FACTOR ANALYSIS ON WEATHER ELEMENTS THAT AFFECT MARINE TRANSPORTATION ACTIVITIES AT TANJUNG PERAK PORT WITH THE PRINCIPAL COMPONENT ANALYSIS METHOD

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ABSTRACT

This research's aim is to analyze weather elements that affect marine transportation activities at Tanjung Perak Port. The data used in this study is secondary data obtained from Meteorology, Climatology and Geophysics Agency of the Republic of Indonesia. The data used is weather element record from the meteorological station in Perak II Surabaya for the 2017-2021 period which includes variables of sunlight exposure, precipitation, humidity, wind direction, air pressure, wind speed, and air temperature. The method used is the Principal Component Analysis method. Based on the test, it is found that all weather variables can be analyzed using the Principal Component Analysis Method. The weather element variables formed 2 components which have Initial Eigenvalues > 1. The first component consists of Air humidity, Precipitation, Sunlight exposure, and Air Pressure. The second component consists of Air Temperature, Wind Direction, and Wind Speed. Based on the two components formed, the first component is the most dominant component element that affects marine transportation activities at Tanjung Perak Port for the 2017-2021 period with Initial Eigenvalues of 3,681. And air pressure is the most dominant weather element with the loading value based on the Principal Component Analysis method is 0,867.

Keywords: Weather Elements; The Principal Component Analysis Method; Marine transportation activities

Introduction

Indonesia is known as the largest archipelagic country in the world with 17,504 islands. Indonesia is located at coordinate's 6° North Latitude - 11°08' South latitude and 95° East longitude – 141°45' West longitude.[1] Indonesia's territory is dominated by the sea so maritime security is a prerequisite for the ongoing national development.[2] Due to these conditions, sea transportation is one of the most important modes of transportation. The government through the ministry of transportation formulates and establishes policies in the implementation of transportation security. Sea transportation security is one of the focuses of the government's attention.[3]

Another institution that plays a role in the safety of sea transportation is the National Transportation Safety Committee which has a role in investigating accidents. Based on the investigation of the National Transportation Safety Committee during 2003-2019, there have been 120 accidents in Indonesia with 36.7% occurring in the Java Sea.[1] One of the ports in the Java Sea that has a high risk of accidents is Tanjung Perak, Surabaya. Tanjung Perak Port is the largest and second busiest port in Indonesia after Tanjung Priok Port. This port became a trading center to the eastern part of Indonesia. According to Pelindo III sources, during 2008-2013, there were 20,582 ships/year that passed the Tanjung Perak Surabaya route.[4] Shipping accidents can be caused by several factors

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including human error, excess capacity, engineering, traffic management and weather factors.[5]

Weather factors, especially bad weather, are much feared in the shipping world because the consequences can cause various accidents at sea such as shipwrecks or stranded which will eventually cause many casualties. When viewed from the factors that cause accidents, due to human error (human error) 41%, nature (force majeure) 38% and due to ship structure (hull structure) 21%.[6] One of the nature factors is the weather. Weather factors can cause dangerous conditions in shipping. This is exacerbated by the lack of attention to provisions related to readiness in dealing with dangerous conditions. In some accident cases, extreme weather factors also contribute to accidents.[1] Weather is influenced by several elements including sunlight exposure, precipitation, humidity, wind direction, air pressure, wind speed, and air temperature.[7] In other studies, air pressure can cause damage to several parts of the ship such as windlass plates and other ship parts. This damage can be dangerous in shipping if the management team does not have good strategic planning and preparation.[5] Considering the importance of weather information for shipping activities, every week the Ministry of Transportation, specifically the Directorate General of Sea Transportation, issues a Shipping Declaration based on the results of monitoring by the Meteorology and Geophysics Agency. In addition, the agency also provides instructions to postpone granting a sailing permit if the weather conditions are dangerous, until the weather conditions are completely safe. These efforts are made to anticipate the occurrence of disasters at sea caused by weather factors.[8]

Based on the description above, this research focuses on conducting factor analysis of weather elements that affect Tanjung Perak Surabaya during 2017-2020 using the Principal Component Analysis method. Thus, it can be known what components are dominant in affecting the weather at Tanjung Perak Surabaya during 2017-2021. Factor analysis was conducted to identify the relationship between variables, in this case the weather elements. Elements that affect the weather can be reduced by determining new factors (known as Component) that have a high relationship using the Principal Component Analysis (PCA) method.

One of the fundamental primitive methods for data analysis is the Principal component analysis (PCA) method. In addition, this method can also be used for array processing analysis, and machine learning methods.[9]

The multivariate approach that transforms correlated variables into linearly uncorrelated variable is the Principal Component Analysis method. This linearly uncorrelated variable is called the principal component.[10] Principal Component Analysis (PCA) basically aims to simplify the observed variables by shrinking (reducing) their dimensions.[11] Principal Component Analysis (PCA) is done by eliminating the correlation between independent variables through the transformation of the original independent variable to a new variable that is not correlated at all or commonly referred to as the principal component. After several components of the Principal Component Analysis (PCA) that are free of multi collinear are obtained, then these components become new independent variables that will be regressed or analyzed for their effects. Principal Component Analysis (PCA) method will get new independent variables that are not correlated, independent of each other, fewer in number than the original variable, but can absorb most of the information contained in the original variable or which can contribute to the variance of all variables.[12] This method has been widely used in various fields involving many variables to produce a new pattern with a simpler form. For example, in determining the factors that affect the quality of cow gravel skin,[13] determining the factors that affect stock prices,[11] Component Analysis on Indonesian Small and Medium Enterprise,[14] Determinants of Financial Distress.[12]

Methods

The research was conducted by applying factor analysis to the variable element of weather that can affect sea transportation activities at Tanjung Perak Port.

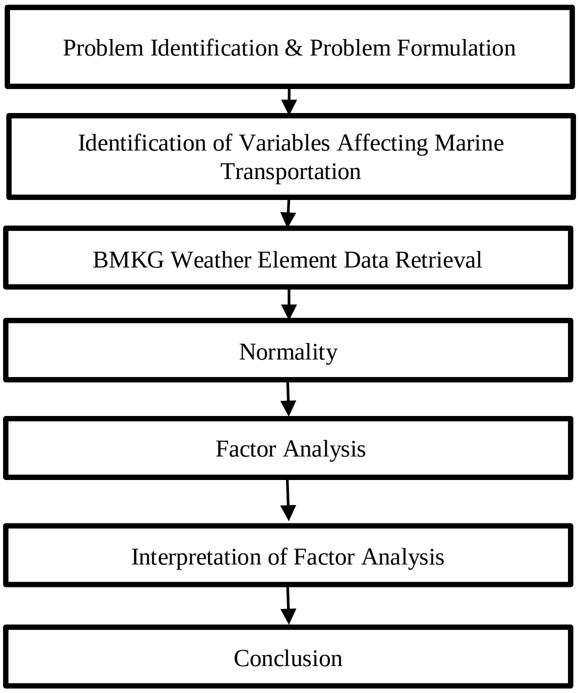

Figure 1. Research steps

The method used in this research is the principal component analysis method. The research was designed with several stages of activities as shown in Figure 1. Based on Figure 1, the research begins by identifying the problem and formulating the problem. The next stage is to determine the weather element variables that affect transportation activities at the port of Tanjung Perak. In this study there are 7 variables of weather elements which include air temperature, humidity, precipitation, wind direction, wind speed, air pressure and sunlight exposure. The seven data are secondary data obtained from the BMKG Perak II Station during the 2017-2021 period [15]. Based on the data obtained, then the normality test and factor analysis test were carried out using the principal component analysis method. This method reduces the 7 variables that affect the weather into a smaller number of variables and becomes simpler. For example, from 7 variables it turns into 3 variables where the 3 variables can represent 7 main variables that are the focus of a study. The test will use the SPSS application with factor analysis using the principal component analysis method. To simplify the variable name in the SPSS software test, it is defined:

a. Air Temperature or V1
b. Air humidity or V2
c. Precipitation or V3
d. Wind Direction or V4
e. Wind Speed or V5
f. Sunlight exposure or V6
g. Air Pressure or V7

The Principal Component Analysis (PCA) method is carried out with the following step procedure[14]:

a. Bartlett's Test and the Keiser Meyer Olkin (KMO) Measure Of Sampling Adequacy (MSA)
b. Anti-Image Correlation Matrix Test
c. Model Improvement (If needed by eliminating variables)
d. Principal component analysis
e. PCA Interpretation
f. Conclusion

Result and Discussion

KMO and Bartlett's Test

KMO and Bartlett's Test is the initial test in factor analysis. This test is used to ensure that the weather element variables are suitable for analysis using the PCA method. Unfeasible variables will be eliminated.

Table 1. KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.749
Bartlett's Test of Sphericity	Approx. Chi-Square	134.704
	df	21
	Sig.	0.000

The KMO and Bartlett's Test consists of 2 tests, the Bartlett's Test and the Keiser Meyer Olkin (KMO) Measure of Sampling Adequacy (MSA). Bartlett's Test is used to see the correlation between variables in a sample of weather elements. Meanwhile, Keiser Meyer Olkin Measure of Sampling Adequacy is a feasibility test for weather elements. The feasible variable will be tested in the next test.[16]

The weather element variable passed the test if the Kaiser Meyer Olkin Measure of Sampling value is > 0.50 and the result of Bartlett's Test Of Sphericity (sig.) < 0.05. The results of the KMO and Bartlett's Test are shown in table 1. Based on the test results, it was found that all weather elements passed the KMO and Bartlett's Test because the Kaiser Meyer Olkin Measure Of Sampling value was 0.749 > 0.50 and the results of Bartlett's Test of Sphericity (sig.) 000 < 0.05.

Measure of sampling adequacy (MSA)

The correlation between variables in the PCA method can be explained by the Anti-Image Correlation test. In this study, the Anti-Image Correlation test can describe the relationship between the weather element variables. This test also explains the level of strong or not the relationship between these variables. If the relationship between the variables is strong enough, the variables will be reduced or removed in the factoring process. The conclusion of the test is determined by the value of Measure of sampling adequacy (MSA). If the value of Measure of sampling adequacy (MSA) > 0.5 then the variable can be predicted and can be analyzed further.[12] The results of the Anti-Image Correlation test can be seen in table 2.

Table 2. Anti-Image Correlation

Variable	MSA	interpretation
V1	0,531	Acceptable
V2	0,809	Acceptable
V3	0,789	Acceptable
V4	0,888	Acceptable
V5	0,641	Acceptable
V6	0,754	Acceptable
V7	0,684	Acceptable

Based on table 2, all of the weather element variables have MSA values greater than 0.5. So it is concluded that all variables are acceptable for inclusion in the core analysis on PCA method. This suggests that these variables are accepted and included in the final analysis on PCA method.

Communalities

The next test on the selected weather element variable is the Communalities test. The Communalities test aims to represent the amount of variance (can be in percentage) of a weather element variable that can be explained by the existing principal component. The test results in table 3 show that there are two types of values, namely the Initial value and the extraction value.

Initial value is used to determine the variance of a principal component with each variable having initial value (1) which indicates the amount of the variance of the principal component. Or in other words, each weather element variable is classified into a principal component that will be formed by the PCA method. Therefore, the Initial Value is 1. While the extraction value is describing the number of variances (%) of the weather element variables that can be explained by the principal component. Based on table 3, it is known that the extraction value of temperature variable is 0.774, it can be concluded that about 77.4% of the variance of the air temperature variable can be explained by the component formed.

Table 3. Communalities

Variable	Initial	Extraction
V1	1,000	0,774
V2	1,000	0,820
V3	1,000	0,740
V4	1,000	0,585
V5	1,000	0,270
V6	1,000	0,867
V7	1,000	0,753

The variance of the humidity variable can be explained by the formed component is 82%. For the Precipitation variable, the variance that can be explained by the formed component is 74%. And for the other elements is 58,5% (Wind Direction), 27% (Wind Speed), 86,7% (Sunlight exposure), 75,3% (Air Pressure).

Total Variance Explained

In the PCA method, the principal component obtained are more than one. The number of principal components is known in the Total Variances Explained test. The number of principal components can be seen from the Eigen values of the seven variables analyzed. The component used in this approach is a component with an Eigen value > 1. If the Eigen value < 1 then the component cannot be included in the model. In testing the seven weather elements, the results of the Total Variances Explained test are shown in tables 4.

Table 4. Initial Eigenvalues

Component	Total	% of Variance	Cumulative %
1	3,681	52,585	52,585
2	1,129	16,126	68,710
3	0,905	12,927	81,637
4	0,508	7,253	88,889
5	0,440	6,291	95,180
6	0,196	2,796	97,977
7	0,142	2,023	100,000

From table 5, the analysis of 7 variables of weather elements produces 7 components. However, only first component and factor second component were accepted by the PCA method. The number of variances that can be explained by first component is 52,585%. While second component is 16,126%. Thus, 68,710% is the total variance of the two components.

Component Matrix

Based on previous testing, there are two factors formed. The next step is to determine the relationship between the weather element variables and the two components. The relationship is expressed by the correlation value in the component matrix test table. The table of component matrix test results is shown in table 5.

Tabel 5. Component Matrix

Variabel	Factor	
	1	2
V1	0,446	0,758
V2	-0,904	-0,059
V3	-0,815	0,274
V4	-0,668	-0,372
V5	0,477	0,207
V6	0,916	-0,170
V7	0,698	-0,515

Rotated Component Matrix

The results of the component matrix test are still unable to show the relationship between weather variables and certain components on several variables. As shown by the variable X7 (Air Pressure) which has a correlation/loading value of 0.698 with the first component and -0.515 with the second component. Based on this value, the variable Air Pressure (X7) can't be ascertained to be correlated with the first or second component. Thus, the Component Matrix test results need to be rotated. This test is called the Rotated Component Matrix test. The results of this test are shown in tables 6.

Tabel 6. Rotated Component Matrix

Variabel	Component	
	1	2
V1	-0,064	**0,878**
V2	**-0,710**	-0,563
V3	**-0,827**	-0,238
V4	-0,338	**-0,686**
V5	0,275	**0,441**
V6	**0,850**	0,381
V7	**0,867**	-0,026

The weather element variable has two loading values on the first and second components. To determine the weather element is classified as first or second component, then look at where the greatest loading value is. Based on this, it can be concluded:

a. The first component consists of Air humidity (X2), Precipitation (X3), Sunlight exposure (X6), Air Pressure (X7).
b. The second component consists of Air Temperature (X1), Wind Direction (X4), and Wind Speed (X5).

Discussion

The application of the PCA method to weather elements begins with an initial process which includes the Bartlett's Test, the Keiser Meyer Olkin (KMO) Measure of Sampling Adequacy (MSA) and the Anti-Image Correlation Matrix Test. This initial test aims to filter weather element data that is accepted by the PCA method requirements. When all the weather elements have passed the test, the weather element variables will be tested to find out the components formed using the PCA method. This process is the core process in the PCA method. The core process includes Communalities test, Total Variance Explained test, Component Matrix test, and Rotated Component Matrix test. In the last stage is component conclusion. All tests were carried out using the SPSS software.

The weather element tested consists of 7 variables as described in the method. Based on the results of the initial process, all of the weather element variables passed the Bartlett's Test and the Keiser Meyer Olkin Measure of Sampling Adequacy. In addition, this variable also passed the Anti-Image Correlation Matrix Test, so there is no need for a Model Improvement step in this study. This means that all variables are declared suitable for analysis using the PCA method.

In the application of the PCA method, 7 variables of weather elements are formed into 2 components. This is indicated by the component that has Initial Eigenvalues > 1. The components are first and second components. Each component has a different member variables. These members are determined by the Component Matrix test and the Rotated Component Matrix test. The first component consists of Air humidity, Precipitation, Sunlight exposure and Air Pressure. The second component consists of Air Temperature, Wind Direction and Wind Speed. Each component has 1 most dominant variable. This is determined from the loading value in table 6. In the first component, the most dominant variable is Air Pressure with a loading value of 0.867. While in the second component, the most dominant variable is Air Temperature with a loading value of 0,878.

Conclusion

The conclusion of this research is the most dominant component that affects marine transportation activities at Tanjung Perak port during 2017-2021 is the first component which consists of Air humidity variable, Precipitation variable, Sunlight exposure variable and Air Pressure variable. The first component has the largest Initial Eigenvalues with an Initial Eigenvalues of 3,681 and the number of variances that can be explained by first component is 52,585%. For the most dominant variable is Air Pressure because it has the largest loading value on the first component. The loading value of the air pressure variable based on the Principal Component Analysis (PCA) method is 0.867. This information can be used as a consideration for related institutions in carrying out mitigation actions against harmful weather elements at Tanjung Perak Port, Surabaya.

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References

1. Saputra AD. Studi Kecelakaan Kapal di Indonesia dari Tahun 2003-2019 Berdasarkan Data Investigasi Komite Nasional Keselamatan Transportasi. War Penelit Perhub. 2021;33(2):87–94.
2. Hidayat AS, Soemantri AI, Poernomo H. Implementasi Strategi Pengendalian Alur Laut Kepulauan Indonesia (ALKI) II Dalam Mendukung Ketahanan Nasional. J Ketahanan Nas. 2019;25(3):313–30.
3. Kementerian Perhubungan Republik Indonesia. Profil Unit Kerja Kementerian Perhubungan Menteri Perhubungan [Internet]. [dikutip 15 Juni 2022]. Tersedia pada: http://dephub.go.id/ppid/kementerian/58
4. Sumarsono S, Nurhadi N, Yuana BR. Studi Kecelakaan Kapal Pada Alur Pelayaran Barat Selat Madura, Tanjung Perak, Surabaya. Info Tek [Internet]. 2018;18(2):215–34. Tersedia pada: http://ppjp.unlam.ac.id/journal/index.php/infoteknik/article/view/4348/3858
5. Tjahyono EB, Umasangaji F, Prakarsa L. Upaya Menghadapi Cuaca Buruk (Typhoon) Guna Mencegah Terjadinya Kecelakaan Pelayaran di Kapal MV. Pan Kristine. In: Prosiding Seminar Pelayaran

dan Teknologi Terapan. Jakarta: Pusat Penelitian dan Pengabdian Kepada Masyarakat (P3M) Sekolah Tinggi Ilmu Pelayaran (STIP) Jakarta; 2020: hal. 56–63.
6. Lutfiana R, Tirono M. Pengenalan Pola Cuaca Maritim (Curah Hujan, Tinggi Gelombang dan Kecepatan Arus) dengan Metode Adaptive Neuro Fuzzy Inference System (ANFIS) pada Jalur Pelayaran Surabaya Makasar. J Neutrino. 2013;6(1):47–52.
7. Perawiska E, Adriat R. Analisis Unsur Cuaca Pada Saat Kejadian Siklon Tropis Haiyan Menggunakan Model Wrf (Weather Research And Forecasting). Prism Fis. 2018;VI(2):129–36.
8. Kementerian Perhubungan Republik Indonesia. Pastikan Cuaca Mendukung Untuk Kapal Berlayar Agar Terwujud Keselamatan Dan Keamanan Pelayaran [Internet]. Tersedia pada: https://hubla.dephub.go.id/
9. Wu SX, Wai HT, Li L, Scaglione A. A Review of Distributed Algorithms for Principal Component Analysis. Proc IEEE. 2018;106(8):1321–40.
10. Mahmoudi MR, Heydari MH, Qasem SN, Mosavi A, Band SS. Principal component analysis to study the relations between the spread rates of COVID-19 in high risks countries. Alexandria Eng J. 1 Februari 2021;60(1):457–64.
11. Purnama SA, Rikumahu B. Analisis Faktor Yang Mempengaruhi Harga Saham Menggunakan Metode Principal Component Analysis (Studi Pada Sub Sektor Perbankan Saham LQ45 Yang Terdaftar Di Bursa Efek Indonesia Periode 2015-2019). 2020;7(2):5240–7.
12. Ayu DC, Rikumahu B, Akuntansi PS, Ekonomi F, Telkom U. Analisis Faktor-Faktor Penentu Financial Distress Dengan Metode Principal Component Analysis (Studi pada Perusahaan Telekomunikasi yang Terdaftar di Bursa Efek Indonesia Periode 2013-2017). 2019;6(3):5663–9.
13. Saepurohman T, Putro BE. Analisis Principal Component Analysis (PCA) Untuk Mereduksi Faktor-Faktor yang Mempengaruhi Kualitas Kulit Kikil Sapi. In: Seminar dan Koferensi Nasional IDEC. Surakarta; 2019: hal. C01.1-C01.10.
14. Ilmaniati A, Putro BE. Analisis Komponen Utama Faktor-Faktor Pendahulu (Antecedents) Berbagi Pengetahuan Pada Usaha Mikro , Kecil , Dan Menengah (Umkm) Di Indonesia. J Teknol. 2019;11(1):67–78.
15. BMKG RI. Badan Meteorologi, Klimatologi, dan Geofisika (BMKG) Republik Indonesia [Internet]. 2022 [dikutip 2 Juni 2022]. Tersedia pada: https://dataonline.bmkg.go.id/
16. Delsen MSN Van, Wattimena AZ, Saputri S. Penggunaan Metode Analisis Komponen Utama Untuk Mereduksi Faktor-Faktor Inflasi Di Kota Ambon. Barekeng J Ilmu Mat dan Terap. 2017;11(2):109–18.