalance of certain unstable political and economic life of the country during the reign of Paul I, as well as Russia's participation in some anti-French coalition, which has changed to some extent, scope and structure of Russian foreign trade and hence impact on the state of the internal market.

Since 1806 in the next four decades, the movement of prices in areas of the Southern RR was constantly coordinated and hence all this time until 1845 (partly until 1850) the process went normal, according to grain prices, the functioning of the Southern RR.

Besides the coordinated trade within the Southern RR, it is actually even necessary to define a spread of market entry in Central Nonchernozem (in 1821 - 40 years) and the West (in 1826 - 45 years) areas, despite the fact that B. M . Mironov described the first half of the XIX century as the downturn of economic life and trade. [20]Relatively long balance of prices in Southern RR in the first half of the XIX century, possibly it is described by the widespread in some provinces of the region elements of capitalist organization of agriculture [21], as well as the almost complete absence in the country's special events covering large areas and affecting the economy a long time (Patriotic War of 1812, Russian-Iranian, Russian-Turkish war - small temporary or territorial coverage).

Then, in 1846-60 years, there has been inconsistency in the price movement, and if in the years 1846-50 and 1856-60 years there were significant relationship between prices still characterized by a few years, then in 1851 - 55 years of double-checked (1846 - 55 and 1851 - 60 years) found there was no such connection, and therefore, the lack of unity of South Rd. The same output at the forefront of local pricing factors was observed in RDP as a whole, although there is only one decade in the years 1846-55 and, therefore, it’s only partially. At the same time, at a lower level, some connections were remained. Yecaterinoslav, Kherson, Taurian provinces and region of Bessarabia (of course, not just in their administrative boundaries) did not sever ties with each other ( according to the price ), and all the provinces of the right bank . Although there was some tendency for the dominance of local factors in the pricing of Bessarabia region (perhaps the latter was associated with the introduction of a special trade regime at the end of the period due to exacerbation of Russian - Turkish relations and the war that began after that). In addition, the common pricing factors predominated in the area that includes the right-and left-bank province and even Ekaterinoslavskuya and Kherson province and region of Bessarabia. However, the local differences in the pricing factors extreme in the four provinces, which are Volyn, Chernihiv, Tauride provinces and region of Bessarabia, were still strong enough to prevent all four inputs simultaneously in a single market other areas, although the territory, which included only one of these four provinces, the analysis of variance recognized the significant consistency prices.

The imbalance in 1846-60 years Southern PP coincided with the same status (only longer - 1836-60) Northern RR (Fig. 5) and covered, so in the 15 years the whole territory of European Russia (although neither 1846-60 or after, at least for 20 years, according to our criteria, a common market in this area was not). Therefore, it seems possible to talk about common reasons for the whole of the territory of this phenomenon. It is determined that the correlation analysis confirms such a complete imbalance. In 1846-55 and 1851-60 years most of the correlation coefficient is negative, indicating that, in the reasonable opinion I.D.Kovalchenko and L.V.Milova, the absence of a significant association between the prices [22], although it retained (at consistency fluctuations) pair bonds that chain (never forming a closed group of areas) bind almost all of the European part of Russia, but again without the North and Baltic (in the first decade) areas.

Further was a short period of consistency in the movement of prices in 1856-70. After a short well-being in the market, the 15-year-period of imbalance came (1866 - 80 years), and it began and ended at the same time (with the accuracy that can give a five-year shift in our arrays) in the South and in the North Rd.In this period there were “borderline five-year partial inconsistency prices” (1866-70 and 1876-80 years) and five-year total absence of a significant association between the prices (1871 - 75 years). Then at this time, regarding to the correlation analysis, unlike the previous period of imbalance, the correlation coefficients, which are significant in z-transform, comparatively smaller values, which also confirms mainly the result of analysis of variance.

RDP, generally, has also undergone deterioration in the 1866-80 years, however, some of the links in it are preserved as in the 1846-55. There is a significant difference (even more than in the previous period) of local factors in pricing groups and left-bank Southern provinces. Therefore, there are two areas with the advantage of each common pricing factors that intersect: 1) the left-and right-bank province; 2) Southern and Pravoberezhnye province. The following RDP recovered and not destroyed until the end of the period studied (1914).

Southern RR recovered partially in 1876 and fully in 1881, and by the end of the period that is studied, there were no trends to repeat steps imbalance. There was even a tendency to spread in this market with the participation of the Western, Central and Nonchernozem West Siberian regions, about what is below.

Thus, Southern RR since its formation (in the 1746-80 biennium) functioned without significant market distortions (price) relationship (with partial lack of balance in some years during the 1775-85 and 1796-1805 years) to about 1845, when passed two stages of imbalance (in 1846-60 and 1866-80 years) and then recovered completely.

Now we can consider the operation of the Northern RR since its final form in 1821-40. Already the last five years of this period is included, seen years of imbalance because array of 1836-45 years are characterized the lack of significant relationship between prices in the region. Since 1840 the 15-year of completely imbalance begins just complete newly formed market which was finished in 1855 (the next five years were as a transition).

After this there was a short period of normal functioning of the market in 1856-60, 1866-70 years), which is also coincides with a similar trend in the development of the South Rd.

Next is again the common trend in European Russia, the 15-year period of imbalance prices (1866-80 years) in North Rd.

Subsequently, prices in Northern RR were in balance (in 1876 - partly, and since 1881 - in full), however, it was more concerned the consistency price fluctuations of their appearance, which confirms the correlation analysis.On the advantages of local and systemic factors of pricing, according to analysis of variance, from 1896 until 1914 there was again observed the existence of a large difference in pricing factors of each of the regions of Northern and PP, respectively, gross inconsistency in the price movement. Concurrently, in this regionthe following paired connection is only retained (according to analysis of variance) between the West and the Baltic (except 1896 - 1905), as well as Western and Central Nonchernozem. Moreover, there is a one pair due North and Baltic regions (in 1896 - 1905 - part).At the same time in this period (except for 1896-1905) West district was in South Rd, and in 1901-1910 prices Nonchernozem Central area were agreed with the prices of South Rd.

So, from its relatively late period of formation and the beginning of 20 century Northern RR was subjected to periods of more imbalanced than the normal functioning and it does not connect to any other currently surrounding areas for over 15 years, unlike South Rd.

The process of development of the Siberian RR is no different variety. Complete imbalance of 169 years, he received only once. It was in 1771 - 1785 (with 1771-76 and 1781 - 85 years –the "borderline" lustre).In the XIX century the movement of prices was only partially inconsistent and for a short time (1811 - 20 years, 1831 – 40 years, 1841 - 50 years, 1881- 90 years). We define that the correlation analysis gives no indication of the formation of a single Siberian RR throughout the period that was studied. Another result is almost impossible because it is difficult to imagine that in such territory the price fluctuations were well matched, which undoubtedly reflected also in those area-based average of the prices, which accounted for two rows representing the West and East Siberian regions. Thus, in general, normal life is not disrupted Siberian RR, approximately from 1781 until the end of the period under review. Due to the fact that from the outset we isolated regions that are very different from those that stand L.V.Milovim [23], we could not identify such territorial markets. Also we do not observe the adjacent areas of regional markets which are showed by L.V.Milovim observed [24]. The conclusions about "autonomy" of Left-bank Ukrainian and Southwestern (according to our classification) areas in the second decade of the XIX century [25] also do not find confirmation in our materials.

Thus, we examined the processes in three regional markets in the Russian Empire from the time of their formation to the early XX century and found that each of the markets throughout the study period, was suffered the periodic stages of imbalance caused in the majority reasons unknown to us. Obviously, it could be both local and all-Russian circumstances.

Consequently, we showed the possibility of using the analysis of variance to study the formation and development of regional agricultural markets in the Russian Empire. We believe that the analysis of variance is more convenient for the study of long-term dynamics of coherent area-based grain prices than the correlation analysis, because it allows simultaneously consider both fluctuations and price level. The distribution of price series for decades which was proposed by us, is the convenient method of studying the long-term dynamics of grain prices by using mathematical and statistical methods, which are shifted by five years that takes into account not only the "purpose" of the decade. Application of this technique provides adequate representation by an almost continuous process dynamics is investigated.

**Notes:**

\* Next - RDP.

\*\* Next - South Rd.

\*\*\* Next - North Rd.

\*\*\*\* Next - Siberian RR.

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**Полевой Н.А. Применение методов математической статистики для анализа функционирования региональных хлебных рынков Российской империи во второй половине XVIII – в начале XX вв.- Статья.**

**Аннотация.** Статья посвящена анализу динамики формирования и функционирования региональных хлебных рынков в Русской империи, что предшествовало формированию общероссийского аграрного рынка. Исследование проведено с помощью методов математической статистики – корреляционного и дисперсионного анализа – и оригинальной методики анализа "смещаемых" десятилетий.

**Ключевые слова:** математическая статистика, кореляционный анализ, дисперсионный анализ, хлебний ринок.

**Анотація.** Статтю присвячено аналізу динаміки формування та функціонування регіональних хлібних ринків в Російській імперії, що передувало формуванню загальноросійського аграрного ринку. Дослідження проведено за допомогою методів математичної статистики – кореляційного та дисперсійного аналізу – та оригінальної методики аналізу «плинних» десятиліть.

**Ключові слова:** математична статистика, кореляційний аналіз, дисперсійний аналіз, хлібний ринок.