

Djalaluddin Gorontalo Airport Passenger Data Forecasting with Holt's-Winters' Exponential Smoothing Multiplicative Event- Based Method

by Ismail Djakaria

Submission date: 20-Mar-2022 01:45PM (UTC+0000)

Submission ID: 1788235108

File name: Djakaria_2019_J._Phys._Conf._Ser._1320_012051-2-9.pdf (717.68K)

Word count: 3006

Character count: 15885

Djalaluddin Gorontalo Airport Passenger Data Forecasting with Holt's-Winters' Exponential Smoothing Multiplicative Event-Based Method

Ismail Djakaria

Statistics Department, Mathematics and Natural Science Faculty,
Gorontalo State University

iskar@ung.ac.id

Abstract. An appropriate time series model for predicting passenger data of Djalaluddin Gorontalo Airport, the interval between 2003 - 2017 with the multiplicative of Holt's-Winters' exponential smoothing as $\hat{Y}_{t+p} = (L_t + pT_t)S_{t-12+p}$, where for time t , the original exponential

smoothing data, $L_t = 0.2 \frac{Y_t}{S_{t-12}} + 0.8(L_{t-1} + T_{t-1})$, smoothing trend patterns

$T_t = 0.2(L_t - L_{t-1}) + 0.8T_{t-1}$ and smoothing seasonal patterns, $S_t = 0.2 \frac{Y_t}{L_t} + 0.8S_{t-12}$, so

the smoothing parameter used are $\alpha = \beta = \gamma = 0.2$. After several treatments, the mean square deviation (MSD) is 3287241 for arrival passenger data and MSD is 2490279 for passenger departure data with a seasonal length of 12 by do not event-based. The next, the MSD is 1334585 for arrival passenger data and MSD is 1433867 for passenger departure data with a seasonal length of 12 by Eid al-Fitr event-based, the MSD is 1259600 for arrival passenger data and MSD is 1252548 for passenger departure data with a seasonal length of 12 by Eid al-Adha event-based.

1. Introduction

Time series analysis in principle is used to analyze data takes into account the influence of time. This data is collected periodically based on a certain time span, for example, hours, daily, weekly, monthly, quarterly, semester, and/or yearly. This analysis is used as a reference in preparing future time planning or predicting a future phenomenon. Forecasting passenger data of an airport in a certain time frame that will come, which is required only passenger data in previous years.

In time series analysis two models are known, namely deterministic models and stochastic (probability) models. Deterministic models are models in which the value of future observations can be calculated or can be predicted with certainty through a function based on past observations, but forecasting only applies to existing data. To determine the forecasting method in the time series data, it is necessary to know the data pattern so that data forecasting can be carried out using the appropriate method. Data patterns can be divided into four types, namely seasonal patterns, cyclical patterns, trend patterns, and irregular patterns [1]. Seasonal patterns are fluctuations of data that occur periodically within one year, such as quarterly, quarterly, monthly, weekly, or daily. The cyclical pattern occurs when the data is affected by long-term economic fluctuations, such as those related to the business cycle. This pattern is difficult to detect and cannot be separated from trend patterns. Trend pattern is the



Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

Published under licence by IOP Publishing Ltd

tendency of data directly in the long term, can be either increase or decrease. While the irregular pattern is an unexpected and random event, its appearance can affect the time series data fluctuations.

For stochastic model data, there are several models that can be used such as AR, MA, ARMA, ARIMA, SARIMA, and others. If the data has a seasonal pattern, the more appropriate method is seasonal ARIMA, and other related methods, such as the multiplicative Holt's-Winters' smoothing method. This last method is the subject of this paper. This method have applied to forecasting electric load demand [2]. Even [3] has described forecasting using seasonal autoregressive integrated moving average (SARIMA) and Holt's-Winters' exponential smoothing.

2. Literature Review

The method that used to forecast airport passenger data in this paper is the multiplicative Holt's-Winters' exponential smoothing method so that what is desribed here are follows.

2.1. Smoothing method

Forecasting at a time series data containing trend patterns, seasonal patterns, or containing both at the same time, can be done with the smoothing method. Smoothing is taking the average value for several years to assess the value of a year [4].

The smoothing method is classified into two parts, namely the smoothing method and the exponential smoothing method [5].

Forecasting on data that is influenced by trend or seasonal patterns is carried out using the exponential smoothing method using different weights for past data and these weights have characteristics exponentially decreasing [5].

2.2. Winters' exponential smoothing method

If the data pattern is not only influenced by trend patterns, but also seasonal patterns, the Holt's exponential smoothing method is not suitable for forecasting, because it cannot detect seasonal patterns. Thus, Winter perfected Holt's exponential smoothing by adding one parameter to overcome seasonal patterns in data. This method is be separated into two models, namely additive and multiplicative models. An additive model analysis is performed if the original data plot shows relatively stable seasonal fluctuations, while the multiplicative model is used if the original data plot shows the seasonal fluctuations varies. Comparing the forecast profiles for the Holt's method and damped Holt's exponential has shown in [6].

In the multiplicative model, there are four equations [1], namely:

1. Exponential smoothing of original data (at the time t), (see also [7])

$$L_t = \alpha \frac{Y_t}{S_{t-s}} + (1-\alpha)(L_{t-1} + T_{t-1}) \quad (1)$$

2. Smoothing trend patterns (at the time t)

$$T_t = \gamma(L_t - L_{t-1}) + (1-\gamma)T_{t-1} \quad (2)$$

3. Smoothing seasonal patterns (at the time t)

$$S_t = \delta \frac{Y_t}{L_t} + (1-\delta)S_{t-s} \quad (3)$$

4. p -period forecasting forward

$$Y_{t+p} = (L_t + pT_t)S_{t-s+p} \quad (4)$$

where $(0 < \alpha, \gamma, \delta < 1)$.

2.3. Event-Based

Forecasting use event-based to forecast Djalaluddin Gorontalo Airport passengers based on special events that occur in certain periods. Thus, increasing and decreasing passenger data, both arrival passengers and departure passengers will be based on the index of each event. Because the forecasting

used is Holt's-Winters' Exponential Smoothing a.k.a Holt's-Winters' Exponential Smoothing event based.

The steps being taken for this event based on calculating the event index are obtained from calculating the average index each year where the month there is a special event that modified formula from [8], [9], [10], [11],

$$I_t = \frac{X_t}{F_t} \quad (5)$$

where I_t = event index for special events period t -th

X_t = actual data period t -th

F_t = forecasting data period t -th

The average special event index that obtained is used for forecasting by Holt's-Winters' Exponential Smoothing event-based method. Thus, the p -period forecasting forward model using the special event index becomes,

$$\hat{Y}_{t+p} = G_{t+p} Y_{t+p} \quad (6)$$

where: G_{t+p} = the event index group $t+p$ -th period

Y_{t+p} = the $t+p$ -th period forecast forward using Holt's-Winters' Exponential Smoothing model.

2.4. The accuracy measures of forecasting methods

The use of forecasting methods depends on the data pattern to be analyzed. If the method used is considered correct for forecasting, the best forecasting method selection is based on the prediction error rate [12]. Each forecasting method cannot accurately predict the future state of the data, so it definitely produces errors. If the resulting error rate gets smaller, the forecasting results will get closer to the right. To calculate the prediction errors used include mean squared deviation (MSD), mean absolute deviation (MAD), mean absolute percentage error (MAPE).

3. Method

This section briefly describes the steps of forecasting with existing methods.

Step 1: Data Collection Method

The data used in this paper is passenger aircraft data in Djalaluddin Gorontalo Airport, which is derived from BPPS data in 2003 - 20017 [13].

Step 2: Data Analysis Methods

Existing data analysis is done with the help of *MINITAB 17 Statistical Software* and *Microsoft Excel*.

Step 3: Results and Discussion

Forecasting passenger data of Djalaluddin Gorontalo Airport, from 2007 to 2014, using Holt's-Winters' exponential smoothing method has been discussed by [14]. However, in this paper, the passenger data of Djalaluddin Gorontalo Airport is reviewed, with an extended time interval, for 2003-2017 data, and considering special events, such as before and after Eid al-Fitr, Eid al-Adha, and Christmas and New Year's events.

Plotting of passenger time series actual data in Djalaluddin Gorontalo Airport, both arrival, and departure, between 2003-2017, Figure 1.

These two data plots show that the data is influenced by trend patterns as well as seasonal patterns because they show increased fluctuations.

Autocorrelation and partial autocorrelation plots for time series data on passenger arrival and departure in succession are shown in Figure 2.

The four plots above show that there is an autocorrelation in the data, namely the existence of a bar that exceeds the dashed line so that the data is non-stationary. While Figures 2(a) and 3(a) shows that trend patterns are stronger than seasonal patterns.

With several methods of experiments carried out, obtained data plots of passenger time series in Djalaluddin Gorontalo Airport, as Figures 4.

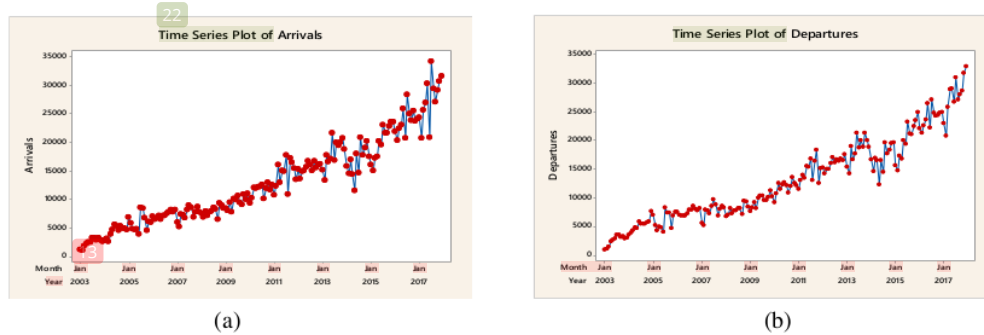


Figure 1. Plotting of passenger time series actual data (a) arrivals and (b) departures in Djalaluddin Gorontalo Airport

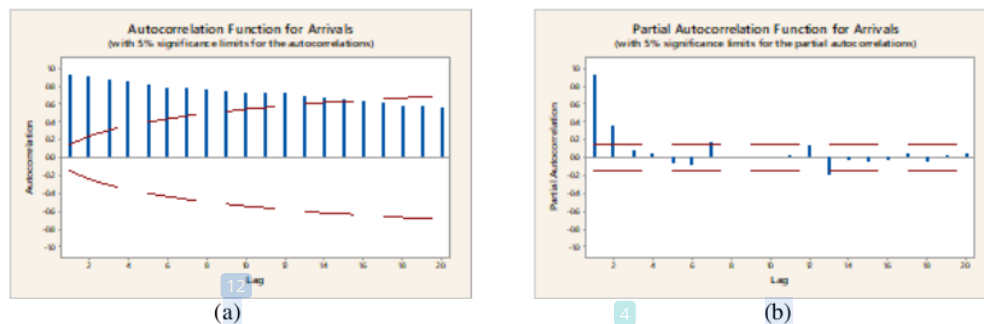


Figure 2. (a) ACF and (b) PACF for time series data on passenger arrival in Djalaluddin Gorontalo Airport

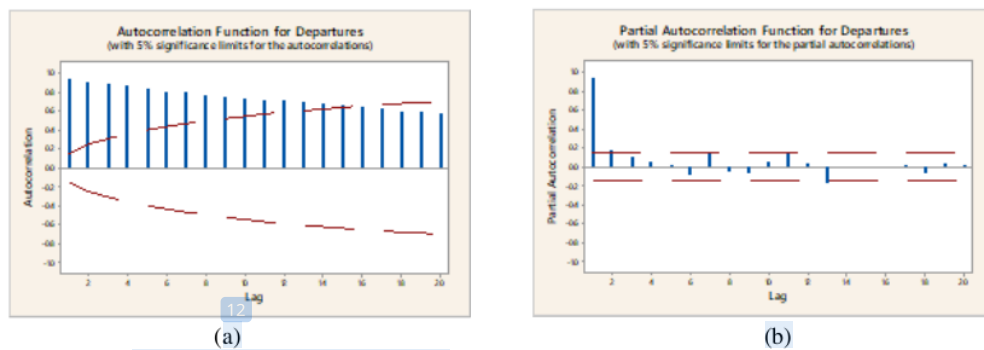


Figure 3. (a) ACF and (b) PACF for time series data on passenger departures in Djalaluddin Gorontalo Airport

Based on the time series data forecasting plot above, the forecasting model is obtained using the Holt's-Winters' exponential smoothing method, as follows.

1. Exponential smoothing of original data (at the time t)

$$L_t = 0.2 \frac{Y_t}{S_{t-12}} + 0.8(L_{t-1} + T_{t-1}) \quad (7)$$

2. Smoothing trend patterns (at the time t)

$$T_t = 0.2(L_t - L_{t-1}) + 0.8T_{t-1} \quad (8)$$

3. Smoothing seasonal patterns (at the time t)

$$S_t = 0.2 \frac{Y_t}{L_t} + 0.8S_{t-12} \quad (9)$$

4. p -period forecasting forward

$$Y_{t+p} = (L_t + pT_t)S_{t-s+p} \quad (10)$$

where $\alpha = \gamma = \delta = 0.2$, we found the forecast error, for passenger departures data in Djalaluddin Gorontalo Airport, from 2003 to 2017, as shown in Table 2 (no event-based).

Plotting of the model in Equation (13) is shown below.

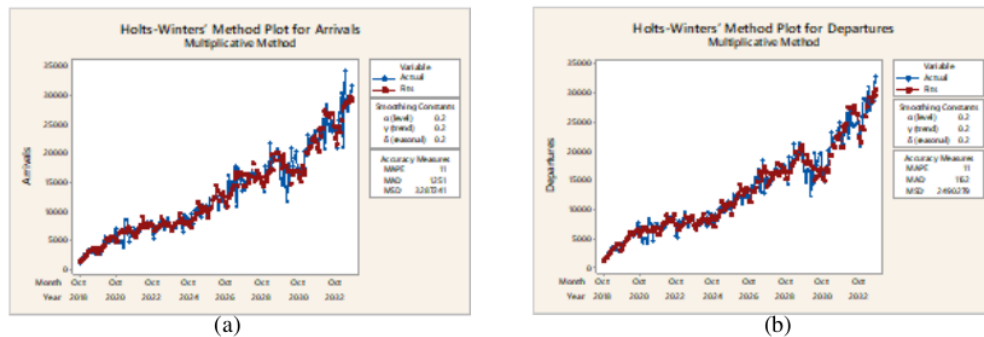


Figure 4. Holt's-Winters' exponential smoothing for time series data on passenger: (a) arrivals and (b) departures

Furthermore, using the Equation (8), an index value is found for each, both Eid al-Fitr, Eid al-Adha, and Christmas and New Year events. The results of the Holt's-Winters' exponential smoothing event based index can be seen in Table 1. According to this table, almost all indices for each event indicate that the arrival and departure of Djalaluddin Gorontalo Airport passengers, exceeding the estimates for the month, especially the Eid al-Fitr event, is indicated by the index value of more than 1, except for Christmas and New Year events almost every year, the index value is less than 1, so the value of the group index is less than 1. This condition shows that the arrival and departure of the Christmas and New Year events have decreased every month compared to the other two events.

The cause of this decline can be interpreted that people will feel reluctant to travel, or even if they travel to neighboring, like Manado, which usually graces Christmas and New Year celebrations, they do so by using land transportation, because Gorontalo with Manado allows for that. Therefore, the Christmas and New Year events cannot be used in the event index calculation, and then this event index is not used in the passenger mode in Djalaluddin Gorontalo Airport.

From the above analysis and using Equation (9), we get the results of passenger forecasting errors, both arrival, and departure, in Djalaluddin Gorontalo Airport, using Holt's-Winters' exponential smoothing event-based, Eid al-Fitr and Eid al-Adha, with parameters $\alpha = \beta = \gamma = 0.2$ as follows.

Comparing the results of the forecast error table above with the same smoothing parameters, the accuracy measures of the Holt's-Winters' exponential smoothing multiplicative forecasting model are more than of the Holt's-Winters' exponential smoothing multiplicative forecasting model using event-based. Holt's-Winters' method modified by [15] to obtaining the best accuracy of Eid effect forecasting

for several ports in Indonesia, but did not specify the effects of Eid al-Fitr or Eid al-Adha. He also did not assess exponential smoothing and reviewing several other events.

The next, plotting of the model using Equation (9), both Eid al-Fitr (Figure 5(a), 5(b)) and Eid al-Adha (Figure 6(a), 6(b)) events, as shown follows.

Table 1. Special event Djalaluddin Airport passengers index

Event Group	Event	Index		Index Group	
		Arrival	Departure	Arrival	Departure
Eid al-Fitr	Eid al-Fitr 2003	1.00	1.40		
	Eid al-Fitr 2004	1.01	1.13		
	Eid al-Fitr 2005	1.11	1.09		
	Eid al-Fitr 2006	1.11	1.03		
	⋮	⋮	⋮	1.05	1.09
	Eid al-Fitr 2013	1.17	1.08		
	Eid al-Fitr 2014	1.12	1.03		
	Eid al-Fitr 2015	1.16	1.20		
	Eid al-Fitr 2016	1.06	1.02		
	Eid al-Fitr 2017	1.00	1.01		
Eid al-Adha	Eid al-Adha 2003	0.84	0.88		
	Eid al-Adha 2004	0.98	1.19		
	Eid al-Adha 2005	1.50	1.27		
	Eid al-Adha 2006	1.22	1.32		
	⋮	⋮	⋮	1.02	1.02
	Eid al-Adha 2013	1.00	1.04		
	Eid al-Adha 2014	1.14	1.09		
	Eid al-Adha 2015	1.02	1.02		
	Eid al-Adha 2016	0.90	0.92		
	Eid al-Adha 2017	0.95	0.98		
Christmas and New Year	C.N.Y. 2003	0.75	0.74		
	C.N.Y. 2004	0.87	1.19		
	C.N.Y. 2005	0.96	1.09		
	C.N.Y. 2006	0.97	0.92		
	⋮	⋮	⋮	0.97	0.98
	C.N.Y. 2013	0.94	0.90		
	C.N.Y. 2014	0.93	1.01		
	C.N.Y. 2015	1.01	1.02		
	C.N.Y. 2016	0.98	0.94		
	C.N.Y. 2017	0.99	1.02		

Table 2. Forecast error using Holt's-Winters' exponential smoothing method

No.	Events	MAPE		Error MAD		MSD	
		Arrival	Departure	Arrival	Departure	Arrival	Departure
1.	No event based	11	11	1251	1162	3287241	2490279
2.	Eid al-Fitr	6	6	775	828	1334585	1433867
3.	Eid al-Adha	6	6	752	774	1259600	1252548

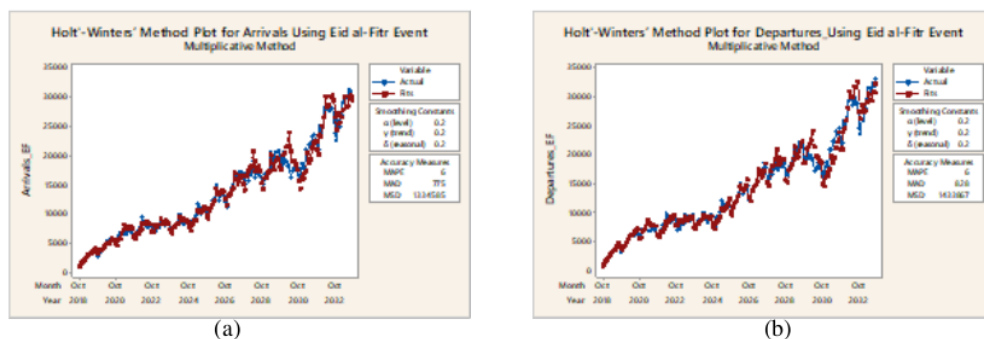


Figure 5. Holt's-Winters' exponential smoothing for time series data on passenger:
(a) arrivals and (b) departures using Eid al-Fitr event

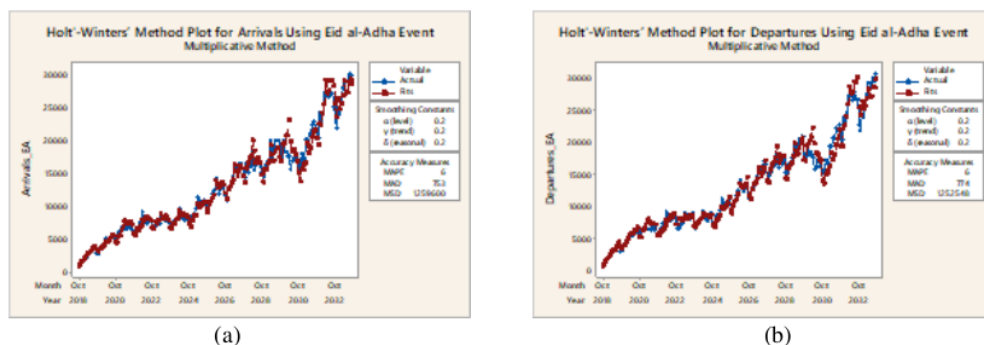


Figure 6. Holt's-Winters' exponential smoothing for time series data on passenger:
(a) arrivals and (b) departures using Eid al-Adha event

4. Conclusion

According to the analysis and discussion of passenger data forecasting in Djalaluddin Gorontalo Airport by considering the special event, it was concluded that:

1. Forecasting data on passenger arrival and departure time in Djalaluddin Gorontalo Airport can be done using the Holt's-Winters' exponential smoothing multiplicative method. This is indicated by plot data which is not only influenced by trend patterns but also influenced by seasonal patterns.
2. Forecasting by considering special events can increase the level of accuracy compared to without special events.
3. Eid al-Fitr and Eid al-Adha are special events that have a more significant influence in increasing passengers in Djalaluddin Gorontalo Airport.

References

- [1] Hanke, J.E. & Wichern, D.W. (2005). *Business Forecasting*, 8th ed. New Jersey: Pearson Prentice Hall.
- [2] Hoshmand, A. R., (2010). *Business Forecasting, a practical approach*, 2nd ed. New York: Routledge.
- [3] Pongdatu, G. A. N., & Putra, Y. H. (2018). Seasonal Time Series Forecasting using SARIMA and Holt's-Winters' Exponential Smoothing. *IOP Conf. Series: Materials Science and Engineering*, **407**(012153) doi:10.1088/1757-899X/407/1/012153
- [4] Jalil, N. A. A., Ahmad, M. H., & Mohamed, N. (2013). Electricity load demand forecasting using exponential smoothing methods. *World Applied Sciences Journal*, **22**(11): 1540-1543

- [5] Makridakis, S., Wheelwright, S.C., Hyndman, R. J., & McGee, V.E. (1999). *Forecasting Methods and Application*, Hoboken: John Wiley & Sons, Inc.
- [6] Taylor, J. W. (2003) *International Journal of Forecasting*, Elsevier, **19**: 715–725
- [7] Jere, S., & Siyanga, M. (2016). Forecasting inflation rate of Zambia using Holt's exponential smoothing. *Open Journal of Statistics*, **6**, 363-372.
- [8] Memon, A. H., Rahman, I. A., & Azis, A. A. A. (2011). Preliminary study on causative factors leading to construction cost overrun. *International Journal of Sustainable Construction Engineering & Technology*, **2**(1)
- [9] Henifa, S. L. & Wahyuningsih, N. (2012). Peramalan penjualan avtur dengan mempertimbangkan special event. *Jurnal Teknik ITS*, **1**, ISSN: 2301-9271
- [10] Roslan, N., Memon, A. H., & Zainun, N. Y. (2013). Indicators of Low-Cost Housing Demand in Malaysia. *Proceedings of Malaysian Technical Universities Conference on Engineering & Technology* (MUCET), 3-4 December 2013, Kuantan, Pahang
- [11] Kalender, M., Baysal, A. N., Ecevit, A. N., Karaca, O. G., Tasar, M., & Salihi, S. (2014). *Surgical Science*, **5**, 411-417.
- [12] Santoso, S. (2009). *Business Forecasting: Metode Peramalan Bisnis Masa Kini dengan MINITAB dan SPSS*. Jakarta: PT. Elex Media Komputindo.
- [13] Badan Pusat Statistik. (2004-2018). *Gorontalo in Figures*. Gorontalo: Statistics of Gorontalo Province.
- [14] Djakaria, I. (2017). Peramalan data penumpang bandar udara Djalaluddin Gorontalo dengan metode Holt's-Winters' Exponential Smoothing Multiplikatif. *Prosiding Seminar Nasional Matematika dan Terapannya*. Banjarbaru: Universitas Lambung Mangkurat, 22 April 2017.
- [15] Bustami, Irawansyah, H., Gamal, M. D. H. (2015). *Science Journal of Applied Mathematics and Statistics*, **3**(6): 257-262

Djalaluddin Gorontalo Airport Passenger Data Forecasting with Holt's-Winters' Exponential Smoothing Multiplicative Event-Based Method

ORIGINALITY REPORT

21 %
SIMILARITY INDEX

15 %
INTERNET SOURCES

11 %
PUBLICATIONS

8 %
STUDENT PAPERS

PRIMARY SOURCES

1 Submitted to Universitas Pendidikan Indonesia 2 %
Student Paper

2 centaur.reading.ac.uk 2 %
Internet Source

3 www.whatdateis.info 2 %
Internet Source

4 hrmars.com 2 %
Internet Source

5 Rosnida Nurhayati, Endah Retnowati. "An Analysis of Errors in Solving Limits of Algebraic Function", Journal of Physics: Conference Series, 2019 1 %
Publication

6 download.garuda.kemdikbud.go.id 1 %
Internet Source

7 media.neliti.com 1 %
Internet Source

8

adoc.pub
Internet Source

1 %

9

Anggi Restyana, Lisa Savitri, Nur Fahma Laili, Neni Probosiwi. "Analysis of Drug Forecasting with Single Moving Average and Single Exponential Smoothing Approach (Case Study in Jombang Regency 2017-2019)", Journal of Physics: Conference Series, 2021

Publication

1 %

10

G A N Pongdatu, Y H Putra. "Seasonal Time Series Forecasting using SARIMA and Holt Winter's Exponential Smoothing", IOP Conference Series: Materials Science and Engineering, 2018

Publication

1 %

11

Stanley Jere, Mubita Siyanga. "Forecasting Inflation Rate of Zambia Using Holt's Exponential Smoothing", Open Journal of Statistics, 2016

Publication

1 %

12

L Hidayat, D U Wutsqa. "Forecasting the farmers' terms of trade in Yogyakarta using transfer function model", Journal of Physics: Conference Series, 2020

Publication

1 %

13

repository.its.ac.id
Internet Source

1 %

14	Submitted to Erciyes Üniversitesi Student Paper	1 %
15	eprints.uny.ac.id Internet Source	<1 %
16	Submitted to University of Malaya Student Paper	<1 %
17	Submitted to The Hong Kong Polytechnic University Student Paper	<1 %
18	www.bonetider.se Internet Source	<1 %
19	zenodo.org Internet Source	<1 %
20	documents.mx Internet Source	<1 %
21	lutpub.lut.fi Internet Source	<1 %
22	nozdr.ru Internet Source	<1 %
23	www.coursehero.com Internet Source	<1 %
24	www.scirp.org Internet Source	<1 %

25 Aneeqe A. Mir, Mohammed Alghassab, Kafait Ullah, Zafar A. Khan, Yuehong Lu, Muhammad Imran. "A Review of Electricity Demand Forecasting in Low and Middle Income Countries: The Demand Determinants and Horizons", Sustainability, 2020

Publication

<1 %

26 Desri Kristina Silalahi. "Forecasting of Poverty Data Using Seasonal ARIMA Modeling in West Java Province", JTAM | Jurnal Teori dan Aplikasi Matematika, 2020

Publication

<1 %

27 "Demand-Driven Forecasting", Wiley, 2012

Publication

<1 %

Exclude quotes On

Exclude matches Off

Exclude bibliography On

Djalaluddin Gorontalo Airport Passenger Data Forecasting with Holt's-Winters' Exponential Smoothing Multiplicative Event-Based Method

GRADEMARK REPORT

FINAL GRADE

/0

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8