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Computational statistics for time-series forecasts via SAS/ETS 9.4 drop-down menu

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Abstract

In this paper, using the Statistical Time Series (TS) methodologies reviewed in the literature, we present a step-by-step computational statistics procedure to execute TS forecasts computing via a point-and-clicks (semi-automatic) option of SAS (Statistical Analysis Software). Such point-and-clicks pathway of computing is via the *SAS Econometrics Time Series* 9.4 (SAS-ETS) drop-down menu. This paper will be very beneficial for forecasters in multiple areas of applications (e.g., business, epidemiology, sociology, etc.) without much expertise in the Statistical TS methodologies.

Subject Classification: *[2010] 37M10 – Time Series Analysis; 62M10 – Time series, Auto-correlation, Regression, etc.; 91B84 – Economic time series analysis.*

Keywords: *Time series, SAS, SAS-ETS, Econometrics time series, Forecasting, Computing, Point-and-click, Drop-down menu.*

1. Introduction

In a rising high-speed industry expectations, a practical need is to speedily forecast the forthcoming demands of a magnitude of entities in a timely manner, yet maintaining reasonably-assured accuracy level. For example, business organizations are forecasting their daily coffee sales, weekly car-wash sales, monthly car rentals, annual housing sales, etc.

For recurring industry demands, most practitioners in today's speed of industry world cannot imitate the academic-way of reading numerous

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forecasting literature and researching hundreds of pages of forecasting software manuals, just to figure-out which computing software is feasible (i.e., sustainable/maintainable long run) to forecast their multitude of industry needs (in timely manner with reasonable-assurance of accuracy). Therefore, in this manuscript, to close the gap between what forecasting methods existed in the literature and which software can execute the forecast computing within timeliness datelines, yet reasonably accurate enough, we present a user-friendly way (point-and-clicks) of producing forecast (from a drop-down menu) via the *SAS Econometrics Time Series* 9.4 (SAS-ETS-DD) pathway.

As briefly introduced in the Rahardja (2020) article, this user-friendly (point-and-clicks from drop-down menu) option of the SAS-ETS-DD software utilizes the default estimator: Maximum Likelihood Estimator (MLE). Although MLE is computationally uneasy to obtain, often even unobtainable, MLE is the most desirable (ideal) estimator because its five (5) criteria/definition of the *best* (*ideal*) estimator (i.e., asymptotically consistent, normal, unbiased, efficient, and invariant to transformations). Hence, in order to obtain the best/ideal estimator, MLE, it is worthy to forecast entities via this point-and-clicks (semi-automatic) pathway of computing: the SAS-ETS-DD software (drop-down menu) option – which we will present the step-by-step procedure, in the next Sections.

Previous literature (Sypsas, 1989; De Gooijer and Hyndman, 2006; and Rahardja, 2020) discussed almost 7-decade worth of available statistical Time-Series (TS) forecasting methods. The aforementioned latest article (Rahardja, 2020) categorized the TS methods into 3-family models: the Exponential Smoothing Model (ESM) family, the Auto-Regressive Integrated Moving Average (ARIMA) model family, and the Unobserved Component Model (UCM) family.

The first category is the oldest and simplest TS family-model in the literature, the ESM-family model, which has eight (8) models. In the literature review, such eight (8) ESM-family models are Simple/Single ESM (Brown, 1959), Double ESM (Brown, 1962), Linear ESM (Holt, 1957), Damped Trend ESM (Gardner and McKenzie, 1985), Additive Seasonal ESM or Triple ESM (Fried and George, 2011), Multiplicative Seasonal ESM (Hyndman and Athanasopoulos, 2018), Additive Winters ESM (Winters, 1960), and Multiplicative Winters ESM (Chatfield, 1978). The former four ESM, Fomby (2008) explained them in more details. The later four ESM, Hyndman and Athanasopoulos (2018) listed the model equations.

As a form of Box-Jenkins model (1976), the second category, is the ARIMA-family models. Using the Spectral Decomposition algorithm,

the abbreviated version for ARIMA-family formulas expressed the TS components in terms of parameters (p, d, q, and P, D, Q). Such parameters are mixture of its auto-regressive attribute (p), differencing (d), moving average attribute (q), and additional TS predictors. Hence, a typical ARIMA equation may include an autoregressive (AR) attribute, a moving-average attribute (MA), and an integrated (I) attribute, if differencing exists.

Harvey (1989) expressed the third and youngest family-model category, the UCM-family category, as the Structural Models. Via Kalman-filtering algorithm, the Structural Models expressed the TS into "terms" (instead of "parameters" as in the second TS-family case) in a nice additive model. Such additive model may include trend, seasonality, cycles, autoregressive term, a regression term, and the normally distributed error term with its variance.

Researching the statistical TS equations is one big matter to discover in the literature review. However, how to execute the TS forecasts, via nowadays existing computational statistics software, is another big matter. Hence, in this paper we aim to prescribe a step-by-step procedure, to execute TS forecast computing, via the SAS-ETS drop-down menu option version 9.4 (2017; 2020) which optimization algorithm utilize the ideal MLE as the default estimator. We note that expertise with any of the aforementioned about 7-decade worth of TS literature for forecasting methods (Box-Jenkins, 1976; Sypsas, 1989; De Gooijer and Hyndman, 2006; and Rahardja, 2020) are not required to forecast through this way. We also note that there is other software choice than the SAS-ETS 9.4 drop-down menu, to execute TS forecasting. Nevertheless, such additional ways, for examples, via SAS Forecast Studio 14.1 (Rahardja, 2021a); via Excel version 2016 or above (Rahardja, 2021b); etc. are outside the discussion here.

We arranged the sections in the following fashion. In Section 2, we present the prerequisite for the data format in order to be SAS-readable. In Section 3, we explain the successive-steps approach of computing forecasts via SAS-ETS 9.4 drop-down menu pathway (SAS-ETS-DD). Lastly, the conclusion is in Section 4.

2. Data

Without loss of generalities (WLOG), we demonstrate the TS data format requirement in Figure 1, in order to *input* (*import*) data series into SAS computing system. The most frequent option is from an Excel file (with a file extension *.xls* or *.xlsx*), or a text file (with a file extension *.txt*).

We note that the data series displayed in Figure 1 were some randomly created datasets stored into an Excel file, intended just for a demonstration.

In Figure 1, we arranged the TS data into two columns. Here, we entered the 'DATE' (for example, monthly entries: Sep-2000, Oct-2000, Nov-2000, etc.) into the first column. Next, we entered the 'VOLUME' or counts of entities into the second column.

Likewise, for multiple input volumes of entities, we entered the input data into the third, fourth, fifth, …, etc. columns of Figure 1 so that Batch Forecasts can be run, using the (semi-automatic) SAS-ETS drop-down menu option (SAS-ETS-DD).

	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 Data Format for "input" (PROC IMPORT) requirements by SAS.

2.1 *Import Data via the SAS-ETS 9.4 Drop-Down Menu*

There are many ways to import data into the SAS system. The steps below are how to use SAS-ETS 9.4 drop-down menu to ***import* data** (*from* our Desktop/Laptop Computer) *to* the SAS-ETS 9.4 System.

1. Locate and open the data set that will be used to create our forecasts. For example, in Excel (*xls* or *xlsx*) format.
2. Make sure data series are in the SAS-readable format described in Figure 1.
3. Open SAS 9.4 to begin importing. Click on File → Import Data.
4. The Import Wizard will open. In the drop-down menu select Microsoft Excel Workbook on PC Files Server and hit Next. This will prompt us to select the workbook we wish to import.
5. Select Browse and navigate to where the Excel file is stored. Select OK.
6. Select the worksheet (tab) that we would like to import. Select NEXT. NOTE: We can only import one worksheet (tab) at a time.
7. Choose which Library we would like to save the SAS data set. In this case we are choosing the WORK library and naming the data set. It will convert to a SAS data set with the extension "*.sas7bdat*". Select FINISH. NOTE: Anything in the WORK library will be deleted once we close/exit SAS.
8. Once complete we can check the log to confirm the data set imported correctly. Make sure we see the correct number of observations and that it was successfully created. Look for any errors. NOTE: We can also open the data set to confirm the data is correct.
9. After data correct, make sure to close the VIEWTABLE. Else, the SAS process will not run.

2.2 *Import Data via SAS-EG Drop-Down Menu*

Alternatively, we can use SAS Enterprise Guide (SAS-EG) System drop-down menu to import data (from our Desktop/Laptop Computer) to the SAS System (particularly, the SAS-ETS system, in this case). Rahardja (2021a) article (specifically, on Section 2.1) showed such (point-and-click) steps (from the SAS-EG drop-down menu).

3. TS-Forecast Computing via SAS-ETS 9.4 Drop-Down Menu

In this section, after we *input* (*import*) the TS-data (*from* our Desktop/Laptop computer) *to* the SAS-computing system (with a SAS-readable format), here we present a pathway of SAS computing software to produce forecasts (series of future projections): via the SAS-ETS version 9.4 (semi-automatic) drop-down menu pathway.

Within the most recent decade, SAS company make a drop-down menu option available (on top of the default SAS Manual Coding option), via the SAS Econometrics Time Series (SAS-ETS) versions 9.2 / 9.3 / 9.4 commercial licenses. Such SAS-ETS drop-down menu option is user friendly (easy-to-use) because unlike its counter-part, the SAS Manual Hard-Coding version [within the same license subscription], SAS-ETS drop-down menu option/pathway does not require high-level technical expertise in statistical knowledge, nor computing hardcode-writing ability, nor much familiarity with the TS methodologies.

3.1 *Develop A Baseline TS Model which Best Fits the Data to Forecast*

After we *import* the TS data into the SAS system (see Section 2), using SAS 9.4 Time Series Forecasting System [i.e., the SAS-ETS 9.4], we are now ready to *develop* a TS Model that *best fits the data* (as a *Baseline Model* to forecast). At the Upper Panel of the SAS 9.4 system, we can click the drop-down menu as follows.

1. Select Solutions → Analysis → Time Series Forecasting System and click OK in the box that pops up. This is only a warning that we do not have SAS/GRAPH software.
2. Next, a dialogue box pops up prompting you to select the data set you plan to use. We will use the (Excel) file we imported from the WORK library. Confirm the Time ID matches the Excel field holding our date values. Also check to make sure the interval is correct. We may change either of these with Select and Specify respectively. Click OK when done.
3. We are now prompted to the dialogue box. Click "Fit Models Automatically".
4. The next dialogue box opens. The system will process all non-date fields in the worksheet unless we specify which series to process. It will process the/all VOLUME variables/series. To change, choose "Select". When done, we next choose a Selection Criteria.

5. For a "Selection Criteria", for example, we can click the "Root Mean Square Error" (an option for a "*Distance-Based*" Model Selection Criteria). Alternatively, clicking "Select" opens another box (for other options for the "*Model Selection Criteria*"). Click the radio box "Show all". As another example of options, we can click Akaike Information Criterion (AIC) (as a "*Likelihood-Based*" Model Selection Criteria). When done, click OK. Verify everything is correct on next screen, and click RUN.
6. A NOTE box will open. Click OK and we will see that SAS is now testing the best [up to] 20 models for each [VOLUME or variable] data series we have included.
7. Now that a "best" model has been run/chosen, SAS will automatically show us which model it has chosen for each respective data series [i.e., VOLUME or variables] we have modeled/entered. We can also see that 2 new data sets were created in the WORK library: *_est_* and *_out_*. NOTE: Each data series may have different SAS-produced "best fit / selected" TS models. After reviewing models, click CLOSE.

3.2 *Validating Final Model and Producing (Exporting) Forecasts*

Next, the procedure below are the steps for *Validating Final Model* and *Producing (Exporting) Forecasts* (from SAS system, back to our desktop/laptop computer system).

1. Now that we have a final model for each data series, we can now produce a forecast. Having closed the previous screen above, we can now click CLOSE in the new screen. NOTE: To see models again, choose Models Fit.
2. We should now be back to the main Time Series Forecasting System screen. Click Produce Forecasts. Another box will open prompting us to choose the forecast horizon. We either choose a specific time period (e.g., SEP2025) for the horizon to forecast or choose a certain number of time periods (say, 20 periods) to forecast. Once ready, click RUN.
3. A data set called Forecast will be created in the WORK library. Click OK on the pop up notifying us of this.
4. Our forecast is now complete, and we can view the output by choosing Output or double-clicking on the Forecast data set in the Explorer tab (at the Left Panel).

5. There are many ways to get our output to Excel, but by far, the easiest uses the following way/method. After choosing one of the above methods to open and validate your output data set, close the VIEWTABLE and right click on the WORK.Forecast icon in the Explorer tab. Choose "View in Excel." This will open the data set in Excel allowing you to organize, manage, graph, etc. as needed. Make sure to rename and save workbook as needed.
6. NOTE: It is up to the forecaster's and/or stakeholders' wisdom to verify/assess the sensibility/meaningfulness of the output forecasts. If nonsense, they can consult subject-matter expert (SME) and/or experienced statisticians, econometricians, or forecasters to test different models, generating one that all parties feel best represents the data and trend you have (certainly, if time/resource permit). Otherwise, "*data massaging*" for the *input data* may need to be applied (to detect, add 'pulse', remove outliers/influential observations, replacing anomalies with the expected/normal observations, etc.)

3.3 *Test Alternative Models*

To *Test Alternative Models*, using SAS 9.4 Time Series Forecasting System (or SAS-ETS 9.4 drop-down menu) pathway, the following steps are presented.

1. There are many ways to look at other potential models. First, to develop our own models by clicking the "Develop Models" button; instead of "Fit Models Automatically" (second/previous way); or third, by choosing a different "Model Selection Criteria" aside from AIC; or the following forth way, by having SAS computing for us the top [up to] 20 number of models, by clicking "Fit Models Automatically", we can update the selection criteria at this point, if desired.
2. Next, right-click in a gray area in the "Automatic Model Fitting" box that pops out. Scroll to Options → Automatic Fit.
3. In the next box drop-down, we can choose how many models we would like to keep. For this example, we will keep 3 best models. Click OK. Then click Run → OK.
4. Now SAS will give us the 3 best models for each data series [VOLUME or variable]; for example, if we have 2 variables or data series, then SAS will output 6 total models. We can now compare/rank models based on the "Model Selection Criteria" pre-specified

before. However, remember that these models were set/chosen based on AIC even though SAS also displays all other criteria of goodness-of-fit. Hence, the selected TS model is up to the forecaster's SME judgment to visualize the data series to determine/select the baseline/endpoint forecasting method.

5. After having decided the best-selected model, we can now produce a forecast by navigating back to the "Develop Models" button on the main screen.
6. At this point, the screen that appears will only show us the best models for one of the data series (or variable). If we desire to see the other data series (variables), we can navigate to them through the Browse button and then looking in the Time Series Variables box.
7. Once we have chosen our "best" model, click the respective checkbox (under "Forecast Model", next to the "Model Title"), and close the Develop Models screen with the "X" in the top-right corner. As previous steps, we can now produce a forecast. Except this time, it will use the models we chose. NOTE: Make sure to choose a model

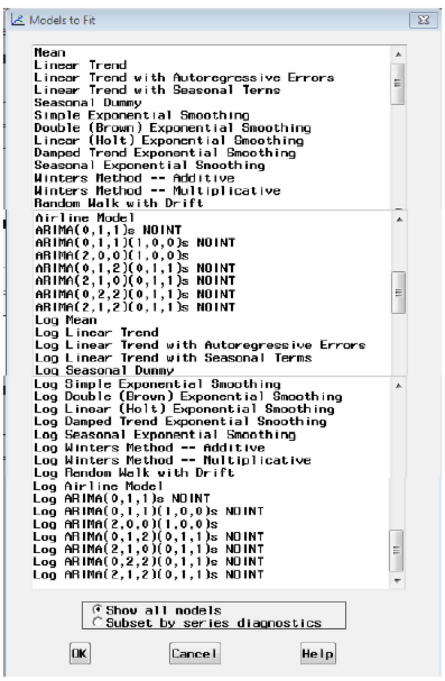

Figure 2

The 42 Time-Series models in the repository of the SAS-ETS version 9.4.

for each data series. When SAS creates a forecast, it will use whatever model was last chosen if we don't choose one.

In general, such user-friendly (point-and-clicks) SAS-ETS (drop-down menu) pathway can achieve up to around 80% accuracy level. Meaning, around 20% forecast margins of errors, are tolerated. If higher forecast accuracy is desired, then more time-consuming and resorting to SAS manual hard-coding are required to upgrade the forecasts beyond the *baseline* forecasts produced by the (semi-automatic, user-friendly, drop-down menu) SAS-ETS pathway.

In Figure 2, the SAS-ETS version 9.4 model repository shows us list of all the candidate/initial/baseline 21-TS models (or 42 models with their corresponding log models) that it can offer.

We note that not all the 42 candidate models can survive being fitted to the inputted/imported data series due to many reasons. In other words, SAS give error messages that it cannot produce forecasts series. Some of the reasons can be (but not limited to): the input data series must be at least 36-month series for majority of the models to produce forecasts; some other models require at least 60-month series, in order to have sufficient degrees of freedom, to produce forecasts; optimization algorithm did not converge or terminated after the default limit of iterations due to slowness to converge, etc. Note that only up-to 20 out of all the 42 candidate models in the model repository (of SAS-ETS version 9.4) can work or be diagnosed, automatically. Majority of the time, only 2 to 8 candidate models can computationally work.

Sometimes, none of those (up-to) 20 candidate models survived, in such automatic drop-down menu environment. In such situation, other pathways (of obtaining some Baseline/Initial Forecast Models) can be resorted. For example, via SAS Manual Coding, using PROC X11, to test/obtain additional 5 candidate models (by clicking the output and search using the keyword "model" using "CTRL-F"). Additionally, via SAS Manual Coding, we can also use PROC FORECAST to test/obtain another additional 12 candidate models. Note that there are over 240 possible (candidate/initial/baseline) TS models but as there is limit for every software, the SAS-ETS drop-down menu can only evaluate up-to 42 alternative TS models (see Figure 2). Those 240+ models are possibly computable via SAS Manual Coding 'PROC' (procedure) pathway, as prescribed in Table 1 of the Rahardja (2020) article. Alternatively, one can also change the default estimator setting, from the MLE to be something else, for example, Conditional Least Squares (CLS) estimator.

3.4 *Model Selection Criteria*

If several candidate models survive, then there are 2-category of [Model Selection] criteria to select the best-fitted (minimum errors) model to forecast the output. Such 2-category of criteria (of measuring minimum errors) are via *Statistical Likelihood-Based* approach (e.g., AIC or Akaike Information Criteria; BIC or Bayesian Information Criteria; etc.) or via *Mathematical Distance-Based* approach (e.g., MAPE or Mean Absolute Percent Error; RMS or Root Mean Squared; etc.) For illustration, typically forecasters choose AIC for likelihood-based criterion or MAPE for distance-based criterion. Then rank those candidate models based on these 2 criteria. In such SAS forecasting context, the top-two ranked candidate models typically would *consistently* have the *smallest* AIC and/or *smallest* MAPE; if not second ranked. So, such top two candidate models are the [statistically] best-recommended one. To pick the best/top ranked model, the final aggregated forecasts/projections should be considered, [meaningfully]. Both *statistical* and *meaningful* interpretations should concur for the *best/final* selected model.

4. Conclusion

We conclude that this article will be beneficial for many average non-statistician forecasters in multiple areas of applications (e.g., business, epidemiology, sociology, etc.) to learn fast and get the initial forecasts.

This SAS-ETS 9.4 (drop-down menu) software option is (SAS-ETS-DD) easy-to-use because it is just point-and-click (from drop-down menu) and require relatively small computing resource. It can run up to around 120 series in one batch submission, before it gets slower; and hence, we need to split the batch forecasts into another batch run. It is also simple to implement TS forecast computing because expertise with the complex statistical TS methodologies in the literature is not required.

The SAS-ETS 9.4 utilized the Maximum Likelihood Estimation (MLE) method as the default optimization algorithm. Although uneasy to obtain (i.e., convergence issues, non-invertible matrices, not twice differentiable, etc.), ideally MLE is most desirable because of its Ideal Properties: asymptotically consistent, normal, unbiased, efficient, and are invariant to transformation. Hence, forecasting via SAS-ETS 9.4 Drop-Down Menu option (SAS-ETS-DD) can typically achieve the ideal (best) estimators (MLE) with around 80% accuracy level.

To enhance the forecast accuracy beyond the initial forecasts, we recommend users or organization to resort to subject-matter expert statisticians via a SAS 9.4 Manual Coding (1995; 2013; 2014a; 2014b; 2018) option. Such SAS Manual Coding discussions are beyond the scope of this article.

There are other software pathways than the SAS-ETS 9.4, to compute statistical TS forecasts. However, those other pathways are outside the scope of discussion of this paper. For instances, using the SAS Forecast Studio 14.1 (Rahardja, 2021a) which utilized Conditional Least Squares (CLS) as opposed to MLE optimization method; using the Excel version 2016 or above (Rahardja, 2021b), etc.

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