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INFORMATION ENTHROPY AND FREEDOM OF CHOICE

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Abstract.*The article proposes a formula for estimating the freedom of choice of a person, similar to the formula for information entropy in information theory. The formula is used to compare the freedom of election in presidential and parliamentary elections in Ukraine and the Russian Federation, as well as in Ukraine, the Russian Federation and EU countries.*

Keywords: *information entropy, information theory, freedom of election, presidential and parliamentary elections in Ukraine.*

Introduction

Statistical physics is steadily gaining new ground in fields that seemingly have nothing to do with it. One of the fundamental concepts of statistical physics is the concept of entropy. In 1877, the ingenious Austrian physicist Ludwig Eduard Boltzmann was the first who understood the connection of the entropy of the physical system with the probability of its being in a macroscopic state, due to the number of microstations that realize this macroscopic state [1, 2]. In 1948, the famous American electrician and mathematician Claude Elwood Shannon proposed to use the concept of entropy to evaluate the uncertainty of information about a particular event [3, 4]. In this way he initiated a new mathematical discipline - information theory, where entropy was called information entropy. The relation of information entropy with the probability of the occurrence of a particular event, he proposed in the same form as the relation of finding the system in a particular macroscopic state, that is, actually used the information entropy Boltzmann formula. Consider the formula for information entropy.

Information entropy or the entropy of choice

Let's have a random experiment with the consequences E_1, E_2, …, E_n, that can be realized with probabilities p_1, p_2, …, p_n . Then the information we get as a result of this experiment is a random variable that assumes value $I(E_i)$ when the experiment results is E_i. With

$$I(E_i) = -\log_2(p_i).$$

The mathematical expectation of this information (information entropy), that is, the average amount of information attributable to one consequence of an experiment, is determined in a standard manner [5]

$$M(I(E_i)) = \sum_{i=1}^{n} p_i I(E_i).$$

The last result can also be written in the form adopted for information theory

$$S = -\sum_{i=1}^{m} p_i \log_2(p_i).$$

Many political processes resemble a random experiment. In particular, in our opinion, such a process is the election of different levels. If the possible consequences of this political process are to consider the victory of a candidate, that is, an event E_1, E_2, …,

E_n with probabilities p_1, p_2, …, p_n, then the preceding formula can be used to evaluate the election results.It would now be advisable to use the term entropy of elections, or the index of freedom of elections instead of information entropy term. Election entropy depends on two main factors: the number of candidates and the probabilities election of the candidates. The entropy of elections with a fixed number of candidates reaches a maximum if the votes between the different candidates are distributed equally, that is $p_1 = p_2 = ... = p_n$. This universal property of entropy has also been warned by Ludwig Edward Boltzmann. In this case, the formula for entropy of elections will look like

$$S = \log_2(n).$$

That is, as the number of candidates increases, the entropy of elections increases as the logarithm of their number. It is nothing more than the famous Ralph Hartley formula [6].

Thus, election entropy characterizes the level of uncertainty in election results. Than are more candidates in an elected office and than are more uniform distributed the probability of winning different candidates, so is greater the entropy of the election, or the index of freedom of election. . It is advisable to use for the basis of the logarithm the number two in the formula for the entropy of elections. In the case of two candidates who have an equal chance of winning, that is the simplest political random experiment, for election entropy we get result one. In information theory this amount of information is called a bit. In our case it would be better to call it otherwise, for example, freed - from the first letters of the English word freedom.

It should be noted that in some countries, where the level of democracy is considered to be high, elections are actually taking place between two candidates with approximately equal chances of winning. It is clear that in this case the entropy of choice will be rather small, for example, comparatively with Ukraine.

In the Soviet Union, elections have always been held on a non-alternative basis. This means that one of the probabilities, for example, $p_1 = 1$ and all others are zero. In this case, the formula for the entropy of elections gives zero result.

If elections are held in two rounds, then the same formula for election entropy should be used for the second round too, and the results, according to the universal entropy property of two independent subsystems of the same system, will be the next sum

$$S = S_1 + S_2,$$

where

$$S_1 = -\sum_{i=1}^{m} p_i \log_2(p_i),$$

$$S_2 = -\sum_{i=1}^{2} P_i \log_2(P_i).$$

From our point of view, the degree of uncertainty of the election results indicates the level of voter freedom in such elections, that is, the level of freedom of the elections themselves. Therefore, since there are no competing variants of the definition for obvious reasons, we propose to call the entropy of elections an index of freedom of elections. In this case, if a voter votes for i–th candidate, then he exercises his freedom of choice in quantitative terms as $-\log_2(p_i)$.

Elections in Ukraine, Russia and EU countries

We apply the formulas we propose to estimate the freedom of choice index in the leading EU countries, as well as in Ukraine and Russia. For simplicity's sake, let's just take the latest elections in Europe. We will have the following result for the parliamentary elections.

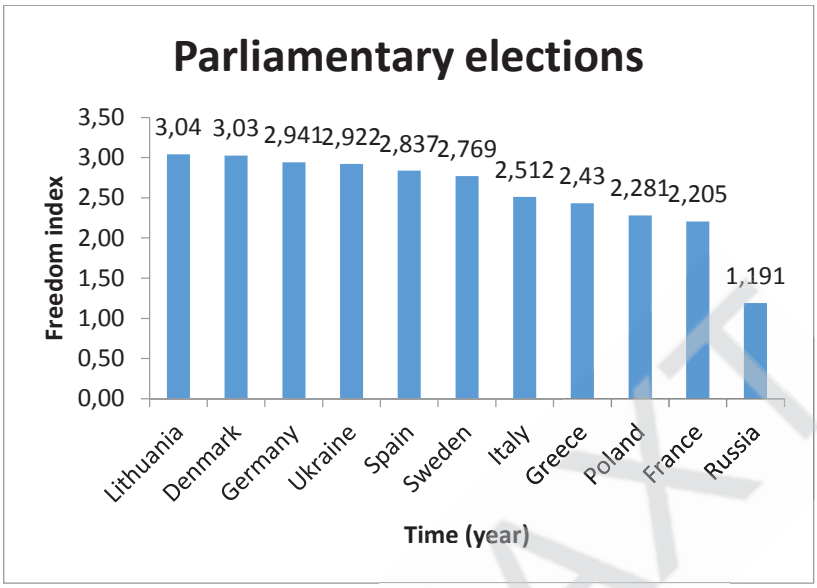

Fig. 1.

The chart above shows that for all the countries considered, which are the leading EU countries, high values of the freedom of election index are characteristic. The difference between the highest and lowest values of this index is relatively small. It is gratifying that only three EU countries have values of the freedom index higher than its value for Ukraine, and the remaining six - lower. Russia, in this list of countries, ranks last by a large margin for the European Union with the lowest value of the freedom of choice index - France. Moreover, the indices of freedom of election for France and Russia differ almost twice in favor of France.

Not all EU countries are elected by direct and general elections. Among the EU countries already considered, there are only four. The relevant chart for the presidential election is as follows.

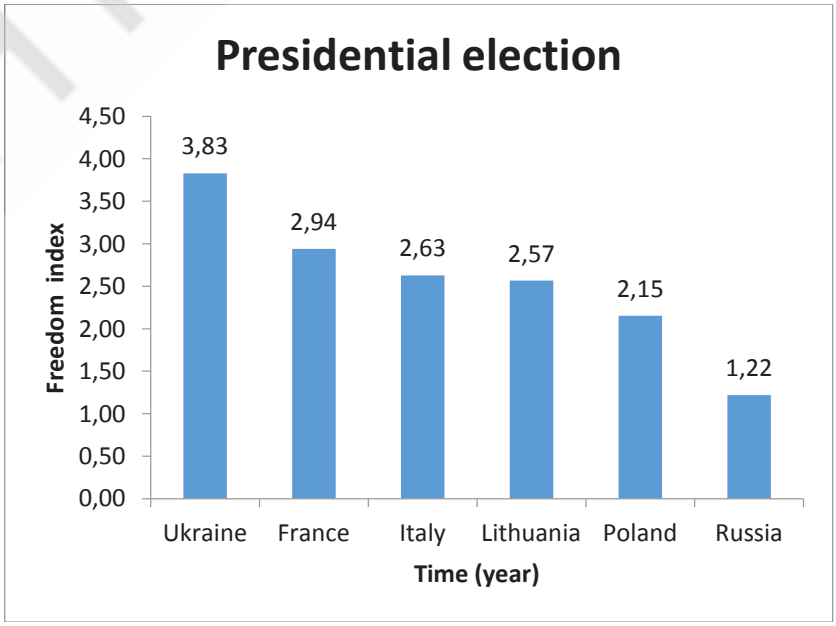

Fig. 2.

Ukraine is already the undisputed leader here, with a large margin for the rest of the countries. Other EU countries are again showing a small variation in the corresponding values of the index of freedom of elections, whose level as a whole is quite high. In the last place in the value of the index of freedom of elections is again Russia. Again, the indices of freedom of election for the EU country with the smallest index of freedom of election - Poland and Russia differ almost twice now in favor of Poland. Note that the data you need to build the charts are easily accessible from the internet, and we did not make any specific links to them.

In order to understand whether the magnitude of the freedom of election index reflects the mentality of the peoples, and whether it can change significantly over time, it is necessary to analyze the behavior of the index over a long period of time in the same country or in several countries with a common past. For this comparison, we chose Ukraine and Russia. They have been part of one empire for hundreds of years, their languages belong to one linguistic group - Slavic, in each of these countries there is still a large percentage of the population, ideologically formed under the same political conditions

Presidential and parliamentary elections in Ukraine

The following chart shows the results of the presidential election in Ukraine over the years of independence.

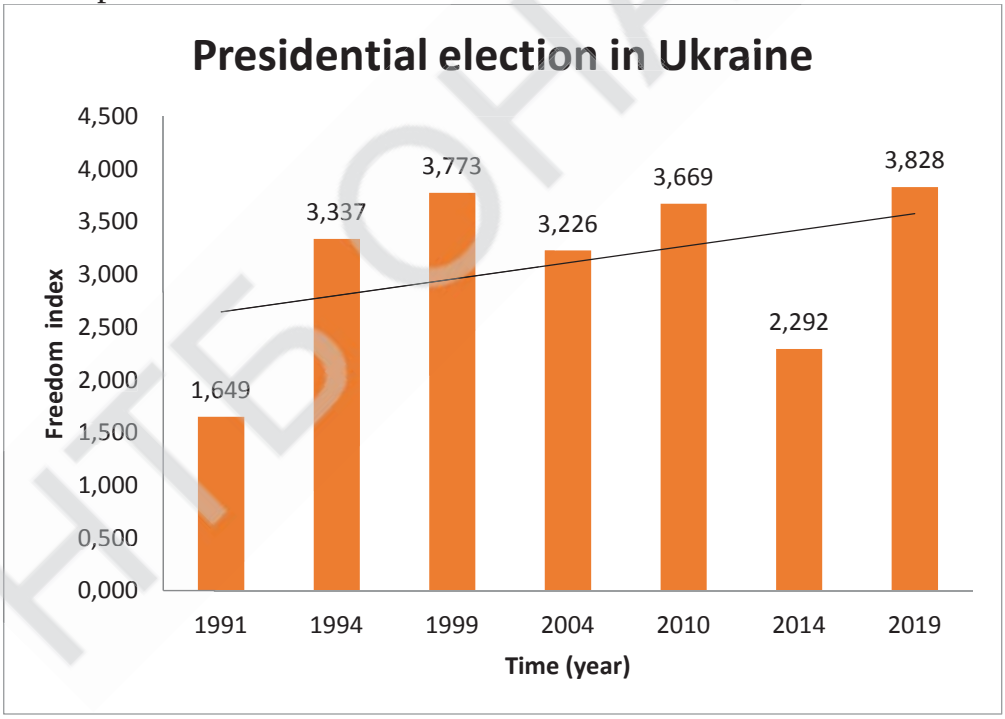

Fig. 3.

The chart shows that the index of freedom of elections in Ukraine is extremely high over the whole period of independence. The lowest level was in the first elections in the recent history of Ukraine. In our view, this was due to the inertia of the thinking of voters, as well as candidates, as a result of the recent Soviet past. This level was relatively low in the 2014 elections. At that time, an imminent war with the Russian Federation was coming to Ukraine. The desire to lead the country at this tragic time for Ukraine was relatively small. Elections in two rounds would be too dangerous for the country. Voters' responsibility for the fate of the state determined exactly this result. One of the candidates surely won the first round.

The highest level of freedom of election was in the last 2019 elections. The elections here took place in two rounds. The number of candidates was unprecedentedly high. The winner of the second round won just over thirty percent of the vote in the first round.

If we follow all the presidential elections in an independent Ukraine, then there is a clear tendency to increase the index of freedom of elections (a straight line that determines the long-term trend).

The following chart shows similar results of the parliamentary elections in Ukraine over the years of independence.

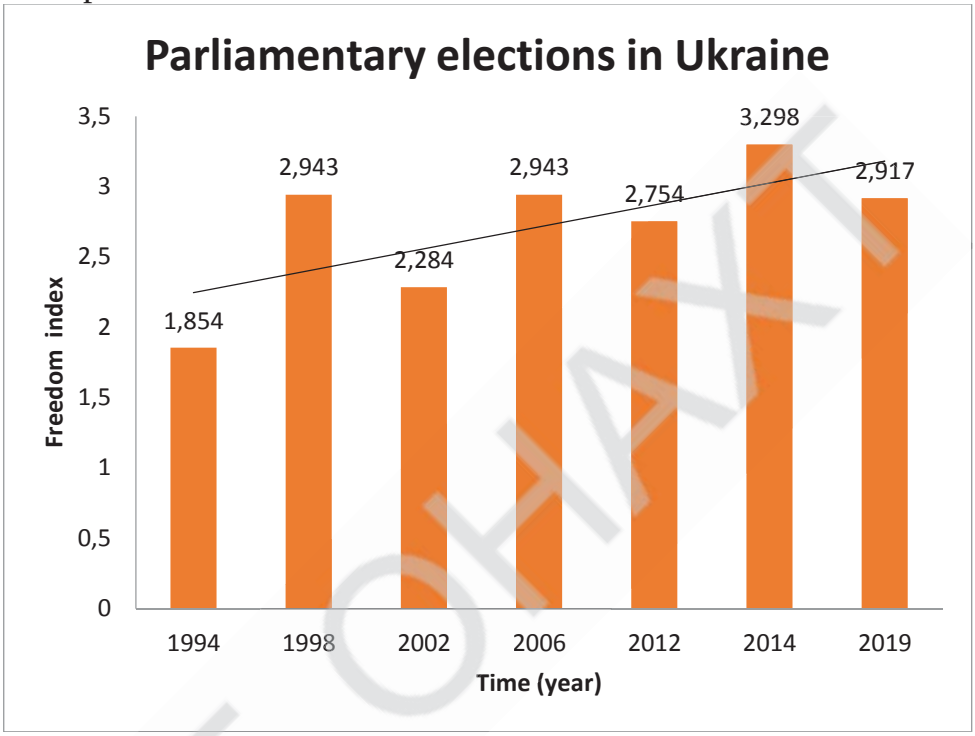

Fig. 4.

The index of freedom in parliamentary elections is also quite high and correlates well with the level of freedom of presidential elections. It also tends to grow. The lowest election freedom was in the first parliamentary elections in 1994, which is consistent with the lowest presidential election rate. However, it was the highest in Ukraine's most difficult year of 2014. A greater number of political parties won a real chance of winning, and the vote was more evenly distributed than in other parliamentary elections. By electing the president in May, the Ukrainian voter brought a huge number of nationally-minded deputies to the parliament on a patriotic wave. There were also parties that did not have such a chance under other conditions. A large number of MPs from the regions occupied by the Russian Federation, traditionally orthogonal to Ukrainian values, did not appear in parliament. Parliament has never worked as effectively as it did between 2014 and 2019.

Presidential and parliamentary elections in the Russian Federation

As we have already said, it is best to compare the Ukrainian elections with the elections in the countries that emerged from the ruins of the Soviet Union. An important factor here is the commonality of starting political and economic conditions. Another important leveling factor is the mentality of the Soviet man, present in all, even the most remote corners of the former Soviet Union at the time of its collapse. If the results of the elections in different countries show significant differences, then those differences would, in the first place, be caused by differences of ethnic origin. The results of the presidential

election in the Russian Federation over the years of its independent existence are as follows.

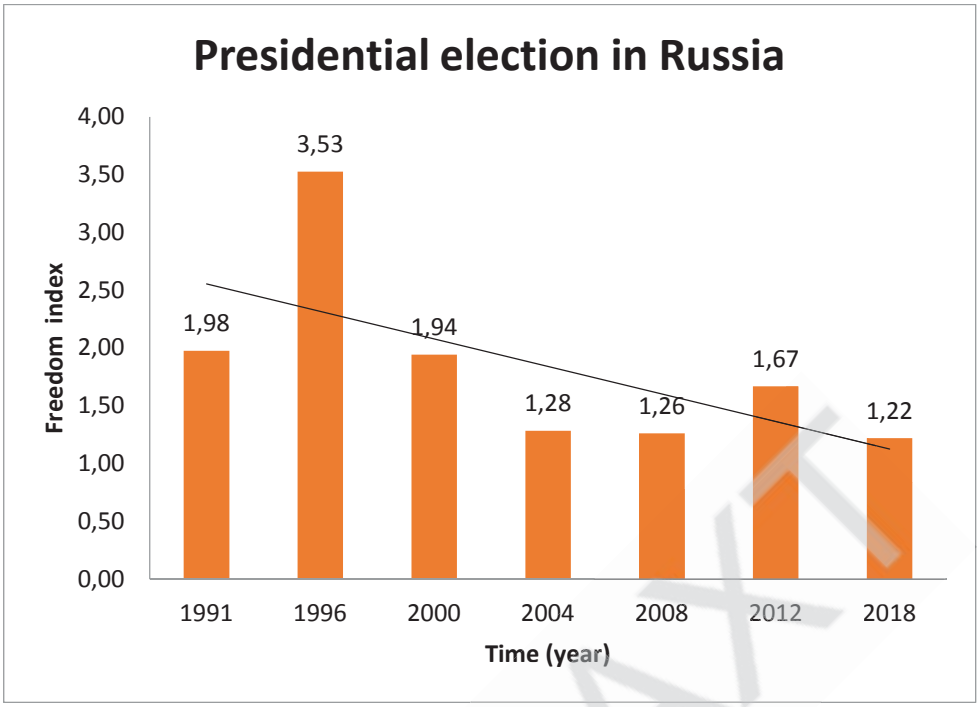

Fig. 5.

The chart shows that the level of freedom of presidential elections in the Russian Federation immediately started from a rather high level in 1991. It peaked in 1996, and for the last nearly twenty years it has shown a clear downward trend. From a mathematical point of view, the immediate reasons for such behavior are the level of freedom of election, both as a decrease in the number of candidates and an increase in the uneven distribution of votes between them. That is, a large number of candidates receive a symbolically small number of votes, but one candidate receives an unprecedented high number of votes.

The results of the parliamentary elections are shown in the following diagram.

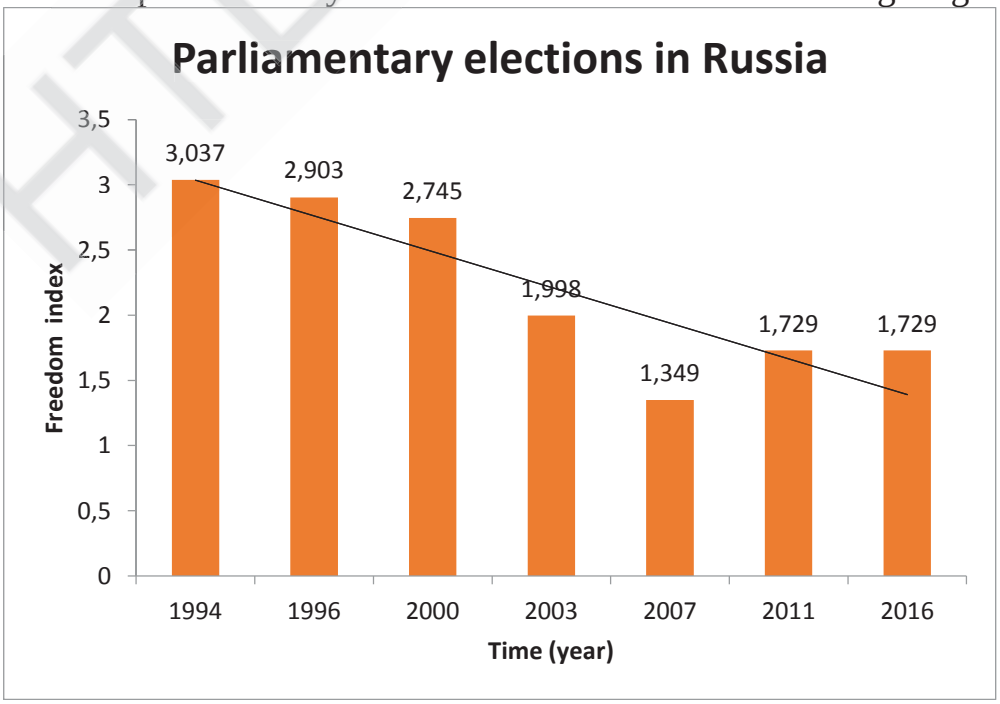

Fig. 6.

This chart also demonstrates the high level of freedom of parliamentary elections in the Russian Federation in 1994, 1996, 2000. However, it also shows a strong tendency to decrease this level for all analyzed years. There is also a strong correlation between the results of the presidential and parliamentary elections. Such a correlation, as in the case of Ukraine, testifies, in our opinion, to the objective nature of the election process for each nation, as the elections may be called. That is, the nature of the election is a reflection of the mentality of one or another nation, its fundamental ethnic values.

Comparing elections in Ukraine and Russia

Only by comparing the election results in different countries gives us the opportunity to determine our own place in today's world political process. The following diagram shows the comparison for the presidential election in Ukraine and the Russian Federation.

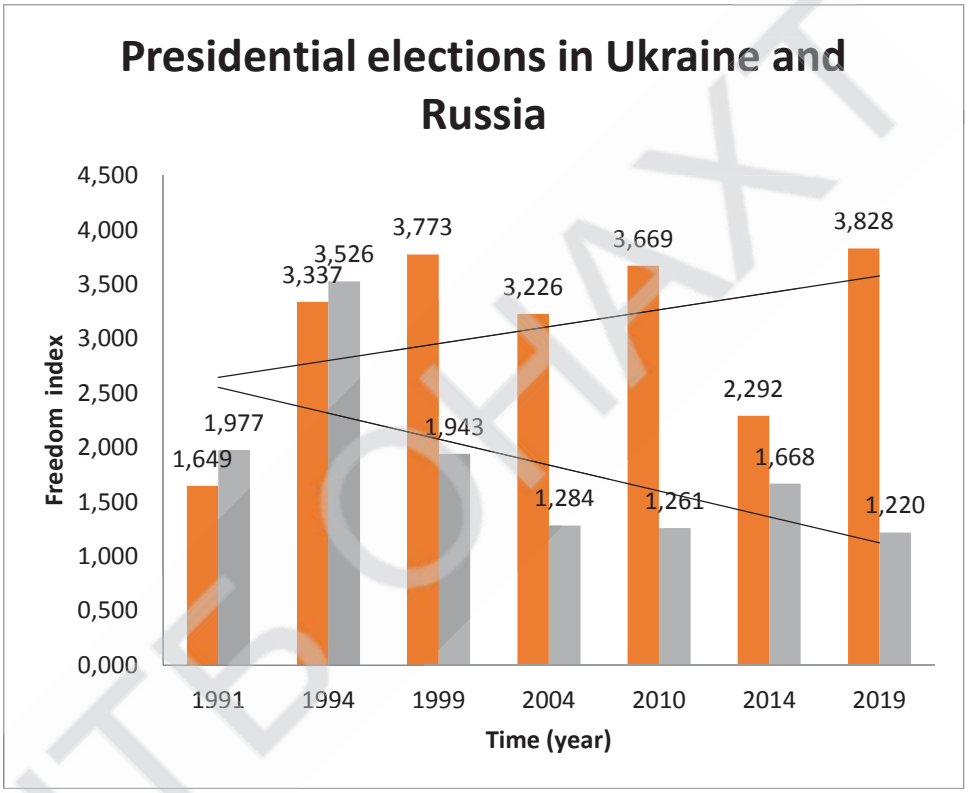

Fig. 7.

The chart shows that the level of freedom of elections in 1991 started in almost the same level in both countries. This may well be explained by the inertia of thinking of Ukrainians and residents of the Russian Federation. Generations of voters in both countries were predominantly formed under the conditions of one political reality - the Soviet Union. But over time, differences began to increase. This was happening as the ballot boxes in Ukraine began to be generated by politically formed voters or even born in an independent Ukrainian state. Accordingly, the number of voters whose outlook was formed in the Soviet Union began to decline substantially for natural reasons. The same evolution began among the voters of the Russian Federation, but in the exact opposite direction. It seems that Soviet education was a compromise for the various ethnic groups that inhabited the Soviet Union. The collapse of the Soviet Union was at the same time the disappearance of this compromise. Then began the evolution of each ethnic group to its own characteristic of its mental worldview. As a result, we received the highest level of freedom of choice in Ukraine's recent presidential elections, and the lowest in the Russian

presidential elections, respectively. However, these results differ in times. The following chart provides a comparative analysis of the presidential elections in both countries.

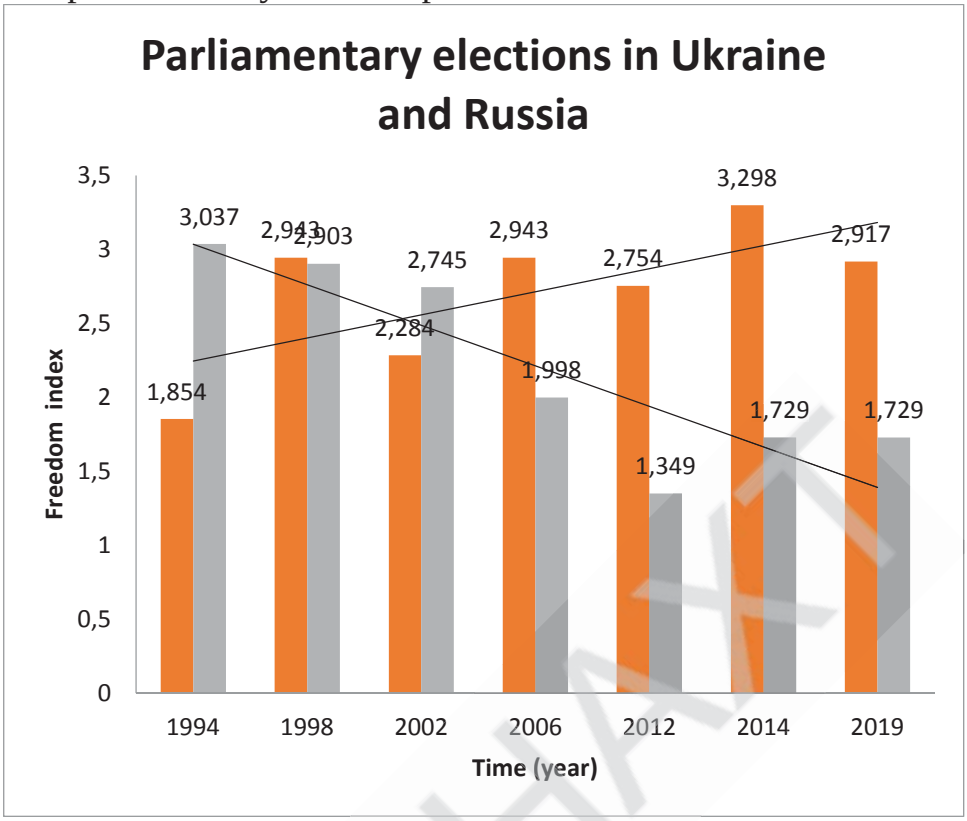

Fig. 8.

The freedom of parliamentary elections in Ukraine and the Russian Federation will also differ significantly in favor of greater freedom of election in Ukraine compared to the Russian Federation. There is a clear tendency for Ukraine to increase freedom of elections, and for the Russian Federation a clear tendency to decrease it. However, there are some differences. The freedom of parliamentary elections in the Russian Federation started with higher values compared to Ukraine. The tendency to significantly reduce the freedom of parliamentary elections in the Russian Federation has become apparent over the last twenty years, when the concentration of power in the hands of the President has increased markedly.

Conclusions:

1. As in the case of the presidential election, the results of all recent parliamentary elections in Ukraine and the Russian Federation differ significantly in favor of greater freedom of election in Ukraine.

2. From the comparative analysis of the presidential and parliamentary elections in Ukraine and the Russian Federation, in our opinion, it follows that the significant difference between the election results in both countries for nearly thirty years testifies to the significant mental difference between the Ukrainians and the residents of the Russian Federation.

3. The index of freedom election in Ukraine is fully consistent with, and sometimes exceeds, the index of freedom election in the leading EU countries. In our opinion, this testifies to the mental closeness of Ukrainians to the peoples of the European Union.

4. The index of freedom election in the Russian Federation is substantially lower than the value of this index for the leading countries of the European Union and

Ukraine. This, in our opinion, testifies to the mental difference of the peoples of the European Union, together with Ukraine, from the peoples of the Russian Federation.

5. All the characteristic features of the bihavior of the index of freedom elections, as seen in the example of two countries with a common history, are of a lasting nature and indicate the existence of deep internal causes of such differences.

6. The mere possibility of noticing the smallest details of both the presidential and parliamentary elections in both countries at the number level indicates, in our opinion, that the formulas proposed by the authors for the election analysis are an effective tool for quantitative research on this political process. We believe that this approach can be applied to quantitative analysis and other aspects of political life in different countries.

7. The some basic ideas of the work have already passed some validation among the scientific community [7,8].

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