



Research Paper

Statistical Time-Series Forecast via Microsoft Excel (FORECAST.ETS) Built-In Function

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ABSTRACT: In this article, we utilize the famous Exponential Smoothing Methods (ESM) family of Time Series (TS) forecast algorithms reviewed in Rahardja (2020), as an easy-and-quick way to forecast in Excel (version 2016 and above) software while taking into account any existence of level (intercept), trend (slope), and seasonality components into the model. We implement such ESM-family forecasting via the Microsoft Excel (2019) built-in function “FORECAST.ETS”. Familiarity with the Box-Jenkins methods (1976) is not required to forecast via such Excel built-in function (version 2016 and above). For an illustration, we apply such Excel (2019) TS forecast function to a sales data-series example.

KEYWORDS: Time Series, Exponential Smoothing Methods, ESM, Excel, Forecast.

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I. INTRODUCTION

Many decision makers in nowadays organizations need to manage and forecast their future demands (volume) of various items or workloads. For example, economics or business studies typically interested in forecasting their constant (daily, weekly, monthly, yearly) demands (volume) such as the weekly bread sales, the monthly beer sales in a mini market, annual vehicle sales, etc.

In today’s fast business world, most practitioners and forecasters cannot afford the academic-way of doing rigorous research, digging-down, or reinventing-the-wheel of all the ever-existed literature review, available online software manuals, nor attempt to understand numerous papers [1–15] all the way to every single comprehensive papers as listed on Rahardja (2020) paper [16], just to find-out what Time-Series (TS) forecasting methods are suitable for their needs and which computing software are implementable by an average [non-statistician] analyst.

Therefore, in this paper, to close the gaps between what’s available and easily-and-quickly producible [by an average non-statistician analyst] within short timeliness, we present and summarize the simple-quick-and-easy TS-forecasting methods via an Excel (FORECAST.ETS) function [17–21], here. Note that such Excel ‘function’ is not an additional Excel ‘add-ons’ to purchase. Rather, it is an already ‘built-in’ function of Excel version 2016 or above.

The Rahardja (2020) paper [16] organized the literature review into the 3-family category of TS-forecasting methods (see Table 1 in that paper, for the listings of each TS-method’s name and its model equation). Recall that such 3-family category TS models are The Exponential Smoothing Model (ESM) family [2–15], the Auto-Regressive Integrated Moving Average (ARIMA) family models, which are a form of Box-Jenkins model [1], and the Unobserved Component Model (UCM) family, which is also called the Structural Models in the TS literature [7]. The last two-family models (ARIMA-family and UCM-family) can handle much more complex factors beyond the ESM-family and are beyond the scope of what Excel can compute.

Recall that the ESM-family TS models [2–15] can only accommodate the existence of level (intercept), trend (slope), and seasonality into the model. The ESM-family of the TS-forecasting methods are simple-and-easy enough to be implemented via the Microsoft Excel (version 2016 or above). Such Excel forecasting can be implemented via the “FORECAST.ETS” function [17–21].

In this paper, the sections are organized as follow. In Section 2, we describe the data format requirement to forecast in Excel (2019) [22]. In Section 3, we describe the ESM-family TS models and how to implement the forecast via Microsoft (2019) Excel function: “FORECAST.ETS” [17–21] using sales time-series

data, for illustration. We then illustrate the TS modeling using the sales-data series [21] as an illustration (Section 4) to apply the Excel (2019) [22] function “FORECAST.ETS” [17–21]. In the end (Section 5) we conclude the key points and make recommendation for the ESM-family TS-forecasting methods [2–15] via Excel (2019) software [22].

II. DATA

The TS data format requirement in Excel is displayed in Figure 1. In Figure 1, we stack the TS data into two columns. Here, the first column is the ‘DATE’ (for example, monthly: Oct-2000, Nov-2000, Dec-2000, etc). The second column is the ‘VOLUME’ or counts of items or workload.

	A	B
1	DATE	VOLUME
2	10/1/2000	6,962
3	11/1/2000	6,058
4	12/1/2000	4,477
5	1/1/2001	13,794
6	2/1/2001	14,745
7	3/1/2001	15,549
8	4/1/2001	11,174
9	5/1/2001	9,707
10	6/1/2001	6,436
11	7/1/2001	6,760
12	8/1/2001	6,971
13	9/1/2001	6,340
14	10/1/2001	5,154
15	11/1/2001	3,652
16	12/1/2001	2,762
17	1/1/2002	8,228
18	2/1/2002	10,656
19	3/1/2002	12,604
20	4/1/2002	9,928
21	5/1/2002	9,216
22	6/1/2002	6,586
23	7/1/2002	6,475

Figure 1: The “Input” Data Format Requirement for Excel.

Note that there is a distinction between forecasting versus last-observation-carry-forward (LOCF) method [23]. In LOCF method [23], the purpose is to use the past data to impute missing values. Imputation methods are intended for missing values; and not purposed to forecast. The purpose of forecasting is to project future values. The consequence for forcing such non-suitable LOCF method [23] in place of TS-forecasting methods is that the resulting estimates can suffer severe biased.

III. EXCEL (FORECAST.ETS) FUNCTION

In this section, after we stack the TS-data into an Excel-readable format, we utilize the Excel (2019) [22] function “FORECAST.ETS” to produce forecasts (series of future projections) using ESM-family algorithms. Such Excel function is simple and easy-to-use (user friendly) because it does not require any familiarity with the (1976) Box-Jenkins methods [1].

To recapitulate, the Table 1 (Column 2) of Rahardja (2020) paper [16] prescribed all the ESM-family models (with the specific TS-model name) which include/exclude any trend and/or seasonality components. Hence, users can do graphical assessment by just plotting the series. Then decide visually (as opposed to numerically) whether there is obvious trend (slope) and/or seasonality. Then obtain the TS-model name. Note that the following two [out of eight] ESM-family models: Multiplicative Seasonal ESM [9] and Winters Multiplicative ESM [11] listed on Table 1 of Rahardja (2020) paper [16] are not implementable by Excel function (due to the complexity of their hybrid models). The following remaining six ESM-family models are implementable by the Excel FORECAST.ETS function:

- 1) SIMPLE (Single) ESM [2]: use it when TS data has No Trend and No Seasonality.
- 2) DOUBLE (Brown) ESM [3]: use it when TS data has Trend but No Seasonality.
- 3) LINEAR (Holt) ESM [8]: use it when TS data has Trend (2 smoothing weights) but No Seasonality.
- 4) DAMPTREND ESM [6]: use it when TS data has Trend (2 smoothing weights & a damping parameter) but No Seasonality.
- 5) ADD-SEASONAL (Additive Seasonal) or TRIPLE (Holt-Winters) ESM [10]: use it when TS has No Trend but Seasonality.
- 6) ADDWINTERS (Winters Additive) ESM [11]: use it when the TS data has Trend and Seasonality.

The Excel “FORECAST.ETS” function is new in Excel 2016. According to the Microsoft Support (2021) website [17], the “FORECAST.ETS” function is available in Excel for Microsoft 365, Excel 2021, Excel 2019, and Excel 2016.

The FORECAST.ETS function [17–21] in Excel is used to forecast data using an Exponential Smoothing Method (ESM) [2–15]. ESM [2–15] in statistics is used for smoothing time series data by assigning weights exponentially to future values over time. This differs from a simple moving average where past observations are weighted equally. Such FORECAST.ETS function [17–21] calculates or predicts a future value based on existing (historical) data by using the AAA (additive error, additive trend and additive seasonality) version of the advanced machine learning Exponential Triple Smoothing (ETS) algorithm. The predicted value is a continuation of the historical values in the target date range, which should be a continuous timeline with an equal interval between dates. It can be used to predict future sales, inventory requirements or general consumer trends. This FORECAST.ETS function [17–21] requires the timeline to be organized with a constant step between the different points. For example, that could be a monthly timeline with values on the first of every month, a yearly timeline, or a timeline of numerical indices. The syntax of the FORECAST.ETS function is as follow.

<code>=FORECAST.ETS(target_date, values, timeline, [seasonality], [data_completion], [aggregation])</code>
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The FORECAST.ETS function [17–21] syntax has the following arguments.

- **Target_date** (Required). The data point for which you want to predict a value. Target date can be date/time or numeric. If the target date is chronologically before the end of the historical timeline, FORECAST.ETS returns the #NUM! error.
- **Values** (Required). Values are the historical values, for which you want to forecast the next points.
- **Timeline** (Required). The independent array or range of numeric data. The dates in the timeline must have a consistent step between them and cannot be zero. The timeline is not required to be sorted, as FORECAST.ETS will sort it implicitly for calculations. If a constant step cannot be identified in the provided timeline, FORECAST.ETS will return the #NUM! error. If timeline contains duplicate values, FORECAST.ETS will return the #VALUE! error. If the ranges of the timeline and values aren't of same size, FORECAST.ETS will return the #N/A error.
- **Seasonality** (Optional). A numeric value. The default value of 1 means Excel detects seasonality automatically for the forecast and uses positive, whole numbers for the length of the seasonal pattern. 0 indicates no seasonality, meaning the prediction will be linear. Positive whole numbers will indicate to the algorithm to use patterns of this length as the seasonality. For any other value, FORECAST.ETS will return the #NUM! error. Maximum supported seasonality is 8,760 (number of hours in a year). Any seasonality above that number will result in the #NUM! error.
- **Data completion** (Optional). Although the timeline requires a constant step between data points, FORECAST.ETS supports up to 30% missing data, and will automatically adjust for it. 0 will indicate the algorithm to account for missing points as zeros. The default value of 1 will account for missing points by completing them to be the average of the neighboring points.
- **Aggregation** (Optional). Although the timeline requires a constant step between data points, FORECAST.ETS will aggregate multiple points which have the same time stamp. The aggregation parameter is a numeric value indicating which method will be used to aggregate several values with the same time stamp. The default value of 0 will use AVERAGE, while other options are SUM, COUNT, COUNTA, MIN, MAX, MEDIAN.

IV. EXAMPLE

Among numerous research examples [17–21] of forecast calculation via Excel built-in function, Exceljet [21] utilized the Excel FORECAST.ETS function beautifully to illustrate a sales-data example in very clear-and-concise way, as follows.

In the sales data-series example on Figure 2, we type the Excel function on the Cell D13 as “=FORECAST.ETS(B13,C5:C12,B5:B12,4)” and press enter. Note that we intentionally stack the forecast output into the third column, given the first two columns have already satisfied the data-format requirement as described in Figure 1, previously. Such intention is purposed so that the plotted graphs will be displayed in two distinctive colors, in order to differentiate between the observed (past) data and the forecasts (i.e., the future projected values). The fourth (last) argument in the above function is the seasonality. Since the data (visually) is quarterly, so seasonality is given as 4, since there are 4 quarters in a year, and the seasonal pattern is 1 year.

Alternatively, to find-out seasonality (numerically), we can use another built-in Excel function “FORECAST.ETS.SEASONALITY” [24] to return the length of the repetitive pattern Excel detects for a specified time series. Note that to apply such seasonality function, we need to re-stack the forecasted values which originally stacked in different column (purposed to differentiate past-versus-forecast sales graphical plots

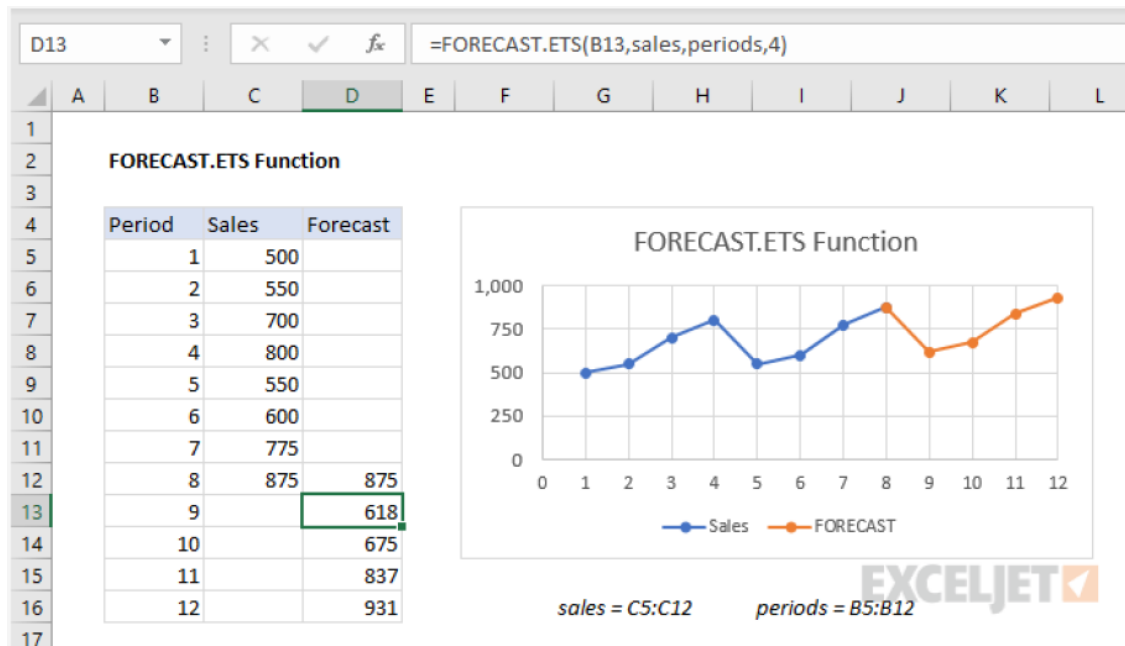


Figure 2: The Excel FORECAST.ETS Function.

in two distinctive colors), to be re-stacked in the same column as the (past) observed data. Hence, for the above sales-data example, the Excel FORECAST.ETS.SEASONALITY function [24] can be used to calculate the length of the seasonal pattern in sales between Period 1 and 12, as “=FORECAST.ETS.SEASONALITY(C5:C16,B5:B16)”, after we re-stack the forecasted series into the same column as the observed (past) data series. In other words, the argument C5:C16 contains the sales values, and the argument B5:B16 contains a timeline. With these inputs, the FORECAST.ETS.SEASONALITY function [24] returns 4, as the seasonality numeric result because the interpreted values in C5:C16 represent quarterly sales data, and the length of the season is 1 year, which is 4 quarters.

V. CONCLUSION

In this paper, we have presented a quick-and-easy option of TS-forecasting via an Excel FORECAST.ETS function [17–21]. We conclude that the built-in function FORECAST.ETS in Excel (version 2016 and above) is very simple-and-quick, easy-to-use (user friendly) way to implement the famous Exponential Smoothing Methods (ESM) family of Time Series (TS) methods [2–15] reviewed in Rahardja [16]. Such Excel function is an easy-and-quick way to forecast while taking into account any existence of level (intercept), trend (slope), and seasonality into the model. This Excel-pathway of TS-forecast option requires very small computing resource. Familiarity with the Box-Jenkins methods [1] is not required to forecast via such Excel function (version 2016 and above). Using a short (only 8-period) time-series sales-data example [21], we have illustrated the application of Excel (2019) [22] FORECAST.ETS function [17–21] to forecast the future 4-period projections of sales volume. Additionally, we also have demonstrated the application of FORECAST.ETS.SEASONALITY function [24] to calculate the seasonality period which numeric output can be entered into the fourth argument (seasonality period) of the FORECAST.ETS function [17–21].

Therefore, this FORECAST.ETS built-in function [17–21] of Excel (version 2016 and above) is highly recommendable for many users without any knowledge of Box-Jenkins methods [1] due to its user-friendliness, economic viability (no add-ons nor new software purchase needed), does not require very long series of TS data, and very small computing resource needed.

DISCLAIMER STATEMENT

This research represents the author’s own work and opinion. It does not reflect any policy nor represent the official position of the U.S. Department of Defense nor any other federal agency.

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