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Forecasting the Number of Child Development Therapy Patients at Mentari Anakku Clinic Tangerang in 2021 with the Double Exponential Smoothing Method

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Abstract. Clinic is a health service facility that organizes and provides basic and specialist medical services, organized by more than one type of health worker and led by a medical worker. This study aims to determine fluctuations and predict the number of therapy patients at the Child Development Clinic (Mentari Anakku) using the time series method, namely double exponential smoothing. Based on the results of the forecast using the double exponential smoothing method in the 2021 period, it is known that the total number of child development therapy patients is 7,062 people. It can be seen that the total number of patients has increased quite significantly and it is necessary for the clinic to improve the performance of the workers.

Keyword: Double Exponential Smoothing, Number of Patients, Clinic, Time Series

Abstrak. *Klinik adalah fasilitas pelayanan kesehatan yang menyelenggarakan dan menyediakan pelayanan medis dasar dan spesialistik, diselenggarakan oleh lebih dari satu jenis tenaga kesehatan dan dipimpin oleh seorang tenaga medis. Penelitian ini bertujuan untuk mengetahui fluktuasi dan meramalkan banyaknya jumlah pasien terapi di Klinik Tumbuh Kembang Anak (Mentari Anakku) menggunakan metode time series yaitu double exponential smoothing. Berdasarkan hasil ramalan menggunakan metode double exponential smoothing diperiode tahun 2021 diketahui jumlah keseluruhan pasien terapi tumbuh kembang anak sebanyak 7.062 orang. Dapat dilihat bahwa jumlah pasien keseluruhan mengalami kenaikan yang cukup signifikan dan diperlukan untuk klinik meningkatkan kinerja para pekerja.*

Kata Kunci: *Double Exponential Smoothing, Jumlah Pasien, Klinik, Time Series*

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1. Introduction

In the development process, it is clear that there are changes that include physical, intellectual, social, moral, language, emotions, feelings, interests, motivations, attitudes, personality, talents and creativity aspects. The science of growth and development is the study of various things related to all efforts to maintain and optimize children's growth and development both physically, mentally and socially [1]. Also establish an early diagnosis of any growth and development disorders and the possibility of effective treatment, as well as find the cause and prevent the condition. Forecasting is an estimate of future events based on data patterns in the past. Forecasting is the art and science of predicting future events [2].

The smoothing method is a forecasting method by conducting smoothing or smoothing of past data, namely by taking the average of the values of several years to estimate the value in the next few years. Brown's Double Exponential Smoothing is a linear model proposed by Brown. This method is used when the data shows a trend. Trend is a smoothed estimate of the average growth at the end of each period.

2. Theoritical Review

2.1 Definition of Forecasting and Forecasting Method

Forecasting is the art and science of predicting future events by taking historical data and projecting it into the future using some form of mathematical model [3]. In the selection of forecasting methods, it is necessary to know in advance the important characteristics in decision making and analysis of circumstances in preparing forecasts. There are 6 main factors that can be categorized as forecasting techniques and methods, namely:

1. Time horizon
2. Data Pattern
3. Types and models
4. Cost required
5. Forecasting accuracy
6. Ease and applicability

Forecasting method based on the use of pattern analysis of the relationship between the variables to be estimated with the time variable which is a time series [4]. Methods that fall into this category are:

1. Smoothing method, is a type of short-term forecasting such as inventory planning. The purpose of using this method is to reduce the irregularity of past data such as seasonality.
2. Box Jenkins method, is a time series using a mathematical model and is used for short-term forecasting.
3. Trend Projection Method with Regression, is a method used for both short and long term.

2.2 Smoothing Method

The smoothing method is a forecasting method by conducting smoothing or smoothing of past data, namely by taking the average of the values of several years to estimate the value in the next few years [5]. In general, smoothing methods can be classified into several parts, namely:

1. Average Method
    a. Mean
    b. Single Moving Average
    c. Double Moving Average
    d. Other Moving Average Combinations
2. Exponential Smoothing Method

2.3 Exponential Smoothing Method

The general form of the exponential smoothing method is:

$$F_{t+1} = \alpha X_t + (1-\alpha)F_t \quad (1)$$

When the general form is expanded it will change to:

$$F_{t+1} = \alpha X_t + \alpha(1-\alpha)X_{t-1} + \alpha(1-\alpha)^2 X_{t-2} + \cdots + \alpha(1-\alpha)^{N-1} X_{t-(N-1)} + (1-\alpha)^N F_{t-(N-1)} \quad (2)$$

Information:

F_{t+1} = forecast one period ahead

X_t = actual data in period

F_t = forecast in period

α = smoothing parameter

From the smoothing of the general form above, it can be said that the exponential smoothing method is a group of methods that shows an exponentially decreasing weighting of the older observation values or in other words the new observations are given a relatively larger weight with the older observation values.

2.4 One-Parameter Linear Double Exponential Smoothing Method from Brown

Brown's Double Exponential Smoothing is a linear model proposed by Brown. This method is used when the data shows a trend. Trend is a smoothed estimate of the average growth at the end of each period. The steps in doing double exponential smoothing are as follows:

1. Determine the first smoothing (S_t')

$$S_t' = \alpha X_t + (1-\alpha)S_{t-1}' \quad (3)$$

2. Determine the second smoothing

$$S_t'' = \alpha S_t' + (1-\alpha)S_{t-1}'' \quad (4)$$

3. Define smoothing constant

$$a_t = S_t' + (S_t' - S_t'') = 2S_t' - S_t'' \quad (5)$$

4. Determine the magnitude of the slope

$$b_t = \frac{\alpha}{1-\alpha}(S_t' - S_t'') \quad (6)$$

5. Determine the size of the forecast

$$F_{t+m} = a_t + b_t(m) \quad (7)$$

Information :

m = The number of periods ahead of the forecast

S_t' = Single smoothing exponential value in period t

S_t'' = Double smoothing exponential value in period t

α = Exponential Smoothing Parameters (0<α<1)

a_t = Moving average value for period t

b_t = Component trend from one period to the next time period

F_{t+m} = Forecasting Result for the next m period

In order to use this formula, the values S_{t-1}' and S_{t-1}'' must be available. But if t = 1, these values are not available. Since these values must be specified at the beginning of the period, it is possible to solve this problem by setting S_1' and S_1'' equal to the value of X_1 (actual data).

2.5 Forecasting Accuraty Measure

The measure of forecasting accuracy is used to evaluate the value of the forecasting parameters. If X_t is the actual data for period t and F_t is the forecast (or match value) for the same period, then the error is defined as follow:

$$e_t = X_t - F_t \quad (8)$$

Information :

e_t = error in period *t*

X_t = actual data in period *t*

F_t = forecast value in period *t*

If there are observed and forecast values for n time periods, then there will be n errors. In this study to determine the size of the forecasting error, the authors used the Mean Absolute Percentage Error (MAPE) relative error measure.

2.6 Mean Absolute Percentage Error (MAPE)

MAPE or the mean absolute percentage error is the average of the overall percentage error (difference) between the actual data and the forecasted data. The formula for calculating MAPE in equation (9) is:

$$MAPE = \frac{\sum_{t=1}^{n} |PE_t|}{n} \quad (9)$$

Table 1. MAPE Value for Prediction Evaluation

Value MAPE	Prediction Accuracy
MAPE ≤ 10%	High
10% < MAPE ≤ 20%	Well
20% < MAPE ≤ 50%	Still good to used
MAPE > 50%	Low

The formula for calculating the percentage error of a forecast:

$$PE_t = \left(\frac{X_t - F_t}{X_t}\right) (100) \quad (10)$$

Information:

E_t = error in period

X_t = actual data in period

F_t = forecast value in period

n = number of time periods

3 Research Methodology

3.1 Research Plan

This research design uses data collection techniques with library research. The type of data is quantitative data. Quantitative data is the type of data which can be measured or calculated directly as a variable or number.

3.2 Type and Data Source

The data used in this study are secondary data types, namely obtained or collected from existing sources. That data usually obtained from the company or from the reports of previous researchers. Data secondary data is also called available data. Data obtained from this study sourced from Mentari Anakku Clinic, namely data on the total number of therapy patients from January 2015 to December 2019.

3.3 Research Steps

The steps to analyze are as follows :

1. Literature Studies
   Collect and study various information in the form of books or journals related to research.
2. Data Collection
   Collecting data on the number of therapy patients in 2015-2019.
3. Data Processing
   The steps taken in data processing are as follows:
   a. Determine the time series method to use double exponential smoothing.
   b. Determine the determination value of (0-1).
   c. Perform double exponential smoothing calculations.
   d. Perform MAPE calculations.
   e. Determine the smallest MAPE determination value
4. Results and Discussion.
5. Conclusions and Suggestions.

4 Results And Discussion

4.1 Data Collection

The data that will be analyzed in this study is secondary data on the number of therapy patients in 2015-2019 at Mentari Anakku Clinic. The data can be seen in the following table.

Table 2. Number of Therapy Patients 2015-2019

Month	Year 2015	Year 2016	Year 2017	Year 2018	Year 2019
JANUARY	48	86	121	197	442
FEBUARY	42	85	120	234	402
MARCH	63	96	130	246	444
APRIL	85	93	113	251	407
MAY	82	73	139	271	454
JUNE	76	74	88	144	246

JULY	35	41	140	321	592
AUGUST	96	88	192	299	583
SEPTEMBER	78	77	174	305	605
OCTOBER	95	101	172	377	755
NOVEMBER	107	117	229	355	741
DECEMBER	85	95	203	367	716
AMOUNT	892	1026	1821	3367	6387

Source: Mentari Anakku Clinic Tangerang

From table 2 it can be seen that the data used fluctuates. This shows that the data is not constant. In addition, it can also be seen that the data has various peaks but tends to increase. Based on table 2, it can be seen that the highest number of therapy patients at Mentari Anakku Clinic was in October 2019 with 755 patients, the lowest was in July 2015 with 35 patients.

4.1 One Parameter Linear Double Exponential Smoothing Method Analysis from Brown For the 3rd year (2017)

The 3rd year (2017) or $X_3 = 1821$, the method of completion is the same as the 2nd year, but in the 3rd year it can be predicted or predicted because between the values of a_t and b_t has been obtained, then the value of F_{t+m} can also be searched to predict the number of patients with child development therapy for the coming year. Then the forecast error value (e_t) can be found by subtracting the actual value (X_t) with the forecast value (F_{t+m}). The following is a solution to find the value of e_t.

$S_t^{'} = \alpha X_t + (1-\alpha) S_{t-1}^{'}$

$= \alpha X_3 + (1-\alpha) S_{3-1}^{'}$

= 0,1 (1821) + (0,9) (905,4)

= 182,1 + 814,86

= 996,96

$S_t^{''} = \alpha S_t^{'} + (1-\alpha) S_{t-1}^{''}$

$= \alpha X_3 + (1-\alpha) S_{3-1}^{'}$

= 0,1 (996,96) + (0,9) (893,34)

= 99,696 + 804,006

= 903,702

$a_t = 2S_t^{'} - S_t^{''}$

$= \alpha X_3 + (1-\alpha) S_{3-1}^{'}$

= 2 (996,96) – 903,702

= 1.993,92 – 903,702

= 1.090,218

$$b_t = \frac{\alpha}{(1-\alpha)}(S_t' - S_t'')$$

$= \frac{\alpha}{(1-\alpha)}(S_3' - S_3'')$

$= \frac{0,1}{0,9}(996,96 - 903,702)$

= 10,362

3rd year forecast with m=1

$$F_{2016+1} = a_{2016} + b_{2016}(m)$$

= 1.090,218 + 10,362 (1)

= 1.100,58

The e_t values for 2017 are:

$$e_{2017} = X_{2017} - F_{2017}$$

= 1.821 – 1.100,58

= 720,42

The error percentage for 2017 is:

$$PE_t = \left(\frac{X_t - F_t}{X_t}\right)100\%$$

$$= \left(\frac{1.821 - 1.100,58}{1.821}\right)100\%$$

= 0,396%

To find out the error rate is:

$$MAPE = \sum_{t=1}^{n} \frac{|PE_t|}{n}$$

$= \frac{1,530\%}{3}$

= 0,509%

Where the number of n used is n = 3 because to find the value of F_{t+m} can not be determined because the value of a_t and b_t has not been determined in the previous year. The value of F_{t+m} can be searched in the 3rd year.

4.3 Parameter Selection α Best

Tabel 3. MAPE value for parameter = 0.41 to = 0.49

Num	Parameter (α)	*Mean Absolute Percentage Error* (MAPE)
1	0,41	0,043%
2	0,42	0,031%
3	0,43	0,024%
4	**0,44**	**0,021%**
5	0,45	0,024%
6	0,46	0,029%
7	0,47	0,034%
8	0,48	0,039%
9	0,49	0,050%

From the table above shows that the smallest value of α parameter is = 0.44 with a MAPE value of 0.021%. The best MAPE score that has been obtained by trial and error, then forecasting can then be done using the Double Exponential Smoothing Brown method.

4.4 Forecasting the Number of Child Development Therapy Patients at Mentari Anakku Clinic

After calculating the first smoothing value, second smoothing value, at value a_t and value b_t using the value of $\alpha = 0.44$, then the prediction of the number of patients on child development therapy at Mentari Anakku Clinic can be determined.

So to determine forecasting in the coming year, the formula $F_{t+m} = a_t + b_t\ (m)$. The values of a_t and b_t are taken from 2019. Because the year to be forecast is 2021, the number of future forecasts is determined by the number of the previous year. The following is the process of completing the forecast for 2021.

a. Forecast for 2020 (m=1)

F_{t+m} = a_t + b_t (m)

F_{2019+1} = a_{2019} + b_{2019} (1)

F_{2020} = 5,436.44 + 1,082.92 (1)

F_{2020} = 6,519.36

Based on the forecasting results, the number of child growth therapy patients that will be predicted in 2020 is 6,519 people.

b. Forecast for 2021 (m=2)

F_{t+m} = a_t + b_t (m)

F_{2019+2} = a_{2019} + b_{2019} (2)

F_{2021} = 5,436.44 + (1,082.92) (2)

F_{2021} = 7,602.28

Based on the forecasting results, the number of child growth therapy patients that will be predicted in 2021 is 7,602 people.

5. Conclusions

Based on the analysis and discussion that has been carried out, it can be concluded that the best α parameter obtained for forecasting the number of child development therapy patients at Mentari Anakku Clinic Tangerang from 2015 to 2019 is $\alpha = 0.44$ with an error percentage of 0.021% for forecasting the number of patients. Child development therapy at Mentari Anakku Clinic Tangerang in 2020 was 6,519 people and in 2021 there were 7,602 people.

REFERENCES

[1] Encep Sudirjo, M. Nur Alif, 2018.Pertumbuhan dan Perkembangan Motorik UPI. Sumedang Press. Sumedang, Jawa Barat.

[2] Pujianti, T. M., Damayanti, D., Erawantini, F. 2014. Perencanaan Kebutuhan Tempat Tidur di Rumah Sakit Paru Jember Tahun 2013-2015. Jurnal Manajemen Informasi Kesehatan Indonesia, ISSN:2337-585X 2(1), 2-10.

[3] Barry, Render., & J. H. Heizer. 2012. Operations Management. Pearson Prentice Hall.

[4] Assauri, Sofyan 1984. Teknik dan Metode Peramalan : Penerapannya dalam Ekonomi dan Dunia Usaha. Jakarta : Lembaga Penerbit Fakultas Ekonomi Universitas Indonesia.

[5] Makridakis, S., S. C. Wheelwright, dan V. E. McGee 1999. Metode dan Aplikasi Peramalan. Jilid 1 edisi kedua. Jakarta : Binarupa Aksara