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Classification of Criminal Events based on Biplot Analysis

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ABSTRACT

Criminality is a crime that violates criminal law or laws and norms that apply in society. The high crime rate in Indonesia needs to be anticipated immediately by making policies that are in accordance with the location conditions. The purpose of this study is analyze data on the number of crimes in various provinces in Indonesia to identify the main patterns of crime in each region. The method used in this research is biplot analysis. This study uses 2022 Criminal Statistics data covering 34 regional police forces and 9 crime classifications. The results of the analysis showed a singular value decomposition value of 73.714%, with the object of the regional police centered in one quadrant. The highest correlation was found between drug-related crimes and crimes of embezzlement, fraud, and corruption, while the lowest correlation was between drug-related crimes and crimes against public order. There were 4 clusters of relationships between observations and variables, with the highest variable diversity in crimes against human freedom and the lowest in crimes against decency. The findings have important implications for crime mapping, crime policy, and more efficient allocation of police resources. This analysis is expected to help design more effective crime prevention and response strategies, enhance interprovincial collaboration, and strengthen the use of technology and data analytics to monitor and predict crime trends, thereby improving security and public order in Indonesia.

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A. INTRODUCTION

The rapid development of science and technology has affected many aspects of human life in various sectors, such as economic, social, political, educational, cultural, ethical, and moral. This has resulted in changes in the pattern of interaction between people (Kurra and Ege, 2023). Positive changes can be beneficial for society, but negative changes are also starting to be seen which cause unrest in the community, such as committing criminal acts.

Criminality is a crime that violates criminal law or laws and norms that apply in society (Susanti and Rahardjo, 2018). Crime is a social phenomenon that can directly or indirectly affect the way we live our daily lives Crime is a global problem that negatively impacts the functioning and stability of society. Therefore, crime prevention has always been the main focus of public policy in all countries due to its social implications and impacts (Rahman and Prasetyo, 2018). Factors that influence crime are motivated by various things. Among them, poverty and education have a significant influence on the number of crimes (Wicaksono et al., 2023). In addition, government policies in law enforcement and crime prevention also have a major influence on crime rates. The ineffectiveness of these policies can result in an increase in the number of crimes (Ramdayani et al., 2019).

According to data from Numbeo, 2021 Venezuela has the highest crime rate in the world with a crime index of 84.2 cases. Papua New Guinea is ranked second with a crime index of 80.2 cases, while Indonesia is ranked 62nd with a crime index of 46.2 cases. Information compiled from Polri registration data shows that in general there is a downward trend in the number of criminal

offenses or crime events in Indonesia between 2019-2021. There were 269,324 criminal events (total crimes) in 2019. However, in 2020 it decreased to 247,218 events and in 2021 to 239,481 events (Direktorat Statistik Ketahanan Sosial, 2022). Data from the Central Bureau of Statistics shows that the proportion of the population who experienced criminal acts between 2019 and 2021 also experienced a downward trend similar to the police registration data (Badan Pusat Statistik, 2021). However, the police report rate each year is still very low. A firm and fair attitude from law enforcement officials in carrying out their duties can have a positive impact both psychologically and socially in efforts to prevent criminal acts (Arifin and Nashori, 2016). Crimes in Indonesia are regulated in Law No. 27 of 1999 concerning amendments to the criminal code relating to crimes against state security. Common cases of crime in Indonesia include theft, fraud, persecution, narcotics, and decency.

The level of security in anticipation of suppressing crime needs to be considered. The security applied in suppressing crime that occurs depends on the crimes that often occur in the area. Therefore, an analysis is needed to find out the majority of crimes in an area. In analyzing crime can be done with various methods, such as using the help of data visualization (Madyatmadja et al., 2022), using the k-means method (Yuliansyah, 2016), using the kernel density method (Nanda et al., 2019), using model-based clustering (Chrisinta et al., 2022), or by mapping directly geographically in knowing the crime distribution points (Syahputra et al., 2019). However, the analysis method using biplot has never been done in the crime classification process. Biplot analysis is a double-dimensional descriptive statistical technique by presenting visually and simultaneously on a number of objects and observation variables in a graph (Leleury and Wokanubun, 2015). Biplot analysis is able to display detailed variables or the most dominant variables of a group of objects formed on the display of biplot analysis results directly (Kuswardono, 2024). The difference between this research and previous research lies in the analysis method used as well as the resulting interpretation. By using the biplot analysis method, four important things will be obtained, namely the closeness between the objects analyzed, the diversity of variables, the correlation between variables, and the value of variables in an object (Ihyakulumudin and Dewi, 2022).

Research conducted by Chrisinta et al. (2022) states that there are several provinces that are summarized into two clusters in knowing the characteristics of the area related to crime. Obtaining the optimal cluster group using the model-based clustering analysis method. The clusters obtained are each characterized based on the level of criminality. Cluster 1 consisting of 16 provinces is categorized into lower crime, and cluster 2 consisting of 18 provinces is categorized into higher crime. However, from the resulting cluster output, it is not yet known how the diversity of variables or the relationship between variables. Therefore, the novelty obtained in this study is that it can determine the diversity of variables and the relationship between variables on crime indicators in Indonesia. In this study, the classification of crime in Indonesia was carried out using the biplot analysis method. This research aims to classify areas where crime occurs and interpret indicators of criminality that may occur in the area. The contribution of this research is that it can be a reference for the government and authorities in implementing policies to reduce the crime rate in the area so that a safe environment can be created.

B. RESEARCH METHOD

The data source in this research is a secondary data source. The Central Bureau of Statistics catalog with the title Criminal Statistics 2022 is the data source used in this research (Badan Pusat Statistik, 2022). The research was conducted by analyzing the level of security in 34 provinces in Indonesia as of January 2022 and the crime indicators that occurred (9 indicators). The research variables are the crime indicators that occurred are presented in Table 1.

Table 1. Research Variables

Variable	Classification of Crimes
a	Number of Crimes against Life
b	Number of Physical Crimes
c	Number of Crimes against Decency
d	Number of Crimes against the Freedom of the Person
e	Number of Violent Property Crimes
f	Number of Property Crimes
g	Number of drug-related crimes
h	Number of Crimes against Fraud, Embezzlement and Corruption
i	Number of Crimes against Public Order

Techniques in this study using biplot analysis. In doing biplot analysis using the help of phyton software. The methods and actions in conducting this research are as follows:

1. Descriptive analysis of research variables.
2. Determining the correlation coefficient between variables and decomposing the Singular Value Decomposition (SVD) value.
   (a) Organize the observation data in the form of X matrix.
   (b) Form the Y matrix which is the data matrix that is corrected to the center value.
   (c) Calculating the $Y'Y$ matrix.
   (d) Calculating the eigenvalues of $Y'Y$ and selecting the the two largest eigenvalues.
   (e) Determining the eigenvectors for the two eigenvalues eigenvalues and form matrix A.
   (f) Calculating the U matrix.
3. Create a biplot analysis graph with the help of phyton software.
   (a) Construct a row matrix G and a column matrix H.
   (b) Create a biplot image based on the row vector g_i and column vector h_j, where the x-axis is the first principal component and y is the second principal component.
4. Image interpretation of the biplot graph.

C. RESULT AND DISCUSSION

1. Descriptive Statistics

Descriptive statistical analysis of the crime indicators that occurred is presented in Table 2 as follows:

Table 2. Descrptive Statistics

Variables	Minimum		Maximum		Mean	Total
	Figures	Regional Police	Figures	Regional Police		
a	0	North Maluku	96	North Sumatera	27.26	927
b	24	Kalimantan Utara	4287	North Sumatera	826.21	28091
c	20	North Kalimantan	904	North Sumatera	173.68	5905
d	0	Central Sulawesi & Riau Islands	375	South Sumatera	48.68	1655
e	1	Gorontalo	564	South Sumatera	142.29	4838
f	92	North Maluku	12433	North Sumatera	2039.62	69347
g	2	NTT	5949	North Sumatera	1086.88	36954
h	40	North Maluku	5439	Metro Jaya (DKI Jakarta)	1032.15	35093
i	0	Riau, Lampung, Kep. Bangka Belitung, Banten, NTB, Central Kalimantan, South Kalimantan, North Kalimantan, & West Sulawesi	616	NTT	74.47	2532

Based on Table 2, it can be seen that the level of security in 34 provinces in Indonesia based on the variable Crimes against Life has an average value of 27.26 with a total value of 927, a minimum value of 0 occurred in North Maluku Regional Police, and a maximum value of 96 occurred in North Sumatra Regional Police; Crimes against Physical has an average value of 826.21 with a total value of 28091, a minimum value of 24 occurred in North Kalimantan Regional Police, and a maximum value of 4287 occurred in North Sumatra Regional Police; Crimes against Decency has an average value of 173.68 with a total score of 5905, a minimum score of 20 was recorded at North Kalimantan Regional Police, and a maximum score of 904 was recorded at Religion Police North Sumatera; Crimes against Freedom of the Person had an average score of 48.68 with a total score of 1655, a minimum score of 0 was recorded at Central Sulawesi & Riau Islands Regional Police, and a maximum score of 375 was recorded at South Sumatera Regional Police; Violent Crimes against Property Rights had an average score of 142.29 with a total value of 4838, a minimum value of 1 occurred at Gorontalo Regional Police, and a maximum value of 564 occurred at South Sumatera Regional Police; Crimes against Property Rights had an average value of 2039.62 with a total value of 69347, a minimum value of 92 occurred at North Maluku Regional Police, and a maximum value of 12433 occurred at North Sumatera Regional Police; Narcotics-related Crimes had an average value of 1086.88 with a total value of 36954, a minimum value of 2 occurred in NTT Regional Police, and a maximum value of 5949 occurred in North Sumatera Regional Police; Fraud, Embezzlement and Corruption related crimes have an average value of 1032.15 with a total value of 35093, a minimum value of 40 occurred at North Maluku Regional Police, and a maximum value of 5439 occurred at Metro Jaya Regional Police (DKI Jakarta); and Crimes against Public Order has an average value of 74.47 with a total value of 2532, a minimum value of 0 occurred at Riau, Lampung, Kep. Bangka Belitung, Banten, NTB, Central Kalimantan, South Kalimantan, North Kalimantan, & West Sulawesi

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Regional Police, and a maximum value of 616 occurred at NTT Regional Police.

2. Biplot Analysis

2.1. Singular Value Decomposition (SVD)

The first step in performing a biplot analysis is to decompose the singular value decomposition (SVD). To evaluate the degrees of freedom, which is the number of modes that overlap at a single frequency, one can do with the singular value decomposition (SVD) of the response matrix. This method is a generalization of the multivariate indicator function (Palerm et al., 2024). The output obtained in the calculation process is shown in Table 3.

Table 3. Singular Value Decompotition Values

Dimension	Inertia	Proportion of Inertia	
		Accounted for	Cummulative
1	5.473	0.60807	0.60807
2	1.162	0.12907	0.73714
3	0.966	0.10732	0.84446
4	0.663	0.7368	0.91814
Total	1	1	1

Based on Table 3. above, the results show that in dimension 1 the inertia value is 5.473 and in dimension 2 the inertia value is 1.162. It can be seen that between dimensions 1 and 2 that have a higher inertia value is dimension 1. The cumulative value of the first two eigenvalues has a percentage proportion of 0.73714. This means that the two row and column vectors have the ability to explain 73.714% of the total inertia. Therefore, the diversity of data that can be explained is 73.714%.

2.2. Biplot Graph

The next step is to display the biplot graph with python software. The results of the biplot graph to classify Regional Police Areas in Indonesia based on crime indicators are shown in Figure 1.

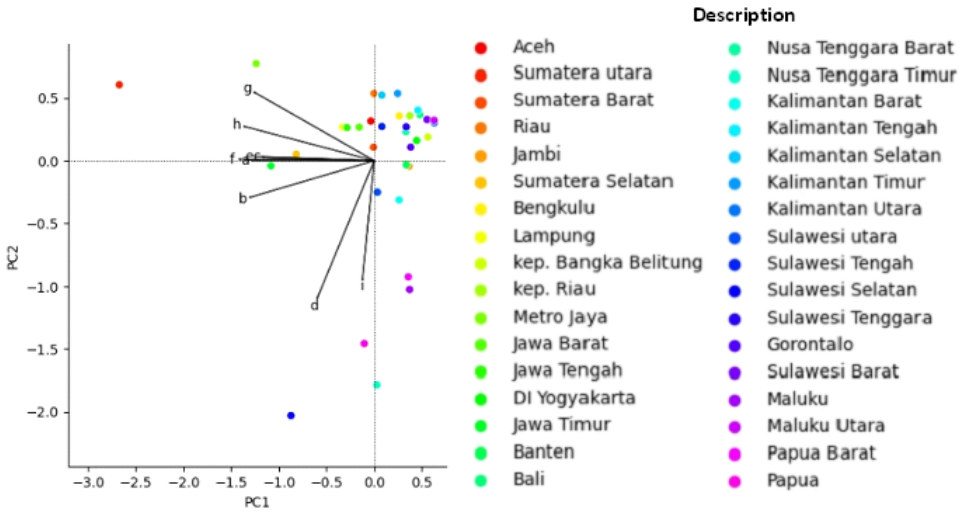

Figure 1. Biplot Graph

3. Relationship between Observations

The relationship between observations or objects can be seen through the proximity between objects. Two objects or observations can be said to be more similar if the location of the two objects is getting closer. From Figure 1, it is known that the observations or objects of the regional police of each province spread across all quadrants, but there is a center of distribution in one quadrant only. The similarity of the object points in the form of neighboring provincial-level regional police is as follows:

1. Central Kalimantan, South Kalimantan, North Kalimantan, East Kalimantan, West Sulawesi, Riau Islands, Bali, Southeast Sulawesi, Gorontalo, Yogyakarta, Southeast Sulawesi, Riau, Central Sulawesi, Lampung, West Java, West Nusa Tenggara, West Sumatra, Jambi, and Banten.
2. Metro Jaya, East Java, South Sumatra, and North Sumatra.
3. South Sulawesi, East Nusa Tenggara, Papua, Maluku and West Papua.

4. Relationship between Variables

The high correlation value between variable vectors indicates the relationship between variables. The magnitude of the correlation value between variable vectors can be determined from the cosine of the angle between the two vectors. The correlation value is close to 1 if the vectors are close to each other or the angle between them is close to 0. The largest correlation between variables is between the vectors of crimes against drugs and crimes related to embezzlement, fraud and corruption, with a correlation value of 0.886. Meanwhile, the lowest correlation value is between the vector of drug-related crime variables and crimes against public order, which has a correlation value of -0.015. The results of the calculation of correlation values between other variable vectors are presented in Table 4.

Table 4. Correlation Values Between Vector Variables

	a	b	c	d	e	f	g	h	i
a	1	0.7	0.584	0.28	0.694	0.728	0.78	0.779	0.183
b	0.7	1	0.786	0.519	0.597	0.862	0.582	0.738	0.053
c	0.584	0.786	1	0.222	0.485	0.82	0.53	0.656	0.018
d	0.28	0.519	0.222	1	0.377	0.39	0.044	0.204	0.135
e	0.694	0.597	0.485	0.377	1	0.786	0.769	0.751	0.06
f	0.728	0.862	0.82	0.39	0.786	1	0.784	0.847	0.009
g	0.78	0.582	0.53	0.044	0.769	0.784	1	0.886	-0.015
h	0.779	0.738	0.656	0.204	0.751	0.847	0.886	1	0,056
i	0.183	0.053	0.018	0.135	0.06	0.009	-0.015	0.056	1

In the Table 4 there are positive and negative correlation values. A negative correlation value indicates that two variables tend to move in opposite directions. A positive change in one variable will be accompanied by a negative change in the other. Meanwhile, a positive correlation value indicates that the variables are moving in the same direction. Positive changes in one variable will tend to accompany positive changes in the other variable.

5. Diversity of Variables

The biplot graph in Figure 1 shows that the longest vector of variables is Crimes against Human Liberty. This means that Crimes against Human Freedom is a variable vector of crime types with a high value of diversity. Meanwhile, the Crimes against Decency variable vector is the shortest of the other 9 variable vectors. In this case, it means that the Crime against Decency variable has the lowest diversity value.

6. Relationship between Observations and Variables

From the visual output in Figure 1, the relationship between provinces and crime indicators can be classified into 4, namely

1. The first group consists of two observation points, namely South Sumatra and East Java, located around the vector variable of crimes against life, decency, property or goods with the use of violence, and property or goods without the use of violence. This shows that the provinces in Indonesia where crimes against life, decency, property or goods with the use of violence, and property or goods without the use of violence occur are South Sumatra and East Java.
2. The second group consists of eight observation points covering North Sumatra, Lampung, Central Java, West Java, Aceh, Metro Jaya, West Sumatra, and Riau around the vector of drug-related crimes and crimes related to fraud, embezzlement, and corruption. This indicates that the provinces in Indonesia where drug-related crimes, as well as crimes including fraud, embezzlement, and corruption occur are North Sumatra, West Java, Lampung, Central Java, Aceh, DKI Jakarta, West Sumatra, and Riau.
3. In the third group, the observation points of South Sulawesi, East Nusa Tenggara, Papua, Maluku, West Papua, North Sulawesi,

West Kalimantan, Banten, and Jambi are located around the vector variables of crimes against physical or body, freedom of person, and public order. This indicates that crimes against physical or body, freedom of the person, and public order occur mostly in the provinces of South Sulawesi, East Nusa Tenggara, Papua, Maluku, West Papua, North Sulawesi, West Kalimantan, Banten, and Jambi.

4. The group whose observation points are not spread over a vector of variables is called the fourth group. West Sulawesi, Bengkulu, Bangka Belitung Islands, Riau Islands, Yogyakarta, Bali, West Nusa Tenggara, Central Kalimantan, South Kalimantan, East Kalimantan, North Kalimantan, Central Sulawesi, Southeast Sulawesi, Gorontalo, and North Maluku are the fifteen observation locations that belong to this group. This indicates that there is no trend in crime indicators in these 15 provinces.

Table 5 shows the clustering of provinces in Indonesia on crime indicators based on the findings of the biplot analysis.

Table 5. Grouping of Provinces in Indonesia based on Criminality Indicators

Group	Criminality Indicators (Variables)	Province in Indonesia (Observation Point)	Number of provinces in Indonesia
1	Crimes against life, decency, property or goods with the use of force, and property or goods without the use of force.	South Sumatra and East Java	2
2	Drug-related crimes as well as crimes related to fraud, embezzlement, and corruption.	North Sumatra, Lampung, Central Java, West Java, Aceh, DKI Jakarta, West Sumatra, and Riau	8
3	Crimes against the body, liberty and public order.	South Sulawesi, East Nusa Tenggara, Papua, Maluku, West Papua, North Sulawesi, West Kalimantan, Banten, and Jambi	9
4	-	West Sulawesi, Bengkulu, Kep. Bangka Belitung, Kep. Riau, DI Yogyakarta, Bali, West Nusa Tenggara, Central Kalimantan, South Kalimantan, East Kalimantan, North Kalimantan, Central Sulawesi, Southeast Sulawesi, Gorontalo, and North Maluku.	15

The novelty of the biplot analysis that has been conducted lies in its ability to display the diversity of variables as well as the proximity between objects in one intuitive visualization. In the context of this analysis, the biplot can clearly see that ”Crimes against the Freedom of the Person” is the variable with the highest diversity, while ”Crimes against Decency” has the lowest diversity. Through the vector length of each variable, it can be seen how much each variable contributes to the total variation of the data.

In addition, this biplot analysis also shows the closeness between objects, in this case provinces in Indonesia, based on the types of crimes that occur. For example, provinces such as South Sulawesi, East Nusa Tenggara, and Papua are grouped together because they are highly similar in terms of the incidence of crimes against the body, liberty, and public order.

The difference from the results of the analysis carried out, in the research conducted by Chrisinta et al. (2022) obtained as many as 2 groups (clusters), while in this study obtained as many as 4 groups. Of the groups obtained, each has different characteristics. In addition, there are two other discussions in this study that are not found in the study, namely on the diversity of variables and the relationship between variables.

Thus, biplots not only facilitate an in-depth understanding of how variables interact, but also provide an effective way to identify and classify objects based on their similarity patterns. This is a significant novelty compared to other analysis methods that may only offer partial or numerical insights without comprehensive visualization.

D. CONCLUSION AND SUGGESTION

The relationship between observations formed three groups that have similar characteristics, the majority of provincial police distribution points are centered in one quadrant, but there are several regional police points that are scattered not in groups. The relationship between the observations of the provincial police force and the vector of crime classification variables resulted in four groups. The first group shows that the provinces in Indonesia with the most crimes against life, decency, property or goods with the use of force, and property or goods without the use of force are South Sumatra and East Java. The second group shows that the provinces in Indonesia where crimes related to narcotics and fraud, embezzlement and corruption are prevalent are North Sumatra, West Java, Lampung, Central Java, Aceh, DKI Jakarta, West Sumatra and Riau. The third group shows that crimes against physical or body, freedom of person, and public order are prevalent in the provinces of South Sulawesi, East Nusa Tenggara, Maluku,

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Papua, West Papua, North Sulawesi, West Kalimantan, Banten, and Jambi. The fourth group describes the group whose observation points are not scattered around any variable vectors. The novelty of this study lies in the simultaneous visualization of variable diversity and object proximity, offering a comprehensive method to identify and classify regions based on crime patterns. To enhance practical implementation, several tangible policies are recommended. In areas with high incidences of violent and property crimes, technology-based police patrol programs such as the use of drones and surveillance cameras at crime hotspots can be implemented to enhance monitoring and crime prevention. For regions with a prevalence of drug-related crimes, governments can implement free detoxification and rehabilitation programs and enhance cooperation with the National Narcotics Agency for drug dealer apprehension operations. Additionally, implementing public education campaigns in schools and communities about the dangers of drugs and ways to protect oneself from fraud can help reduce crime rates. In areas with incidences of physical assault and crimes against personal freedom, governments can establish more crisis centers for violence victims and enhance law enforcement training to handle such cases effectively. Furthermore, inter-provincial collaboration to share crime data and best practices in crime prevention can enhance regional policy effectiveness. Investment in technologies such as integrated criminal data management systems using predictive analytics can also aid law enforcement in identifying crime trends and responding swiftly. These concrete steps can translate the insights from the study into actionable measures, significantly improving public safety and security.

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