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Criminological research on statistics concerning judicial examination of criminal proceedings using cluster analysis algorithms

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ABSTRACT

The purpose of the research is to reveal the essence of criminological research on statistics concerning judicial examination of criminal proceedings using cluster analysis algorithms. Main content. The article demonstrates the use of the cluster analysis method in the process of criminological research to identify regions of Ukraine with abnormal indexes of legal statistics. Methods of the Data Mining module based on STATISTICA (StatSoft) were applied in order to identify atypical observations. Methodology: The dialectical method of scientific knowledge is the methodological basis of the research. Through application of this method considered was the essence of judicial examination of criminal proceedings using cluster analysis algorithms (development, relationship and mutual influence of these aspects). Results. Quantitative indexes of the work of appellate courts were analyzed in absolute numbers, a graphic presentation and visualization of individual stages of the conducted analysis was performed in order to demonstrate the method, ways of practical application of the obtained results of cluster analysis were outlined in order to improve the activity of courts in criminal proceedings.

KEY WORDS: Criminology, judicial examination, cluster analysis, appeal courts, criminal proceedings.

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Investigación criminológica sobre estadísticas relativas al examen judicial de procesos penales utilizando algoritmos de análisis de conjuntos

RESUMEN

El propósito de la investigación es revelar la esencia de la investigación criminológica sobre estadísticas relacionadas con el examen judicial de procesos penales utilizando algoritmos de análisis de conglomerados. Contenido principal. El artículo demuestra el uso del método de análisis de conglomerados en el proceso de investigación criminológica para identificar regiones de Ucrania con índices anormales de estadísticas legales. Se aplicaron métodos del módulo de Minería de Datos basados en STATISTICA (StatSoft) para identificar observaciones atípicas. Metodología: El método dialéctico del conocimiento científico es la base metodológica de la investigación. Mediante la aplicación de este método se consideró la esencia del examen judicial de los procesos penales utilizando algoritmos de análisis de conglomerados (desarrollo, relación e influencia mutua de estos aspectos). Resultados. Los índices cuantitativos del trabajo de los tribunales de apelación se analizaron en números absolutos, se realizó una presentación gráfica y visualización de las etapas individuales del análisis realizado para demostrar el método, se describieron formas de aplicación práctica de los resultados obtenidos del análisis de conglomerados para mejorar la actividad de los tribunales en los procesos penales.

PALABRAS CLAVE: Criminología, examen judicial, análisis de conglomerados, tribunales de apelación, proceso penal.

Introduction

Throughout the world, activities of courts are an important component of countering and preventing crime. There are established mechanisms for implementing stages of the judicial examination of criminal proceedings. In particular, appeal in criminal proceedings plays an important role and it is one of the guarantees of observance of the rights of both the defendant and other participants in the judicial process.

Ukraine has been reforming the judicial system for many years. Implementation of this reform involves improvement of both the legislation on the judicial system and norms of procedural legislation regulating the administration of justice.

The strategy of judicial reform in May 2015 provided for consolidation of judicial districts; as it was declared, this consolidation should have become one of the ways to

improve efficiency of courts. In December 2017, a decree was issued which eliminated 27 appeal courts. Instead, 26 "new" courts were created. Although in fact, only their renaming took place. Only the appeal courts of the city of Kyiv and the Kyiv region were united into one - the Kyiv Court of Appeal. However, the courts started their work in the new format much later.

It should be noted that different regions of Ukraine are characterized by different social and economic indexes, demographic characteristics, local traditions as well as by different ratios of certain types of crime. Criminological characteristics of a separate region of Ukraine are aimed at forming an improved analytical concept of judicial reform, as well as (in a broader context) the concept of law enforcement reform and administrative reform in Ukraine.

The purpose of the research is to reveal the essence of criminological research on statistics concerning judicial examination of criminal proceedings using cluster analysis algorithms.

1. Literature review

There are many scientific studies on formation and development of appeal courts in Ukraine. In particular, we should highlight the dissertation work by V.M. Koval "Appeal Courts in Ukraine: Formation and Development" (2004). The author emphasizes that formation of a full-fledged judicial power in Ukraine requires adoption of additional organizational and legal measures. At the same time, functions of the judicial power include delivery of justice and preventing crime, and the control activity of courts is carried out within the scope of the function of justice (Koval, 2004).

L.M. Moskvich analyzed international standards of effective justice with simultaneous projection on the Ukrainian judicial system (2009). In particular, these standards include: 1) actual (real) access of a person to institutions of the judicial system; 2) openness of the judicial process; 3) reasonable terms of the judicial process; 4) due legal procedure; 5) legally established independence and impartiality of courts (Moskvych, 2009).

Analysis of international scientific publications also provides an opportunity to get an idea about effectiveness of legal procedure of criminal cases, in particular, in countries of the European Union and in the United States. Such efficiency mainly based on optimal terms of

legal procedure, terms of appeals and execution of judgments (decisions) of courts (Leheza ect., 2021).

Thus, when analyzing activities of appeal courts in England and the USA Burton Atkins notes that despite the research on appeal courts conducted in the last few decades, little attention has been paid to assessing the role of appeal courts at the international level. The author considers in particular appellate courts in England, in particular the English Court of Appeal and the US courts of appeals (Leheza ect., 2021).

The American and English systems are proposed by the author as alternative models of interaction between courts and their political systems in Western common law regimes. Through highlighting the work of intermediate courts of appeals and their interaction with the respective courts of the last resort, the data presented show greater commonality than divergence in the work of the two judicial hierarchies (Burton, 1990).

2. Materials and methods

The research is based on the work of foreign and Ukrainian researchers on revealing the essence of the criminological research on statistics concerning judicial examination of criminal proceedings using cluster analysis algorithms.

The role of statistics concerning judicial examination of criminal proceedings using cluster analysis algorithms has been determined with the help of the gnoseological method. Constituent elements of the judicial examination of criminal proceedings using cluster analysis algorithms were investigated by means of system-structural method. Structural-logical method was used to designate the main directions in optimization of criminal proceedings using cluster analysis algorithms.

3. Results and discussion

The data structure is represented as 27 indexes which were selected from the public records of the State Judicial Administration of Ukraine for 2019 and 2020. The figures for 2021 and the beginning of 2022 are anomalous due to the quarantine and military aggression of the Russian Federation against Ukraine. The rows of the formed table are presented for the regions of Ukraine in the amount of 25 observations. Data from Donetsk and Luhansk regions represent only the territory controlled by Ukraine. Data from the Autonomous

Republic of Crimea and the city of Simferopol is absent due to temporary occupation of the peninsula (Fediuk, 2016).

Variables of the analysis include the following parameters:

1) Number of revised sentences (total);

2) Number of sentences left unchanged;

3) Number of changed sentences;

4) Number of changed sentences with mitigation of the imposed punishment;

5) Number of changed sentences with a change in the legal qualification of the criminal offense to a less serious one;

6) Number of sentences with changed amounts to be recovered;

7) Number of canceled sentences (total);

8) Number of canceled absolutory sentences;

9) Number of sentences canceled on the basis of an agreement;

10) Number of sentences canceled due to incomplete judicial examination;

11) Number of verdicts canceled due to inconsistency of the court's conclusions with the actual circumstances;

12) Number of sentences canceled due to a significant violation of the requirements of the criminal procedural legislation;

13) Number of sentences canceled due to an incorrect application of the law on criminal responsibility;

14) Number of sentences canceled due to an inconsistency of the prescribed punishment with the severity of the respective criminal offense and the personality of the accused;

15) Number of canceled sentences with appointment of a new trial (total);

16) Number of canceled sentences with appointment of a new trial due to absence of a defense attorney during the trial;

17) Number of canceled sentences with appointment of a new trial due to absence of the victim during the court proceedings;

18) Number of canceled sentences with appointment of a new trial due to absence of a court session log or a technical information carrier;

19) Number of canceled sentences with closure of the criminal proceedings (total);

20) Number of canceled sentences with closure of the criminal proceedings due to insufficient evidence to prove the person's guilt;

21) Number of canceled sentences with the closure of the criminal proceedings due to the death of the suspect (accused);

22) Number of canceled sentences with the closure of the criminal proceedings due to relief of the accused person from criminal responsibility;

23) Number of canceled sentences with adoption of a new one (total);

(24) Number of canceled sentences with adoption of a new one due to the need to apply the law on a more serious criminal offense;

25) Number of canceled sentences with adoption of a new one due to the need to apply a more severe punishment;

26) Number of canceled sentences with adoption of a new one due to the abolition of the unjustified absolutory sentence;

27) Number of canceled sentences with adoption of a new one due to an unlawful relief of the accused from enduring his/her punishment.

A fragment of the formed database is presented in tables 1, 2.

If we compare the data of 2019 and 2020, it is obvious that in 2020 these data reflect the situation worse than the respective data for 2019 due to the Covid-19 pandemic and mostly quarantine restrictions which also affected the work of judicial institutions, and in different regions such an impact could differ significantly (sometimes courts were almost out of operation for a long period of time) Also, taking into account the fact that during the period 2019-2021 there were no significant changes to the procedural legislation regulating operation of appeal courts, the data for 2019 most plausibly characterize the situation concerning consideration of cases by the appeal authority in various regions of Ukraine.

In relation to the methods chosen by us for performing the analysis, the following should be said. In general, most of the methods used to detect atypical observations solve the problem of classification. They require the presence of objects in advance known to belong to this or that class (of the two classes available). Such methods belong to the class of supervised learning.

Our task consists in the need to identify atypical observations, without obtaining information about their belonging to this or that class. It is clustering that belongs to the

class of unsupervised learning. The problem of clustering is solved at the initial stages of the research. Solution of this problem helps to better understand the data itself and its nature.

Table 1: Official data of the State Judicial Administration regarding activities of appeal courts of Ukraine in 2019

Regions of Ukraine	Var 1	Var 2	Var 3	Var 7	Var 15	Var 19	Var 23
Vinnytsia region	807.00	271.00	316.00	220.00	90.00	20.00	109.00
Volyn region	344.00	173.00	82.00	89.00	42.00	5.00	41.00
Dnipropetrovsk region	1832.00	613.00	489.00	730.00	347.00	45.00	331.00
Donetsk region	863.00	371.00	240.00	252.00	113.00	27.00	110.00
Zhytomyr region	438.00	222.00	63.00	153.00	90.00	3.00	59.00
Zakarpattia region	160.00	54.00	42.00	64.00	50.00	9.00	5.00
Zaporizhia region	936.00	538.00	120.00	278.00	140.00	29.00	109.00
Ivano-Frankivsk region	291.00	147.00	46.00	98.00	68.00	13.00	17.00
Kyiv region	485.00	211.00	116.00	158.00	80.00	15.00	60.00
Kirovohrad region	372.00	162.00	86.00	124.00	75.00	7.00	41.00
Luhansk region	184.00	63.00	66.00	55.00	30.00	6.00	17.00
Lviv region	659.00	300.00	146.00	213.00	117.00	38.00	54.00
M. Kyiv (city)	1083.00	676.00	178.00	229.00	87.00	31.00	107.00
Mykolayiv region	450.00	220.00	76.00	154.00	107.00	8.00	35.00
Odesa region	502.00	195.00	145.00	162.00	90.00	14.00	49.00
Poltava region	559.00	376.00	96.00	87.00	14.00	16.00	57.00
Rivne region	298.00	164.00	71.00	63.00	35.00	3.00	23.00
Sumy region	389.00	178.00	70.00	141.00	109.00	6.00	26.00
Ternopil region	158.00	83.00	29.00	46.00	29.00	10.00	7.00
Kharkiv region	1023.00	508.00	236.00	279.00	145.00	41.00	93.00
Kherson region	556.00	204.00	145.00	207.00	119.00	11.00	77.00
Khmelnytskyi region	437.00	206.00	77.00	154.00	65.00	10.00	79.00
Cherkasy region	158.00	94.00	19.00	45.00	34.00	2.00	9.00
Chernivtsi region	311.00	166.00	56.00	89.00	18.00	17.00	54.00
Chernihiv region	591.00	311.00	90.00	190.00	77.00	7.00	104.00

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Table 2: Official data of the State Judicial Administration regarding activities of appeal courts of Ukraine in 2020

Regions of Ukraine	Var 1	Var 2	Var 3	Var 7	Var 15	Var 19	Var 23
Vinnytsia region	580.00	251.00	184.00	145.00	75.00	9.00	61.00
Volyn region	230.00	132.00	62.00	36.00	12.00	4.00	19.00
Dnipropetrovsk city	1428.00	576.00	347.00	505.00	285.00	21.00	198.00
Donetsk region	676.00	299.00	177.00	200.00	81.00	14.00	102.00
Zhytomyr region	310.00	158.00	41.00	111.00	65.00	8.00	38.00
Zakarpattia region	89.00	35.00	16.00	38.00	29.00	6.00	3.00
Zaporizhia region	753.00	433.00	109.00	211.00	107.00	20.00	84.00
Ivano-Frankivsk region	239.00	113.00	52.00	74.00	51.00	8.00	15.00
Kyiv region	361.00	199.00	66.00	96.00	37.00	12.00	47.00
Kirovohrad region	357.00	185.00	71.00	101.00	65.00	4.00	31.00
Luhansk region	179.00	92.00	53.00	34.00	11.00	2.00	21.00
Lviv region	588.00	333.00	103.00	152.00	81.00	26.00	44.00
M. Kyiv	739.00	424.00	99.00	216.00	84.00	30.00	91.00
Mykolayiv region	389.00	215.00	50.00	124.00	78.00	8.00	36.00
Odesa region	678.00	299.00	176.00	203.00	104.00	28.00	68.00
Poltava region	431.00	279.00	74.00	78.00	16.00	19.00	40.00
Rivne region	226.00	119.00	33.00	74.00	57.00	6.00	11.00
Sumy region	241.00	137.00	45.00	59.00	41.00	10.00	8.00
Ternopil region	155.00	93.00	25.00	37.00	24.00	1.00	12.00
Kharkiv region	1208.00	582.00	266.00	360.00	192.00	76.00	89.00
Kherson region	494.00	176.00	122.00	196.00	97.00	16.00	80.00
Khmelnytskyi region	275.00	182.00	36.00	57.00	13.00	10.00	33.00
Cherkasy region	301.00	171.00	48.00	82.00	43.00	8.00	31.00
Chernivtsi region	279.00	159.00	52.00	68.00	16.00	10.00	42.00
Chernihiv region	499.00	303.00	83.00	113.00	46.00	6.00	61.00

Cluster analysis gives an opportunity to divide objects into clusters not one by one feature, but by a whole set of features, automatically determining the optimal number of clusters.

To implement the clustering module, it is necessary that the variables should have the same variability (range). For this purpose we will use the standardization procedure in Data Mining.

After standardization we get a slightly modified table and it is for these data that we will use the K-means clustering algorithm available in the module. This algorithm divides a subset of the vector space elements into a known number of clusters k. The algorithm's effect is that it seeks to minimize the root mean square deviation at the points of each cluster. The main idea is that at each iteration recalculated is the mass center for each cluster obtained in the previous step; then the vectors are divided into clusters again based on the fact which of the new centers is closer according to the chosen metric. The algorithm ends when there is no change in centers of clusters at a certain iteration.

The results of clustering are presented in Table 3.

Table 3: Summary for k-means clustering (standardized)

	Summary for k-means clustering (Standardize Number of clusters: 3 Total number of training cases: 25
Algorithm	k-Means
Distance method	Euclidean distances
Initial centers	Maximize initial distance
MD casewise deletion	Yes
Cross-validation	10 folds

Averages in each cluster, obtained as a result of the analysis, are brought by the program to the table. Its fragment is shown in the form of Table 4.

The rows of Table 4 contain cluster numbers. Number of columns in the table obtained in STATISTICA is 27 columns (according to number of variables involved in the analysis) The fragment presented in Table 4 contains only 7 main variables of the analysis. The last two columns of the table indicate number of observations and their percentage in each cluster.

Table 4: Centroids for k-means clustering (standardized). Number of clusters: 3

Total number of observations: 25

Clusters	Number of revised sentences (average)	Number of unchanged sentences (average)	Number of changed sentences (average)	Number of canceled sentences (average)	Number of canceled sentences with a new trial appointed (average)	Number of canceled sentences with criminal proceedings closed (average)	Number of canceled Sentences with a new sentence adopted (average)
1	0.90257	1.09402	0.78722	0.54047	0.43278	1.22715	0.46223
2	-0.48927	-0.48135	-0.45708	-0.40670	-0.36379	-0.53969	-0.37952
3	3.39149	2.10016	3.50409	4.08315	3.95152	2.35150	4.05801

Continuation of Table 4

Clusters	Number of observations	Percentage (%)
1	6	24.000
2	18	72.000
3	1	4.000

The following clusters were obtained:

Cluster 1: Appeal courts in regions of Ukraine with annual average number of revised sentences – 895, with average number of sentences left unchanged – 444, average number of changed sentences – 206, average number of canceled sentences – 245. In total, 6 regions, the share in the total volume of observations is 24%.

Cluster 2: Appeal courts in regions of Ukraine with annual average number of revised sentences – 371, with average number of sentences left unchanged – 179, average number of changed sentences – 76, average number of canceled sentences – 116. In total, 18 regions, the share in the total volume of observations is 72%.

Cluster 3: Appeal court in the region of Ukraine with annual average number of revised sentences – 1832, with average number of sentences left unchanged – 613, average number of changed sentences – 489, average number of canceled benefits – 730. In total, 1 region, the

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share in the total volume of observations is 4%. Regions divided into clusters are shown in Table 5.

Table 5: Regions of Ukraine, grouped by clusters

Cluster 1	Cluster 2	Cluster 3
Vinnytsia, Donetsk, Zaporizhzhya, Lviv, Kharkiv regions, Kyiv (city)	Volyn, Zhytomyr, Zakarpattia, Ivano-Frankivsk, Kyiv, Kirovograd, Lugansk, Nikolaev, Odessa, Poltava, Rivne, Sumy, Ternopil, Kherson, Khmelnytsky, Cherkasy, Chernivtsi, Chernihiv regions	Dnipropetrovsk region,

The distances between clusters (Cluster distances) are shown in Table 6.

Table 6: Standardized distance between centroids of k-means clustering (standardized)

	Standardized distance between centroids of k-means clustering (Standardize) Number of clusters: 3		
	Cluster 1	Cluster 2	Cluster 3
Cluster 1	0,000000	1,561369	2,926194
Cluster 2	1,561369	0,000000	3,917100
Cluster 3	2,926194	3,917100	0,000000

In cluster 1, number of changed sentences is average and number of canceled sentences is also average, but number of sentences left unchanged is rather large.

In cluster 2, number of changed sentences is the smallest as well as number of canceled sentences, but at the same time number of sentences left unchanged is also the smallest.

Cluster 3 includes an appeal court of only one region of Ukraine (Dnipropetrovsk region). It is characterized by a large number of changed sentences, a large number of canceled sentences and a large number of sentences left unchanged.

In order to identify atypical observations (i.e. appeal courts in regions where results of the work performed differ significantly from the average results in the corresponding cluster) it is necessary to compare the average value of each variable in each cluster (data from Table 4) with the value of each variable separately for each region (data from Table 1).

In our research there is no possibility for such comparison in cluster 3, because it includes only one region of Ukraine. Therefore, further comparisons will apply only to

clusters 1 and 2. We will also limit ourselves to comparing the indexes of the following variables: Var2, Var3, Var7 (variables being the most informative in this research).

As a result of the comparison performed, anomalous observations (that is, those that do not fit into the general trend of the respective cluster) were revealed in three regions of Ukraine. Operation indexes of the appeal courts in these regions have significant deviations of at least one significant index in the direction of increase and at least one significant index in the direction of decrease, compared to the average index for the cluster (Leheza ect., 2020).

It is about appeal courts *of Vinnytsia, Zaporizhzhya and Poltava* regions. All the three mentioned regions have a rich and diverse investment and resource potential and broad-based economy, ranging from agriculture to food processing, mining, construction, machine-building and tourism. They are located at the crossroads of transport routes; they are important transit points for passenger and cargo transportation, as well as for supply of electricity, oil and gas. Another feature of these regions consists in availability of networks of higher and professional-technical educational institutions; and this fact gives an opportunity to have a well-trained competitive labor force. The unemployment rate in general does not differ significantly. Zaporizhzhya region is a developed industrial region and it significantly dominates in terms of number of active enterprises and the level of wages, but is inferior to Poltava region in terms of the gross regional product (Fediuk, 2016).

At the next stage, crime and justice indexes of 2019 in the regions were analyzed separately from social and economic indexes. It was the following information: Number of crimes detected; number of persons found to commit crimes; number of persons found to have committed crimes previously; number of persons convicted of crimes; number of convicted persons whose court decisions have come into legal force (Verner, 2020).

All the above-mentioned predictors have been converted into relative indexes. Thus, the index "number of crimes detected" as a percentage of the permanent population of the region (crime rate per 100 persons of the permanent population of the region) allows to separate Vinnytsia region – 0.77; Zaporizhzhia region – 1.35; Poltava region – 1.39. That is, only Zaporizhzhia and Poltava regions differ significantly by the noted index, which is higher than the average value for Ukraine – 1.07. Vinnytsia region, on the contrary, has a low crime rate.

Based on number of identified persons who committed crimes we have the following coefficients: Vinnytsia region – 0.23; Zaporizhzhya region – 0.36; Poltava region – 0.33; at the average Ukrainian value – 0.27. This trend is quite logically in line with the previous one.

The index "number of persons found to have committed crimes previously" was converted into a relative index by calculating number of such persons per 100 convicted in 2019 by region. The following data was obtained: Vinnytsia region – 29.9; Zaporizhzhya region – 42.4; Poltava region – 45.9. The average index in Ukraine is 30.83.

The index "number of convicted persons whose court decisions have come into legal force" was converted into a relative one by means of similar actions: number of such persons per 100 convicted persons in the region in 2019 was calculated. The obtained information comes down to the following: Vinnytsia region – 78.4 (and this time it is a noticeably higher index than in any other region of Ukraine); Zaporizhzhya region – 60.6; Poltava region – 75.3. The average index of this kind in Ukraine is 64.0. That is, at this stage of the research exactly Vinnitsa and Poltava regions have the highest analysis indexes (Leheza ect., 2020).

Based on the systematic analysis of the results of our research, we can state that appeal courts of three regions of Ukraine (namely: Vinnytsia, Zaporizhzhya and Poltava regions) have real differences in results of their work during the consideration of criminal proceedings.

Conclusions

Thus, we conducted an analysis of raw data on activities of appeal courts in 25 regions of Ukraine. With the help of special clustering algorithms, 3 atypical observations were revealed; they are presented in statistical reports on the revision of court decisions by appeal courts of Vinnytsia, Zaporizhzhia, and Poltava regions. Data obtained during the research indicates the existing need for further reform of general jurisdiction courts in Ukraine as well as the need to pay special attention to activities of judicial institutions located in the named regions of Ukraine. It is definitely necessary to conduct an additional research of causes of atypical statistical data, which, in turn, may lead to a possible revision of personnel policy in the judicial branch of government in the above regions. The revealed discrepancies should be brought to the attention of the Supreme Court; according to the law this court must: to carry out analysis of judicial statistics and generalization of judicial practice, ensure equal application of law by courts of various specializations in the order and manner determined

by procedural law (Art. 38 of the Law of Ukraine "On judicial System and Status of Judges"

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