Identifying Best Method for Forecasting Tax Income using Time Series Analysis

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Abstract

Regional independence can be seen from the high or low local indigenous income. In doing planning, forecasting is needed as consideration for policy making. For economic development planning, accurate predictions of regional income are needed. Majalengka Regency as one of the districts included in the national legislation program Segitiga Rebana area is projected as the driving force for the economic growth of Java Province Barat. The research method uses secondary data on regional tax revenue receipts of Majalengka Regency obtained from the Central Statistics Agency. Data analysis using *time series* with models tested including *Single Exponential Smoothing, Double Exponential Smoothing*, *Winters Method Additive,* and *Winters Method Multiplicative*. The study aimed to find the best forecasting methods for receiving local tax incomes. The results indicated the Winters Method Additive is the best forecasting method that can be used to forecast local tax incomes. The Mean Absolute Percentage Error of Winters Method Additive reaches the accurate category with a value of 14% when level is 0.1, trend is 0.2, and seasonal is 0.1.

Keywords:

exponential smoothing; winters method; multiplicative; additive

Introduction

Regional independence can be represented by the amount of Regional Original Income (PAD) to the Regional Revenue and Expenditure Budget (APBD). (Juliarini, 2020). With the establishment of regional autonomy, it is hoped that local governments will be able to dive into the potential of financial resources in fulfilling government financing and regional development (Pramesti et al., 2016). The Financial Audit Agency (BPK) of the Republic of Indonesia (RI) (2020) stated that regional autonomy and fiscal decentralization aim to optimize regional governments to be more financially autonomous. According to the result Fiscal Independence Index (IKF) analysis conducted by the Financial Audit Agency (BPK), it shows that 443 of the 503 local governments are included in the Not Yet Independent category, with 50 other local governments included in the Towards Independent category, and 10 local governments included in the Mandiri category (Saraswati & Nurharjanti, 2021)(Badan Pemeriksa Keuangan, 2021).

In addition to the Equalization Fund and other sources of income, PAD is the main element of regional fiscal capacity and is a source of strength for local governments in supporting their regional development (Mintahari & Lambey, 2016; Saraswati & Nurharjanti, 2021). Measuring a region's financial management ability can be judged from the size of the PAD obtained by the relevant region (Karenina et al., 2021). In this case, the increase in PAD follows an increase in regional income at the district/city level (Juliarini, 2020).

In Juliarini (2020), based on the results of research by Kusuma and Wirawati (2013), regional tax and retribution income have a substantial influence on increasing PAD with a greater contribution of regional taxes affecting PAD. In line with this, Rosidin (2015) in the results of his research stated that local taxes and regional levies can increase PAD, so that local governments can optimize local tax incomes and regional levies to increase PAD (Julia et al., 2020). Regulated in Undang-Undang (UU) Nomor 28 Tahun 2009 (concerning Regional Taxes and Regional Levies (PDRD), Regional Taxes are mandatory contributions to areas owed by individuals or entities of a coercive nature based on the Law, with indirect rewards and used for regional purposes for the prosperity of the people (Pemerintah Indonesia, 2009).

The value of local tax income as one of the sources of income for the regions can experience a fluctuating trend. In this case, the local tax income can increase or decrease at a particular time. In light of this trend's volatility, a forecast or projection is required to estimate the quantity of income receipts for the coming year (Ilmi, 2012). Forecasting is a method of predicting or predicting the future by requiring and paying close attention to past and present data (Latipah et al., 2019; Maricar, 2019). When establishing plans, forecasting is one factor that must be considered (Ilmi, 2012). For economic planning, the government needs accurate tax revenue estimate figures (Ofori et al., 2020). In addition, development implementation will be disrupted if tax revenues fall short of expectations (Khairina et al., 2019). Making accurate predictions will affect the precision of future policymaking (Atrivi, 2017).

The purpose of this study is to determine the best forecasting method for forecasting local tax income receipts in the coming year. The method of forecasting utilized in this study consists of four forecasting methods, namely Single Exponential Smoothing, Double

Exponential Smoothing, Winters Method Additive, and Winters Method Multiplicative. In this study, it will be applied to the data on regional tax incomes of Majalengka Regency. This is due to the fact that Majalengka Regency, as one of the regencies located in West Java Province (West Java), is included in the national legislation program, which is an area in the Segitiga Rebana (Cirebon-Patimban) Metropolitian from the northern region that is projected to drive future economic growth in West Java through the development of innovative, integrated, collaborative, highly competitive industrial estates that are sustainable (Ramdhani, 2020).

In general, forecasting methods are divided into two main categories, namely qualitative and quantifiable methods (Latipah et al., 2019; Maricar, 2019). Forecasting using qualitative methods is intuitive and is carried out when there is no past data, so in forecasting qualitative methods do not carry out systematic calculations. This method usually utilizes the opinions of experts in decision-making considerations. Meanwhile, forecasting with quantitative methods is a forecasting that utilizes past data to hammer mathematical calculations (Maricar, 2019). A method that is often used in quantitative method forecasting is time series.

Mills defines a time series as a time series that occurs over a period of time with data contained in a time series appearing sequentially, either every day, every week, every month, even every year. On this time series displays various features to understand its nature and evolution, including calculating future forecasts (Mills, 2019) . There are many statistical methods that can forecast time series data, such as exponential smooting method, Box-Jenkins, econometrics, regression, and transfer functions (Nurhamidah et al., 2020).

Similar studies have been conducted and relevant to the research topic are found in Table 1.

Table 1.
Relevant Previous Research

Nama Peneliti	Judul Penelitian	Tahun Penelitian
Maricar	Analisa Perbandingan Nilai Akurasi *Moving Average* dan *Exponential Smoothing* untuk Sistem Peramalan Pendapatan pada Perusahaan XYZ	2019
Khairina, Muaddam, Maharani, dan Hatta	*Forecasting of Groundwater Tax Revenue Using Single Exponential Smoothing Method*	2019
Talia, Astuti, Arifin	Peramalan Tingkat Kemiskinan Penduduk Provinsi Kalimantan Timur Menggunakan Metode *Double Exponential Smoothing* Zainal Arifin	2019
Dewi dan Listiowarni	Implementasi *Holt-Winters Exponential Smoothing* untuk Peramalan Harga Bahan Pangan di Kabupaten Pamekasan	2020
Setyowati	*Comparison of Exponential Smoothing and Moving Average Methods in Forecasting for Motor Vehicle Testing Retribution at Blitar City Transportation Service*	2022

Source: Processed by researchers (2021)

Prihatmono and Utami (2017), Rismawati and Darsyah (2018), and Dewi and Listiowarni The Exponential Smoothing Method is more precise than other time series analysis techniques, according to their research findings. (Dewi & Listiowarni, 2020). Setyowati (2022) in her research entitled *Comparison of Exponential Smoothing and Moving Average Methods in Forecasting for Motor Vehicle Testing Retribution at Blitar City Transportation Service* stated that the *Singl*e *Exponential Smoothing* method is an appropriate method to forecast the levy of motor vehicle testing (Setyowati, 2022).

Mean Absolute Percentage Error (MAPE) is a model for calculating the level of forecasting accuracy. The MAPE method is frequently used as a tool for measuring the precision of predictions for a population with varying time interval scale values. This method expresses the average of absolute presentation errors; the forecast with the smallest MAPE value is the most precise (Manuaba et al., 2022). For the percentage of accuracy of prediction of forecasting errors is found in Table 2.

Table 2.
MAPE Value for Prediction Accuracy

MAPE value	Prediction Accuracy
MAPE ≤ 10%	High
10% mape ≤ ≤ 20%	Good
20% ≤ MAPE ≤ 50%	Reasonable

MAPE ≥ 50%	Low

Source: Khairina et al., (2019) (Funa and Kusumawati, 2016; Nugroho, 2016)

Mean Absolute Deviation (MAD) is a model's forecasting error value. The MAD value can be computed by dividing the sum of absolute forecasting error values by the number of data periods (Pongdatu & Putra, 2018). Mean Squared Deviations (MSD) can be a consideration for determining which method gives the lowest deviation in generating the best estimate (Olaniyi et al., 2018).

Mean Square Deviation (MSD) represents the average of the squared values of the data deviation. A smaller forecast error of a unit. MSD is calculated with the same denominator, n, regardless of the model. MSD is a more sensitive metric for estimating extremely big errors than MAD.

Methods

The secondary data sources for this study were obtained from the Central Statistics Agency of the Province of Majalengka. This study's sample is comprised of Majalengka Regency's realized regional tax revenues from 2012 to 2021. For data analysis strategies employing Single Exponential Smoothing, Double Exponential Smoothing, Holt-Winters Additive, and Holt-Winters Multiplicative procedures, Minitab software is utilized for the study of each of these techniques.

Single Exponential Smoothing

Exponential Smoothing is a technique for short-term forecasting. The Moving Average method's development method emphasizes an exponential decrease in the priority of older observation objects. This Single Exponential Method can be used to randomly predict fluctuations (Khairina et al., 2019). Formula Single Exponential Smoothing:

$$F_{t+1} = \alpha . x_t + (1 - \alpha) F_t$$

details:

F_{t+1} = forecast value for period t+1

F_t = forecast value period t

x_t = data value at time t

α = alpha (smoothing constant)

Double Exponential Smoothing

This method can be used when data exhibits a trend and two other components, such as levels and trends, are updated each period. Trend is a smoothed estimate of the average growth over each period, while Levels smoothes the data values at the end of each period. (Talia et al., 2019). Formula Double Exponential Smoothing:

1. Computes the exponential smoothing value (S't) given a symbol (S't) and an equation.

$$S'_t = \alpha . Xt + (1 - \alpha) S'_t - 1$$

2. Calculates the second exponential smoothing value given a symbol (S''t) using the given equation

$$S''_t = \alpha . S^1 + (1 - \alpha) S''_t - 1$$

3. The equation t represents the function that computes the magnitude of a constant's value.

$$\alpha_t = 2S'' - S''t$$

4. Using an equation to determine the slope's value

$$\beta_t = 2S'' - S''t$$

5. Using an equation, calculates the magnitude of the predicted value.

$$F_{t+m} = a_t + b_t m$$

details:

S'_t	= first exponential smoothing value
$S''t$	= second exponential smoothing value
α_t	= the magnitude of the t-period constant
β_t	= trend estimation
F_{t+m}	= predicted value m of the future period
m	= prediction timeframe
Xt	= actual value of period to t
α	= exponential smoothing parameters of magnitude $0< \alpha<1$

Winters Method

The Winters Method, also known as Holt-Winters, has three smoothing stages: actual data smoothing, trend estimation smoothing, and seasonal estimation smoothing. This method is used for non-stationary data to handle seasonal factors and trends that appear simultaneously in time series data. Holt-Winters has two methods: Winters Method Additive, which is used for seasonal variations with fixed increases/decreases, and Holt-Winters Multiplicative, which is used for seasonal variations of data with increases/decreases (fluctuations). (Arumningsih & Darsyah, 2018)

Total Smoothing : $S_t = \alpha X_t + (1- \alpha p)\ (S_{t-1} + T_{t-1})$

Trend Smoothing : $T_t = \beta\ (S_t - S_{t-1}) + (1- \beta)\ T\ b_{t-1}$

Forecast Holt Method : $F_{t+m} = S_t + T_{t*m}$

St = Single smoothing value

Xt = Actual data at t-time

Tt = Trend smoothing

Ft+m = forecast value

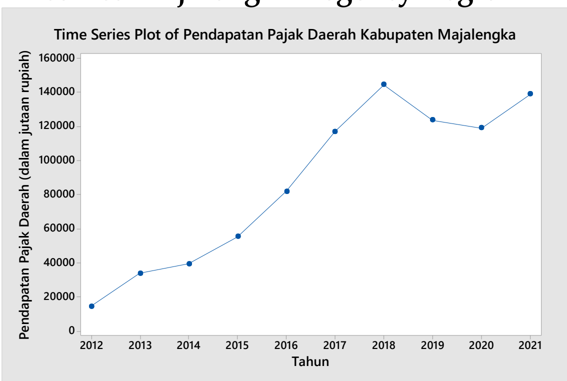
m = prediction timeframe

α, β = constants with values between 0 and 1

Results and Discussion

Predictions of tax income are more accurate with shorter estimates. In addition, the accuracy of forecasting predictions for the following year is strongly correlated with the accuracy of forecasting predictions for the subsequent two to three years (Murdoch et al., 2015). The value of the alpha constant (α) used in each method is 0.1, the value of that constant will result in a forecasting error value that will be considered for the accuracy of the data. For the process of calculating the value of the constant α is chosen randomly (Khairina et al., 2019; Talia et al., 2019). However, the value of the alpha constant used in this study was 0.1, since the best forecasting result was to use an alpha value of 0.1 (Khairina et al., 2019; Maricar, 2019).

Figure 1.
Plot Tax Incomes Majalengka Regency Regional 2012-2021



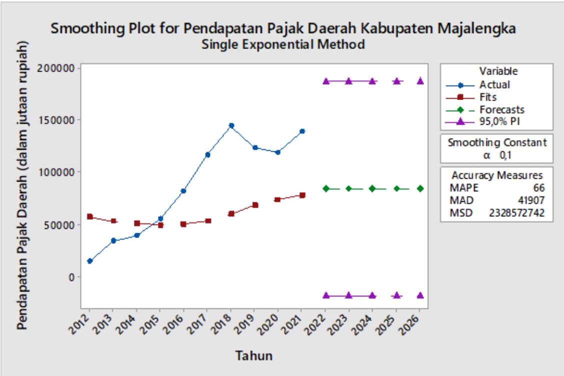
Source: Processed by Researcher (2021)

Figure 1 displays a trend for the Majalengka Regency Regional Tax Income Plot (trend). Depending on the yearly changes in the data, it may increase or even decrease. Consequently, the data pattern is incorporated into the nonstationary data pattern.

Single Exponential Smoothing

The alpha value for *the Single Exponential Smoothing* method uses a value of 0.1. Though this method with the highest accuracy value is the *Exponential Smoothing* method with *an alpha* value of 0.1 (Maricar, 2019).

Figure 2.
Plot of Single Exponential Smoothing of Tax Incomes of Majalengka Regency Area in 2012-2021



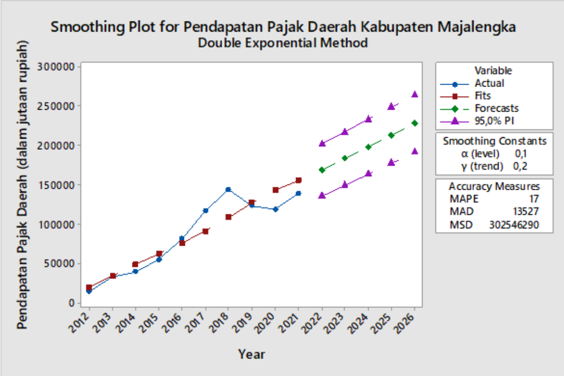
Source: Processed by researchers (2021)

Mean Absolute Percentage Error (MAPE) equals 66 for the Exponential Smoothing (SES) method with a of 0.1. Even though this forecasting accuracy is included in the Low category, where MAPE reaches a figure of more than 50%, thus, the regional tax income forecasting method is not appropriate if using the SES Method. The regional tax income data pattern characteristics exhibit an ascending and descending trend. This SES method can only forecast data as horizontal data patterns.(Aden, 2020)

Double Exponential Smoothing

The constant values used in the *Double Exponential Smoothing* (DES) Method are α=0.1 and γ=0.2.

Figure 3.
Plot Double Exponential Smoothing Plot of Tax Incomes of Majalengka Regency Area in 2012-2021

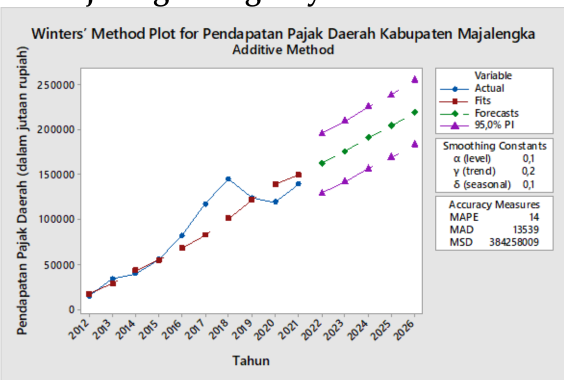


Source: Processed by researchers (2021)

Using the Double Exponential Smoothing (DES) technique with parameters α=0.1 and the γ=0.2, the Mean Absolute Percentage Error (MAPE) is 17. This forecasting accuracy is categorized as Good, with a MAPE of 17%, so the DES forecasting method can be used to predict local tax incomes with seasonal pattern characteristics. Every year, Majalengka Regency's seasonal pattern of regional tax incomes fluctuates both upwards and downwards. Atalis (2019) proposed that the Double Exponential Smoothing technique is more appropriate for data models with two seasonal patterns. (Nurhamidah et al., 2020)

Winters Method Additive

Figure 4.
Winters Method Additive Plot of Tax Income Majalengka Regency Area 2012-2021

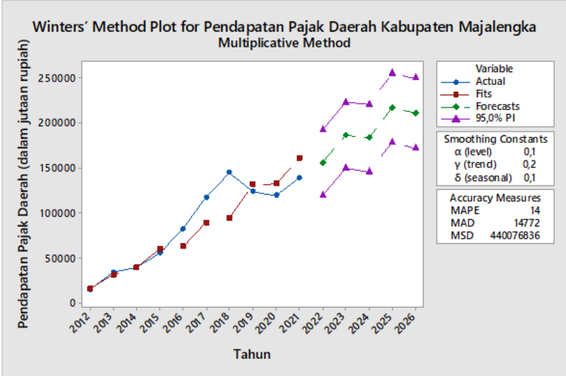


Source: Processed by researchers (2021)

M.A.P.E. (Mean Absolute Percentage Error) for the Winters Method Additive with the α = 0.1, γ = 0.2, and δ= 0.1 is 14. This forecasting accuracy falls within the Good category, with a MAPE of 14%. Consequently, the Winters Method Additive forecasting method could be used to forecast nonstationary local tax income.

Winters Method Multiplicative

Figure 5.
Winters Method Multiplicative Plot of Tax Incomes of Majalengka Regency Area In 2012-2021



Source: Processed by researchers (2021)

The Mean Absolute Percentage Error (MAPE) for prediction using the Winters Multiplicative Method with α = 0.1, γ = 0.2, and δ= 0.1 is 14. Even though this forecasting accuracy falls within the Good category where MAPE reaches 14%. Consequently, the Winters Method Multiplicative forecasting method can be used to forecast local tax income with nonstationary characteristics.

Table 3.
Comparison of Forecasting Methods

Forecasting Methods	MAPE	MAD	MSD
Single Exponential Smoothing	66	41907	2328572742
Double Exponential Smoothing	17	13527	302546290
Winters Method Additive	14	13539	384258009
Winters Method Multiplicative	14	14772	440076836

Source: Processed by researchers (2021)

As can be seen in Table 3, The Winters Method Additive is the best method for forecasting local tax income. This consideration is decided by the MAPE, MAD, and MSD values. This consideration is based on the results of MAPE, MAD, and MSD values with descriptions mape 14, MSD 13539, and MSD 384258009.

The results of this study have differences with research conducted by Talia, Astuti, Arifin (2019) which states that in the *Double Exponential Smoothing* method the best forecasting results are obtained with an alpha value of 0.3. In this study, the *Double Exponential Smoothing* method obtained the best forecasting results with an alpha value of 0.3.

In addition, this study's findings contradict those of Maricar (2019), Prihatmono and Utami (2017), and Rismawati and Darsyah (2018) who concluded that the Exponential Smoothing Method is more accurate than other time series analysis techniques. This research contradicts the findings of Maricar (2019), Prihatmono and Utami (2017), and Rismawati and Darsyah (2018), who stated that the Exponential Smoothing Method is more accurate than other time series analysis techniques. In this study, the Winters Method Additive was more accurate than Single Exponential Smoothing, Double Exponential Smoothing, and the Winters Method Multiplicative. Comparable to the findings of Dewi and Listiowarni (2020), Holt-Winters Additive has a lower MAPE value than Holt-Winters Multiplicative.

Conclusion

Determining the forecasting method is included in the things that need to be considered in making plans. This can affect the realization of local tax incomes. If local tax incomes fall short of the target, it will have an effect on the implementation of development and may even impede its progress. Determining the suitable forecasting method will affect the accuracy of decision-making in the future. The proper forecasting method for local tax incomes is the Winters Method Additive because it produces the smallest MAPE, MAD, and MSD values, with MAPE values being 14, MAD 13539, and MSD 384258009. In this case, the data pattern of regional tax incomes in Majalengka Regency follows the characteristics of the data pattern for the Winters Method Additive.

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