Paper SAS3258-2019

Writing a Gradient Boosting Model Node for SAS® Visual Forecasting

Yue Li, Jingrui Xie, and Iman Vasheghani Farahani, SAS Institute Inc.

ABSTRACT

SAS Visual Forecasting, the new-generation forecasting product from SAS, includes a web-based user interface for creating and running projects that generate forecasts from historical data. It is designed to use the highly parallel and distributed architecture of SAS® Viya®, a cloud-enabled, in-memory analytics engine that is powered by SAS® Cloud Analytic Services (CAS), to effectively model and forecast time series on a large scale. SAS Visual Forecasting includes several built-in modeling strategies, which serve as ready-to-use models for generating forecasts. It also supports custom modeling nodes, where you can write and import your own code-based modeling strategies. Similar to the ready-to-use models, these custom modeling nodes can also be shared with other projects and forecasters. Forecasters can use SAS Visual Forecasting to create projects by using visual flow diagrams (called pipelines), running multiple built-in or custom models on the same data, and choosing a champion model based on the results. This paper uses a gradient boosting model as an example to demonstrate how you can use a custom modeling node in SAS Visual Forecasting to develop and implement your own modeling strategy.

INTRODUCTION

SAS Visual Forecasting includes a web-based user interface for creating and running projects to generate forecasts. It provides automation and analytical sophistication to generate millions of forecasts in the fast turnaround time that is necessary to run your business. Forecasters can create projects by using visual flow diagrams (also called pipelines), and can run multiple models on the same data set and choose a champion model on the basis of the forecast results.

Because SAS Visual Forecasting runs in SAS Viya, which has a highly parallel and distributed architecture, is designed to effectively model and forecast time series on a large scale. SAS Cloud Analytic Services (CAS) provides the speed and scalability needed to create the models and generate forecasts for millions of time series. Massive parallel processing within a distributed architecture is one of the key advantages in SAS Visual Forecasting for large-scale time series forecasting.

SAS Visual Forecasting includes a number of modeling strategies that you can use to generate forecasts. These strategies include two hierarchical forecasting models, a panel neural network model, an auto-forecasting model, a naïve model, a multistage forecasting model, a stacked model, and more. Furthermore, you can create your own modeling strategies that you can share with other projects and forecasters. These custom modeling strategies are called pluggable modeling strategies.

The following sections use a gradient boosting model (GBM) as an example to illustrate the steps for writing a pluggable modeling strategy. Gradient boosting is a popular machine learning technique for regression and classification problems. It produces a prediction model in the form of an ensemble of weak prediction models. The example in this paper uses the GRADBOOST procedure in SAS® Visual Data Mining and Machine Learning to implement a GBM. PROC GRADBOOST enables you to build a GBM that consists of multiple decision trees.

FILES REQUIRED TO DEFINE A PLUGGABLE MODELING STRATEGY

The following files are required to define a pluggable modeling strategy in SAS Visual Forecasting 8.3:

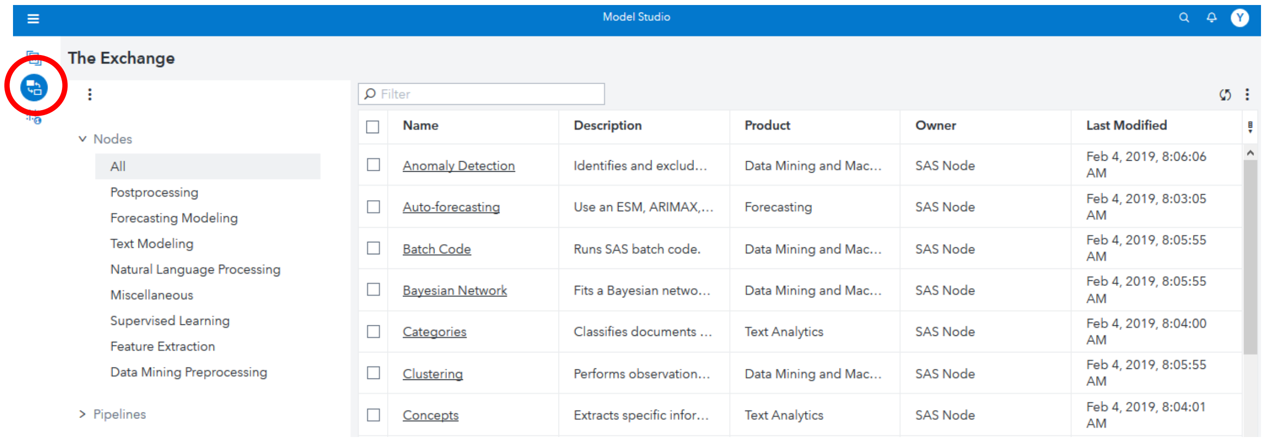
- **code.sas**, which contains the SAS® code to be executed
- **validation.xml**, which defines the validation rules for the strategy specification settings (properties)
- **template.json**, which defines the metadata of the strategy

Starting from SAS Visual Forecasting 8.4, another file is required, **metadata.json**. This file guarantees that the version of the modeling strategies matches the current version of Model Studio. You can download an existing strategy from the exchange and copy the metadata.json file to your modeling strategy to make sure you have the correct version.

These files are packed in a .zip file for uploading to or downloading from **The Exchange** in SAS Visual Forecasting. You can download an existing pluggable modeling strategy and learn from the downloaded example files. Then you can modify the contents accordingly and use the modified files.

To download an existing pluggable modeling strategy:

1. On the **Build Model** tab of the main page of Model Studio, click the button to open **The Exchange**, as shown in Display 1.


Model Studio

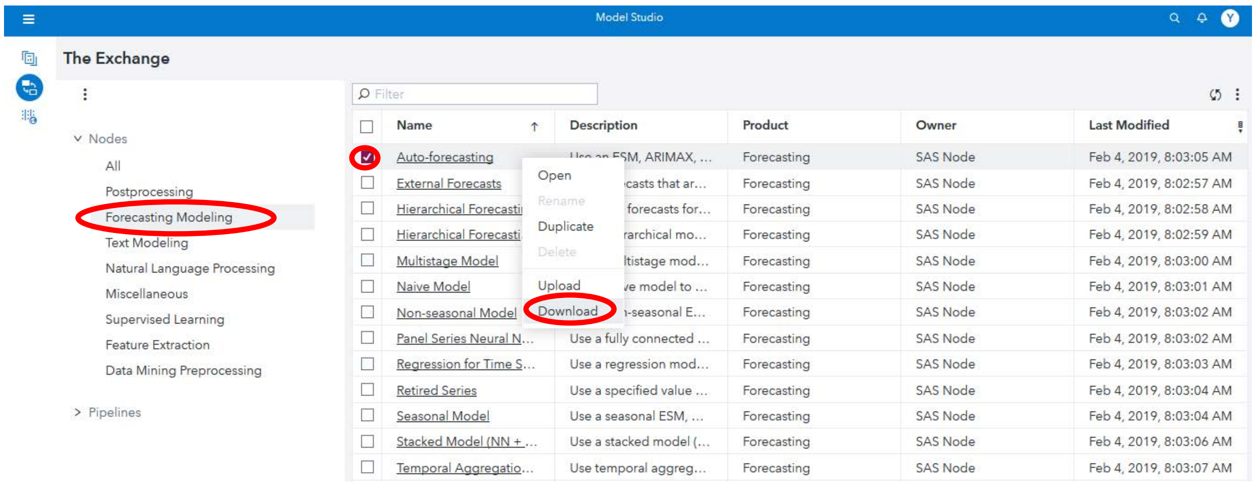
The Exchange

- Nodes
  - All
  - Postprocessing
  - Forecasting Modeling
  - Text Modeling
  - Natural Language Processing
  - Miscellaneous
  - Supervised Learning
  - Feature Extraction
  - Data Mining Preprocessing
- Pipelines

Name	Description	Product	Owner	Last Modified
Anomaly Detection	Identifies and exclud…	Data Mining and Mac…	SAS Node	Feb 4, 2019, 8:06:06 AM
Auto-forecasting	Use an ESM, ARIMAX,…	Forecasting	SAS Node	Feb 4, 2019, 8:03:05 AM
Batch Code	Runs SAS batch code.	Data Mining and Mac…	SAS Node	Feb 4, 2019, 8:05:55 AM
Bayesian Network	Fits a Bayesian netwo…	Data Mining and Mac…	SAS Node	Feb 4, 2019, 8:05:55 AM
Categories	Classifies documents …	Text Analytics	SAS Node	Feb 4, 2019, 8:04:00 AM
Clustering	Performs observation…	Data Mining and Mac…	SAS Node	Feb 4, 2019, 8:05:55 AM
Concepts	Extracts specific infor…	Text Analytics	SAS Node	Feb 4, 2019, 8:04:01 AM

Display 1. The Exchange in Model Studio

2. Select **Forecasting Modeling** from the **Nodes** list, right-click an existing modeling strategy (such as **Auto-forecasting** in Display 2) to be downloaded, and then click **Download**.


Model Studio

The Exchange

- Nodes
  - All
  - Postprocessing
  - Forecasting Modeling
  - Text Modeling
  - Natural Language Processing
  - Miscellaneous
  - Supervised Learning
  - Feature Extraction
  - Data Mining Preprocessing
- Pipelines

Name	Description	Product	Owner	Last Modified
Auto-forecasting	Use an ESM, ARIMAX, …	Forecasting	SAS Node	Feb 4, 2019, 8:03:05 AM
External Forecasts	…casts that ar…	Forecasting	SAS Node	Feb 4, 2019, 8:02:57 AM
Hierarchical Forecasti…	…forecasts for…	Forecasting	SAS Node	Feb 4, 2019, 8:02:58 AM
Hierarchical Forecasti…	…rarchical mo…	Forecasting	SAS Node	Feb 4, 2019, 8:02:59 AM
Multistage Model	…ltistage mod…	Forecasting	SAS Node	Feb 4, 2019, 8:03:00 AM
Naive Model	…ve model to …	Forecasting	SAS Node	Feb 4, 2019, 8:03:01 AM
Non-seasonal Model	…-seasonal E…	Forecasting	SAS Node	Feb 4, 2019, 8:03:02 AM
Panel Series Neural N…	Use a fully connected …	Forecasting	SAS Node	Feb 4, 2019, 8:03:02 AM
Regression for Time S…	Use a regression mod…	Forecasting	SAS Node	Feb 4, 2019, 8:03:03 AM
Retired Series	Use a specified value …	Forecasting	SAS Node	Feb 4, 2019, 8:03:04 AM
Seasonal Model	Use a seasonal ESM, …	Forecasting	SAS Node	Feb 4, 2019, 8:03:04 AM
Stacked Model (NN + …	Use a stacked model (…	Forecasting	SAS Node	Feb 4, 2019, 8:03:06 AM
Temporal Aggregatio…	Use temporal aggreg…	Forecasting	SAS Node	Feb 4, 2019, 8:03:07 AM

Display 2. Download Modeling Strategy

3. Unzip the downloaded .zip file to view the code.sas, validation.xml and template.json files. The following sections describe these files in more detail.

CODE.SAS FILE

The code.sas file contains the run-time SAS code that can be executed in a pipeline to generate forecasts. You can use a set of system-defined macro variables and macros in the run-time code to obtain references to the input data, output forecasts, variable roles, settings, and so on from the pipeline.

Table 1, Table 2, and Table 3 in the appendices show the system-defined macro variables and macros that contain project information such as CAS session, caslibs, table names, and variable roles and settings.

When you write the run-time code, you can refer to these macro variables and macros to retrieve information and generate TSMODEL procedure statements.

Figure 1 shows the contents of the code.sas file, which contains the run-time code.

The code first defines a `%fx_prepare_input` macro that uses the built-in data preparation macro code to prepare input data. The input table is prepared by the Data node in the pipeline. For more information about the input data, see the chapter "Setting Up Your Project" in *SAS Visual Forecasting: User's Guide*. If you want to refer to the input table in code, you can use the macro variable definition, as follows.

```
&vf_libIn.."&vf_inData"n
```

The main code, which is wrapped in a `%gbm_run` macro, first calls the data preparation macro to prepare the input and transform the dependent variable (if needed), and then calls PROC GRADBOOST to build a gradient boosting model. When lag variables for the dependent variable are used in the model, a DATA step is used to recursively score both the historical and future periods according to score code output from the GBM. Another DATA step is then used to prepare the required output. At the end of the file, the main code macro is invoked.

```
/*
    Macro for adding features into input data
        I: &vf_libIn.."&vf_inData"n
        O: &vf_libOut..&vf_tableOutPrefix..&outTblName
*/
%macro fx_prepare_input(outTblName=, byVars=,
                        trendVariable=, seasonalDummy=,
                        seasonalDummyInterval=,
                        esmY=, lagXNumber=, lagYNumber=,
                        holdoutSampleSize=, holdoutSamplePercent=,
                        criteria=, back=);

    %local filerootpath;
    %let filerootpath = &sas_root_location/misc/codegenscrpt/source/sas;
    %include "&filerootpath./vf_data_prep.sas";
    %let temp_work_location = %sysfunc(pathname(work));
    %include "&temp_work_location./vfDataPrepMacro.sas";

%mend;

/*
    Main macro for forecasting using a gradient boosting model
*/
%macro gbm_run;

    /*Protection against problematic _seasonDummy value*/
    %if (not %symexist(_seasonDummy)) %then
        %let _seasonDummy=&vf_timeIDInterval;
    %if "&_seasonDummy" eq "" %then
        %let _seasonDummy = &vf_timeIDInterval;
    %if %sysfunc(INTTEST( &_seasonDummy )) eq 0 %then %do;
        %put Invalid seasonal dummy interval.
             Use &vf_timeIDInterval instead.;
        %let _seasonDummy = &vf_timeIDInterval;
    %end;

    /*Parepare input data with extracted feature used for modeling*/
    %fx_prepare_input(outTblName=fxInData, byVars=&vf_byVars,
                      trendVariable = &_trend,
                      seasonalDummy = &_seasonDummy,
                      seasonalDummyInterval = &_seasonDummyInterval,
                      esmY =FALSE, lagXNumber=&_lagXNumber,
                      lagYNumber=&_lagYNumber,
                      holdoutSampleSize=&_holdoutSampleSize,
                      holdoutSamplePercent=&_holdoutSamplePercent,
                      criteria=RMSE, back=0);

    /*Dependent variable transformation if needed*/
    %let targetVar=gbmTargetVar;
    %let predictVar=P_&targetVar;
    data &vf_libOut.."&vf_tableOutPrefix..fxInData"n /
        SESSREF=&vf_session;
        set &vf_libOut.."&vf_tableOutPrefix..fxInData"n;
        &targetVar = &vf_depVar;
        %if %upcase(&_depTransform) eq LOG %then %do;
          if not missing(&vf_depVar) and &vf_depVar > 0 then
             &targetVar = log(&vf_depVar);
          else call missing(&targetVar);
        %end;
    run;

    /*Train the gradient boosting model*/
    proc gradboost data=&vf_libOut.."&vf_tableOutPrefix..fxInData"n
                   seed=12345;
        id &vf_byVars &vf_timeID;
        partition rolevar=_roleVar(TRAIN="1" VALIDATE="2" TEST="3");
        input &vf_byVars  /level=NOMINAL;
        %if "&vf_indepVars" ne "" %then %do;
          input &vf_indepVars  /level=INTERVAL;
        %end;
        %if %intervalFeatureVarList ne  %then %do;
          input %intervalFeatureVarList /level=INTERVAL;
        %end;
        %if %nominalFeatureVarList ne  %then %do;
          input %nominalFeatureVarList /level=NOMINAL;
        %end;
        target &targetVar / level=interval;
        autotune maxtime=3600
                 tuningparameters=( ntrees(lb=50 ub=500 init=50)) ;
        %if %eval(&_lagYNumber>0) %then %do;
           code file="&temp_work_location./_gbScore.sas";
        %end;
        %else %do;
```

```
            output out=&vf_libOut.."scored_gb"n
                   copyvars=(&vf_byVars &vf_timeID &vf_depVar);
        %end;
    run;

    %if %eval(&_lagYNumber>0) %then %do;
        /*When lagYNumber is nonzero,
          score the model for the whole data set with
          recurrent dependent variable value for the future periods*/
        %let count=%sysfunc(countw(&vf_byVars,%str( )));
        %let lastByVar=%scan(&vf_byVars, &count, %str( ));
        data &vf_libOut.."scored_gb"n /SINGLE=YES;
            set &vf_libOut.."&vf_tableOutPrefix..fxInData"n;
            by &vf_byVars  &vf_timeID;
            retain copyY . %do i=1 %to &_lagYNumber;
                                copyY_lag&i. . %end;;
            gbmLastByVar = &lastByVar;
            if first.gbmLastByVar  then do;
                copyY=.;
                %do i=1 %to &_lagYNumber; copyY_lag&i.=.; %end;
            end;
            %do i=&_lagYNumber  %to 1 %by -1;
                %if &i eq 1 %then %do;
                    if not missing(copyY) then copyY_lag1=copyY;
                %end;
                %else %do;
                    if not missing(copyY_lag%eval(&i -1)) then
                      copyY_lag&i = copyY_lag%eval(&i -1);
                %end;
            %end;
            %do i=1 %to &_lagYNumber; _lagY&i = copyY_lag&i.; %end;
            %include "&temp_work_location./_gbScore.sas";
            if &vf_timeID >= &vf_horizonStart then copyY = &predictVar;
            else copyY = &targetVar;
            drop copyY %do i=1 %to &_lagYNumber; copyY_lag&i.  %end;;
        run;
    %end;

    /*Prepare the required output tables*/
    data &vf_libOut.."&vf_outFor"n;
       set &vf_libOut.."scored_gb"n;
       actual = &targetVar;
       predict = &predictVar;
       %if %upcase(&_depTransform) eq LOG %then %do;
          if not missing(actual) then actual = exp(actual);
          if not missing(predict) then predict = exp(predict);
       %end;
       %if "&vf_allowNegativeForecasts" eq "FALSE" %then %do;
          if not missing(predict) and predict < 0 then predict = 0;
       %end;
       %if &targetVar ne &vf_depVar or &predictVar ne predict %then %do;
          drop &targetVar  &predictVar;
       %end;
    run;

%mend;
```

```
/*Invoke the main macro */
%gbm_run;
```

Figure 1. Contents of code.sas File for the Gradient Boosting Model Example

The only required output table is the OUTFOR table. The other tables are all optional.

The required OUTFOR table contains forecasts from the forecast models; it can be referred to as follows:

```
&vf_libOut..&vf_outFor
```

The OUTFOR table must have the following columns:

- byVars
- timeID
- actual (actual value of the dependent variable)
- predict (predicted value of the dependent variable)

The OUTFOR table can also have the following columns:

- std (standard deviation of errors)
- lower (lower confidence limit of predicted values)
- upper (upper confidence limit of predicted values)

SAS Visual Forecasting automatically validates the OUTFOR table and promotes it so that it can be used as a global CAS table. If the required columns do not exist, the modeling node reports errors. SAS Visual Forecasting also checks the OUTFOR table for invalid values (such as extreme values and negative values) and reports warning messages if it detects any.

The optional OUTSTAT table contains forecast accuracy measures such as MAPE and RMSE; it can be referred to as follows:

```
&vf_libOut..&vf_outStat
```

The OUTSTAT table must have the following columns:

- byVars
- summary statistics, including DFE N NOBS NMISSA NMISSP NPARMS TSS SST SSE MSE RMSE UMSE URMSE MAPE MAE RSQUARE ADJRSQ AADJRSQ RWRSQ AIC AICC SBC

APC MAXERR MINERR MAXPE MINPE ME MPE MDAPE GMAPE MINPPE MAXPPE MPPE MAPPE MDAPPE GMAPPE MINSPE MAXSPE MSPE SMAPE MDASPE GMASPE MINRE MAXRE MRE MRAE MDRAE GMRAE MASE MINAPES MAXAPES MAPES MDAPES GMAPES

If the pluggable modeling strategy run-time code generates this table, the pipeline will validate the table and promote it so that it can be used as a global CAS table. If any required columns or measurements are missing from the table or the run-time code does not output this table, the pipeline will automatically compute the statistics and generate this table on the basis of actual and predicted series from the OUTFOR table.

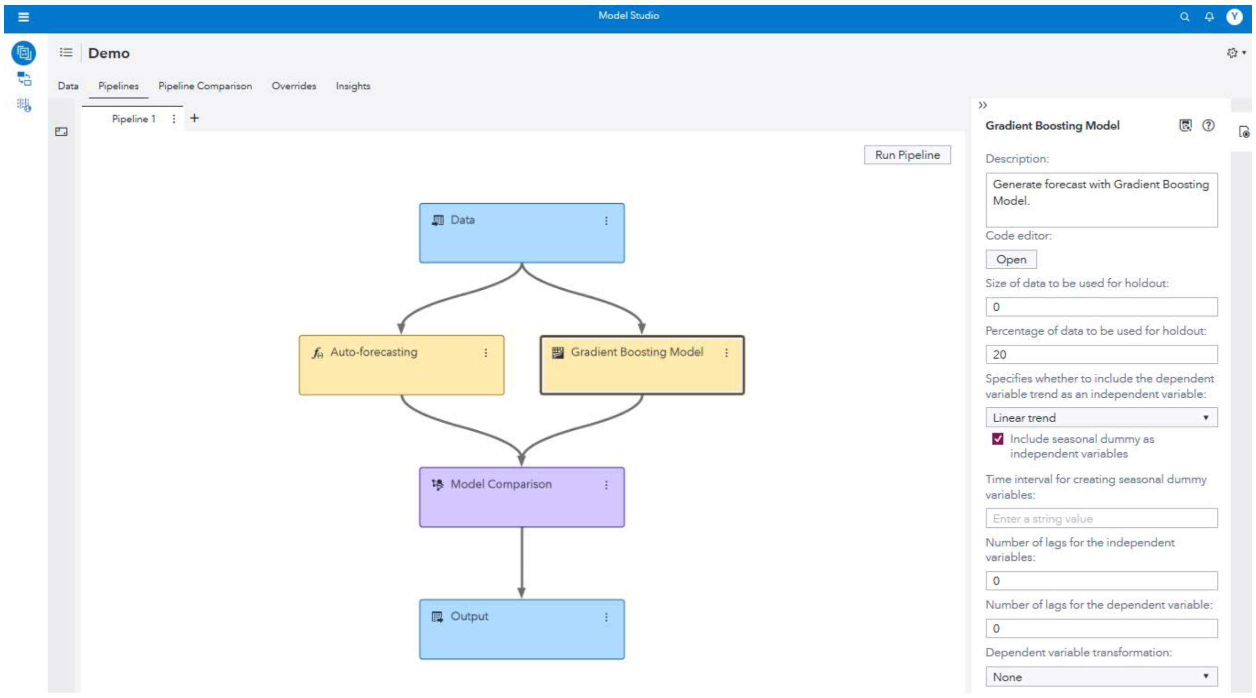
SAS Visual Forecasting automatically promotes the OUTFOR table and the OUTSTAT table (if it exists) so that they can be used as global CAS tables. You can promote any additional output tables in the run-time code by calling the `%vf_promoteCASTable` macro.

VALIDATION.XML FILE

The validation.xml file validates the specification settings against valid values in XML format. The file conforms to an XML schema that is used to validate any XML you provide to the validation service when you define a new validation model.

When a pluggable modeling strategy is added to a pipeline, the strategy specifications (type, name, displayName, choicelist, and so on) are retrieved from the validation.xml file and are displayed on the right panel of the modeling pipeline interface, with the default values defined in the template.json file and the allowable values defined in the validation.xml file.

A validation model can be best described via an example. Display 3 shows how the GBM example modeling node specifications are displayed in a pipeline.



Gradient Boosting Model

Description:
Generate forecast with Gradient Boosting Model.

Code editor:
Open

Size of data to be used for holdout:
0

Percentage of data to be used for holdout:
20

Specifies whether to include the dependent variable trend as an independent variable:
Linear trend

☑ Include seasonal dummy as independent variables

Time interval for creating seasonal dummy variables:
Enter a string value

Number of lags for the independent variables:
0

Number of lags for the dependent variable:
0

Dependent variable transformation:
None

Display 3. Modeling Pipeline Interface with the GBM Node Property

Figure 2 shows the contents of the validation.xml file for this GBM example. The root element in this file is validationModel; it can have a name and a description as shown in Figure 2.

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<validationModel
    description="Generate forecast with Gradient Boosting Model."
    name="Gradient Boosting Model" revision="0">
    <links/>
    <version>1</version>
    <properties>
        <property name="_holdoutSampleSize"
                  displayName="Size of data to be used for holdout"
                  type="integer">
            <constraints>
                <range min="0" includeMin="true"/>
            </constraints>
        </property>
        <property name="_holdoutSamplePercent"
                  displayName="Percentage of data to be used for holdout"
                  type="double">
            <constraints>
                <range min="0" max="100"
                 includeMin="true" includeMax="false"/>
            </constraints>
        </property>

        <property name="_trend"
                  displayName="Specifies whether to include the dependent
                               variable trend as an independent variable"
```

```
                   type="string">
            <constraints>
                <choicelist>
                  <choice value="None"      displayValue="No trend"/>
                  <choice value="Linear"    displayValue="Linear trend"/>
                  <choice value="Damptrend" displayValue="Damped trend"/>
                </choicelist>
            </constraints>
        </property>
        <property name="_seasonDummy"
                  displayName="Include seasonal dummy
                               as independent variables"
                  type="boolean"/>
        <property name="_seasonDummyInterval"
                  displayName = "Time interval for creating
                                 seasonal dummy variables"
                  type = "string" required="false"
                  enabledWhen="_seasonDummy">
        </property>
        <property name="_lagXNumber"
                  displayName="Number of lags for the independent variables"
                  type="integer">
            <constraints>
                <range min="0" includeMin="true"/>
            </constraints>
        </property>
        <property name="_lagYNumber"
                  displayName="Number of lags for the dependent variable"
                  type="integer">
            <constraints>
                <range min="0" includeMin="true"/>
            </constraints>
        </property>
        <property name="_depTransform"
                  displayName="Dependent variable transformation"
                  type="string">
            <constraints>
                <choicelist>
                    <choice value="NONE" displayValue="None"/>
                    <choice value="LOG" displayValue="Logistic"/>
                </choicelist>
            </constraints>
        </property>

   </properties>
</validationModel>
```

Figure 2. Contents of validation.xml File for the Gradient Boosting Model Example

Within the model, properties are defined in a “properties” element, which can contain any number of “property” elements or “group” elements. Each property that is defined in the model describes how values are interpreted by the validation engine when it is asked to validate a map of name, value pairs. The basic required information for a property is as follows:

- **name**: this corresponds to the key used in the map being validated. This is also the macro variable name that can be used in the code.sas file to refer to the property setting value.
- **displayName**: a localizable, user-friendly name for the property. This is provided so that the SAS Visual Forecasting GUI can display meaningful content to instruct users to specify the property values.
- **type**: the type of this property. Currently supported types are string, integer, double, and Boolean.
- **required** (optional): a true or false value that indicate whether a value for this property is required. The default is true.
- **enabledWhen** (optional): a Boolean expression, which, when evaluated, indicates whether this property is enabled. A property that is not enabled is not validated. This field can also be used by the GUI to disable controls that are associated with properties that have been made unavaiable as values in the properties map change. In the GBM example, the **Time interval for creating seasonal dummy variables** box is available only when the **Include seasonal dummy as independent variables** checkbox is checked.
- **Constraints** (optional): constraints on the property value. Properties can have one or more constraints. Typically, only one constraint is needed. Constraints themselves support the “enabledWhen” attribute so that it is possible for a property to have different constraints that depend on some condition. Two types of constraints are currently supported: choice lists and ranges. You can see how these work by referring to the Figure 2. For example, _trend property has a choicelist constraint that requires the choice value to be “None”, “Linear”, or “Damptrend”, and the _holdoutSampleSize property has a range constraint that required its value to be an integer. Note that some properties do not specify any constraints.

TEMPLATE.JSON FILE

The template.json file contains the metadata about the strategy in JSON format. Figure 3 shows the file contents for the GBM example.

```
{
  "name" : "Gradient Boosting Model",
  "description" : "Generate forecast with Gradient Boosting Model.",
  "revision" : 0,
  "version" : 1,
  "prototype" : {
    "name" : "Gradient Boosting Model",
    "revision" : 0,
    "executionProviderId" : "Compute",
    "status" : "undefined",
    "componentProperties" : {
      "_holdoutSampleSize": 0,
      "_holdoutSamplePercent": 20,
      "_trend": "Linear",
      "_seasonDummy": true,
      "_lagXNumber": 0,
      "_lagYNumber": 0,
      "_depTransform": "NONE",
      "preProcessTransformationsCode": ""
    }
  },
  "applicationId" : "forecasting",
  "classification" : "pluggable",
  "providerId" : "CustomTemplate",
  "group" : "modeling",
  "hidden" : false
}
```

Figure 3. Contents of template.json File for the Gradient Boosting Model Example

The following information is included in this file:

- **name**: name of the strategy; this name will be displayed as the name of the node
- **description**: description of the strategy; this description will be displayed as the description of the node
- **revision**: revision information
- **version**: version information
- **prototype**
    - **name**: Specify the same value as the first name field
    - **revision**: Specify the same value as the first revision field
    - **executionProviderId**: Specify “Compute”
    - **status**: Specify “undefined”

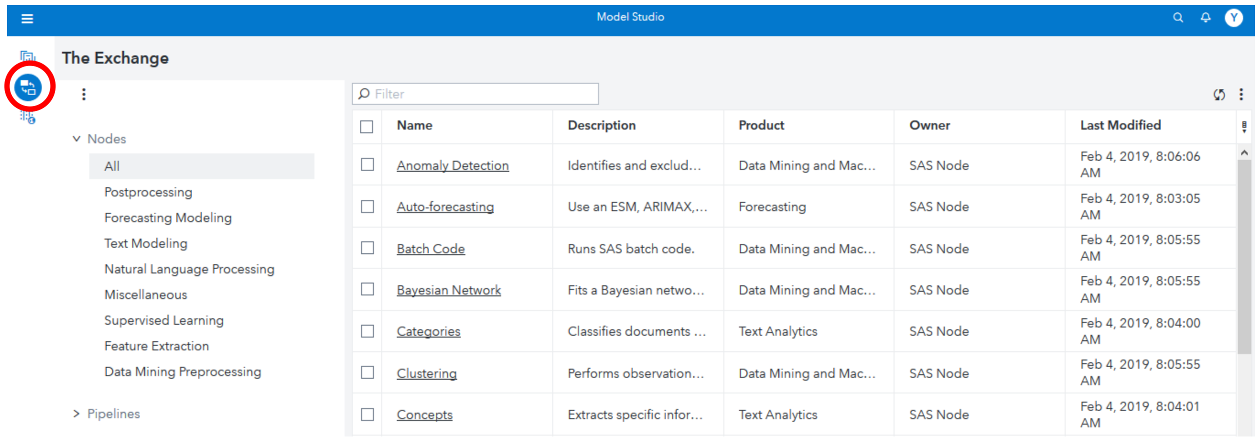
- **componentProperties**: contains the specifications and the corresponding default values. The file can contain two types of properties:
  - Model properties: In this example, seven out of the eight specifications that are defined in the validation.xml file are declared in this file with default values. It is not necessary to declare the "_seasonDummyInterval" option because required="false" is specified in the validation.xml file.
  - Process property: You also need to include one additional property called preProcessTransformationsCode with default value set to "" to make sure the pipeline works as expected.

- **applicationId**: Specify the application, which can be "forecasting", "text", or "datamining". The value "forecasting" should always be used for SAS Visual Forecasting strategies.
- **classification**: Specify "pluggable"
- **providerId**: Specify "CustomTemplate"
- **group**: Specify "modeling"
- **hidden**: Specify false

PUTTING EVERYTHING TOGETHER

After you create a .zip file from the files of the pluggable modeling strategy, you can upload the .zip file through **The Exchange** as follows:

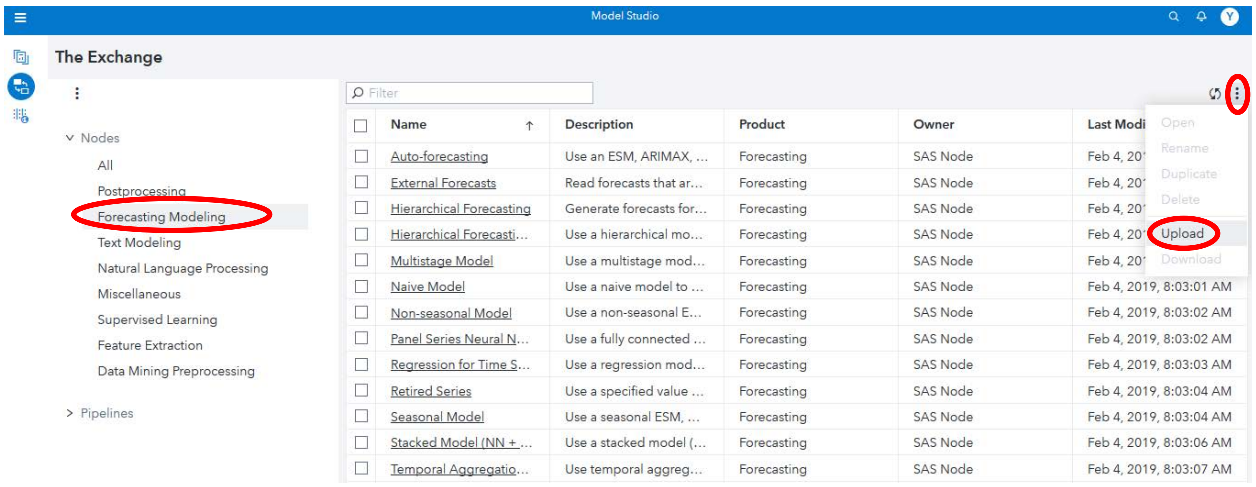
1. On the **Build Model** tab of the main page of Model Studio, click the button to open **The Exchange**.



Name	Description	Product	Owner	Last Modified
Anomaly Detection	Identifies and exclud…	Data Mining and Mac…	SAS Node	Feb 4, 2019, 8:06:06 AM
Auto-forecasting	Use an ESM, ARIMAX,…	Forecasting	SAS Node	Feb 4, 2019, 8:03:05 AM
Batch Code	Runs SAS batch code.	Data Mining and Mac…	SAS Node	Feb 4, 2019, 8:05:55 AM
Bayesian Network	Fits a Bayesian netwo…	Data Mining and Mac…	SAS Node	Feb 4, 2019, 8:05:55 AM
Categories	Classifies documents …	Text Analytics	SAS Node	Feb 4, 2019, 8:04:00 AM
Clustering	Performs observation…	Data Mining and Mac…	SAS Node	Feb 4, 2019, 8:05:55 AM
Concepts	Extracts specific infor…	Text Analytics	SAS Node	Feb 4, 2019, 8:04:01 AM

Display 4. The Exchange in Model Studio

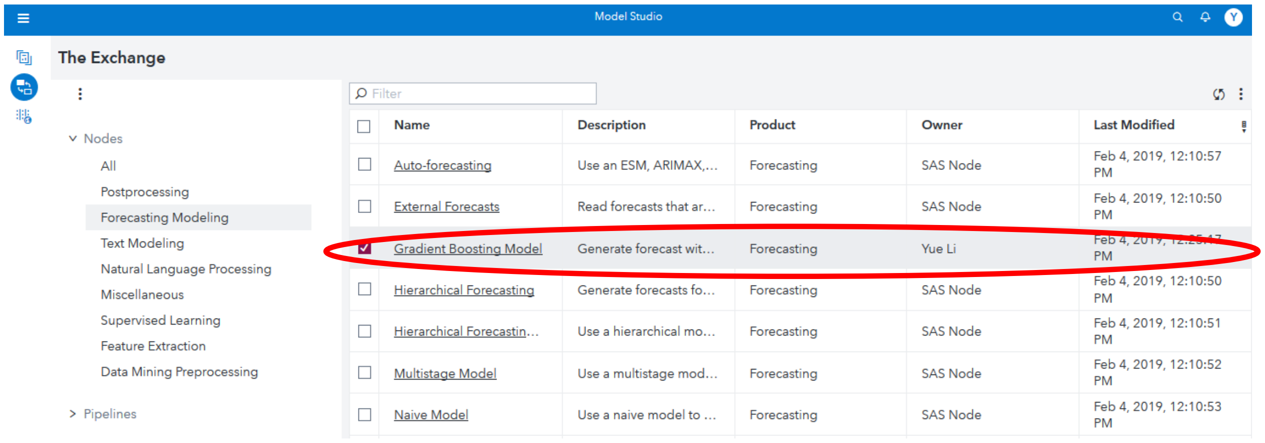
2. Select **Forecasting Modeling** and click the three dots in upper right corner of the page. Select the **Upload** option to open another window as shown in Display 5. Select the .zip file of the pluggable model that you want to upload and click **OK**.



Name	Description	Product	Owner	Last Modi
Auto-forecasting	Use an ESM, ARIMAX, …	Forecasting	SAS Node	Feb 4, 20
External Forecasts	Read forecasts that ar…	Forecasting	SAS Node	Feb 4, 20
Hierarchical Forecasting	Generate forecasts for…	Forecasting	SAS Node	Feb 4, 20
Hierarchical Forecasti…	Use a hierarchical mo…	Forecasting	SAS Node	Feb 4, 20
Multistage Model	Use a multistage mod…	Forecasting	SAS Node	Feb 4, 20
Naive Model	Use a naive model to …	Forecasting	SAS Node	Feb 4, 2019, 8:03:01 AM
Non-seasonal Model	Use a non-seasonal E…	Forecasting	SAS Node	Feb 4, 2019, 8:03:02 AM
Panel Series Neural N…	Use a fully connected …	Forecasting	SAS Node	Feb 4, 2019, 8:03:02 AM
Regression for Time S…	Use a regression mod…	Forecasting	SAS Node	Feb 4, 2019, 8:03:03 AM
Retired Series	Use a specified value …	Forecasting	SAS Node	Feb 4, 2019, 8:03:04 AM
Seasonal Model	Use a seasonal ESM, …	Forecasting	SAS Node	Feb 4, 2019, 8:03:04 AM
Stacked Model (NN + …	Use a stacked model (…	Forecasting	SAS Node	Feb 4, 2019, 8:03:06 AM
Temporal Aggregatio…	Use temporal aggreg…	Forecasting	SAS Node	Feb 4, 2019, 8:03:07 AM

Display 5. Upload New Modeling Strategy

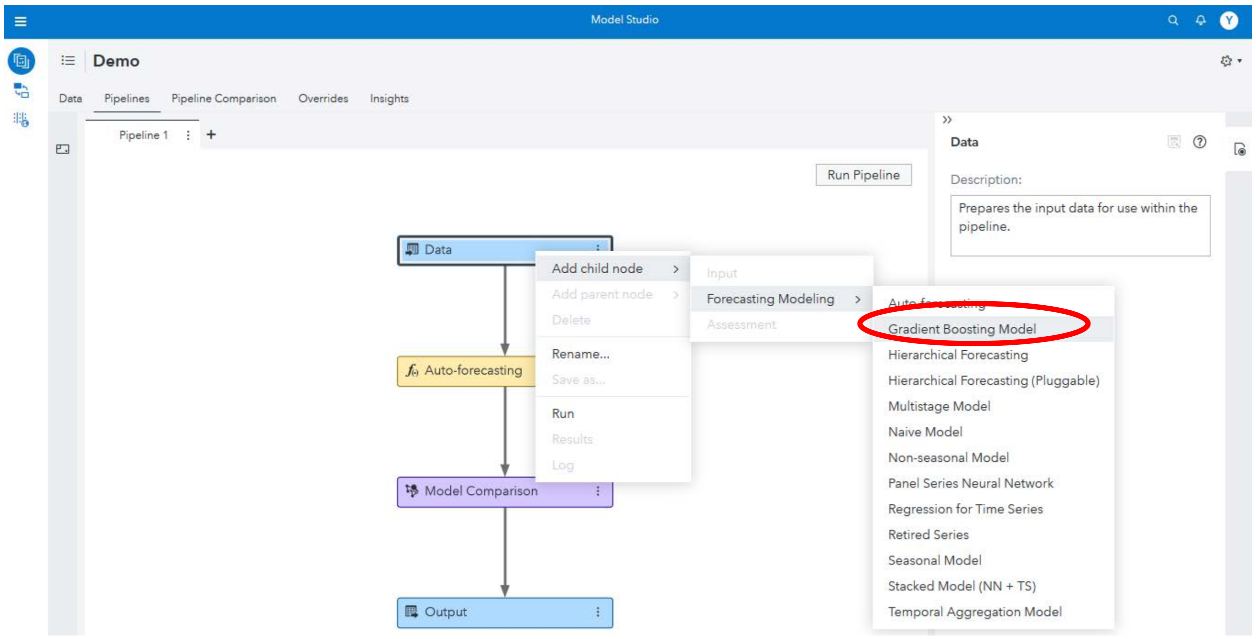
After the pluggable modeling strategy has been successfully uploaded, it will show up under the **Forecasting Modeling** node as shown in Display 6.



	Name	Description	Product	Owner	Last Modified
☐	Auto-forecasting	Use an ESM, ARIMAX,...	Forecasting	SAS Node	Feb 4, 2019, 12:10:57 PM
☐	External Forecasts	Read forecasts that ar...	Forecasting	SAS Node	Feb 4, 2019, 12:10:50 PM
☑	Gradient Boosting Model	Generate forecast wit...	Forecasting	Yue Li	Feb 4, 2019, 12:25:17 PM
☐	Hierarchical Forecasting	Generate forecasts fo...	Forecasting	SAS Node	Feb 4, 2019, 12:10:50 PM
☐	Hierarchical Forecastin...	Use a hierarchical mo...	Forecasting	SAS Node	Feb 4, 2019, 12:10:51 PM
☐	Multistage Model	Use a multistage mod...	Forecasting	SAS Node	Feb 4, 2019, 12:10:52 PM
☐	Naive Model	Use a naive model to ...	Forecasting	SAS Node	Feb 4, 2019, 12:10:53 PM

Display 6. Gradient Boosting Model Appears in The Exchange

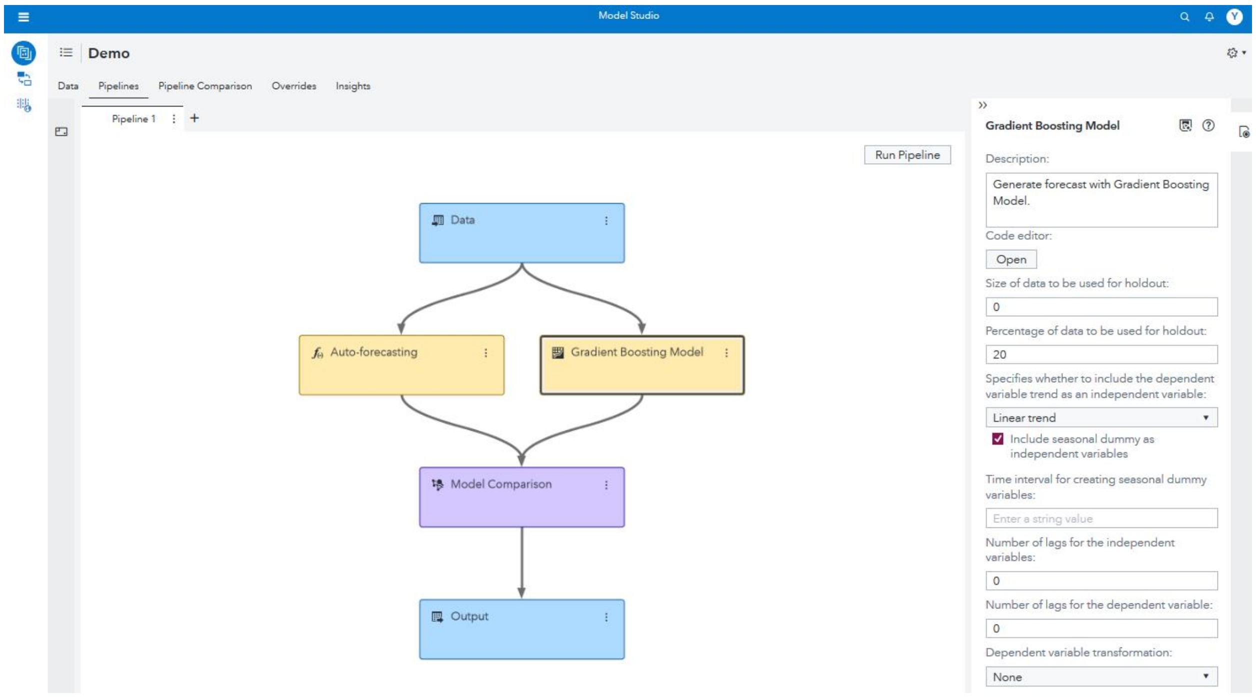
The pluggable model (**Gradient Boosting Model** in this example) becomes available when you build a SAS Visual Forecasting pipeline, as shown in Display 7.



Prepares the input data for use within the pipeline.

Display 7. Add the New Gradient Boosting Model Node

You can use the pluggable model to add a modeling node. When the modeling node is selected, related information is displayed in the side panel. From there, you can view the code or change the parameter settings. In Display 8, all parameter settings that are defined in the GBM model are correctly displayed and are ready to receive your input.



Gradient Boosting Model

Description:
Generate forecast with Gradient Boosting Model.

Code editor:
Open

Size of data to be used for holdout:
0

Percentage of data to be used for holdout:
20

Specifies whether to include the dependent variable trend as an independent variable:
Linear trend

✓ Include seasonal dummy as independent variables

Time interval for creating seasonal dummy variables:
Enter a string value

Number of lags for the independent variables:
0

Number of lags for the dependent variable:
0

Dependent variable transformation:
None

Display 8. Pipeline with the New Gradient Boosting Model Node

Checklist

You can use the following checklist to sort out everything required to build a pluggable modeling node:

1. Create a .zip file that contains the files: template.json, validation.xml, and code.sas.
2. Make sure the code in the code.sas file follows the I/O contracts for input and output tables.
3. Upload the .zip file to **The Exchange**.
4. The pluggable model is ready to use in the pipeline.

CONCLUSION

This paper introduces how you can build a customized modeling strategy node in SAS Visual Forecasting by going through a step-by-step example of building a gradient boosting modeling node. You can follow the instructions and build your own customized modeling node for forecasting purposes.

APPENDICES

APPENDIX I. SYSTEM-DEFINED MACRO VARIABLES

Table 1 shows the system-defined macro variables that are related to input and output.

Macro Variable	Description
vf_session	CAS session name
vf_sessionID	CAS session ID
vf_caslibIn	caslib where input data is stored
vf_caslibOut	caslib where output data is stored
vf_libIn	CAS engine libref for input data
vf_libOut	CAS engine libref for output data
vf_tableInPrefix	Input table name prefix, which is used to differentiate input tables among different projects
vf_tableOutPrefix	Output table name prefix, which is used to differentiate output tables among different projects
vf_inData	Input table name
Vf_inAttribute	Input attribute table name
vf_outFor	Output forecast table name
vf_outStat	Output statistics table name
vf_outInformation	Output information table name
vf_outSelect	Output model selection table name
vf_outModelInfo	Output model information table name
vf_outLog	Output log name

Table 1. System-Defined Macro Variables That Are Related to Input and Output

Table 2 shows the macro variables that are related to data specification.

Macro Variable	Description
vf_depVar	Dependent variable name
vf_depVarAcc	Accumulation setting for the dependent variable
vf_depVarAgg	Aggregation setting for the dependent variable
vf_depVarSetMissing	Missing-value interpretation setting for the dependent variable
vf_byVars	BY variables defined for the project
vf_timeID	Time ID variable name
vf_timeIDInterval	Time series interval
vf_timeIDSeasonality	Time series seasonality
vf_setMissing	Missing-value interpretation setting for the time ID
vf_lead	Forecast lead
vf_horizonStart	Forecast horizon start date
vf_reconcileLevelNumber	Reconcile level number specified for the project; the _TOP_ level number is 0
vf_reconcileLevel	BY variable that corresponds to the reconcile level specified for the project
vf_allowNegativeForecasts	Boolean value indicating whether negative values are allowed in the forecast results
vf_indepVars	Strings that specify the independent variable names (for example, promotion, price, and inventory)
vf_indepVarsAcc	Accumulation settings for the independent variables
vf_indepVarsAgg	Aggregation settings for the independent variables
vf_indepVarsSetMissing	Missing-value interpretation settings for the independent variables

Macro Variable	Description
vf_indepVarsRequired	Specification of whether independent variables are required (YES, NO)
vf_indepVarsExtend	Forecast method for extension
vf_events	List of events defined in the project
vf_eventsRequired	Specification of whether the events are required
vf_inEventData	Event definition data
vf_inEventObj	inEventObj with all event data definitions specified, which can be used in PROC TSMODEL with the ATSM package

Table 2. Macro Variables That Are Related to Data Specification

APPENDIX II. SYSTEM-DEFINED MACROS

Table 3 shows the system-defined macros.

Macro	Description
%vf_depVarTSMODEL	Declares the dependent variable for PROC TSMODEL (Note 1)
%vf_indepVarsTSMODEL	Declares the independent variables for PROC TSMODEL (Note 1)
%vf_varsTSMODEL	Declares statement both the dependent variable and independent variables for PROC TSMODEL (Note 1)
%vf_addXTSMODEL(tsdf)	Adds independent variables tothe ATSM package data frame in PROC TSMODEL (Note 2)
%vf_addEvents(tsdf, eventsObj)	Declares and adds event specification to the ATSM package data frame and event object in PROC TSMODEL (Note 3)
%vf_promoteCASTable(localCASTable = , globalCASTable =)	Promotes a local CAS table to a global CAS table (Note 4)

Table 3. List of Macros

Notes:

1. The %vf_varsTSMODEL macro generates the VAR statements of the PROC TSMODEL to define the dependent and independent variables. It combines the statements that are generated by the %vf_depVarTSMODEL and %vf_indepVarsTSMODEL macros. The statements also include the ACC= and SETMISS= settings for the corresponding variables. For example, when there is one dependent variable, y, and two independent variables, x1 and x2, the macro generates the following statement:

```
var y /acc=SUM setmiss=MISSING;
var x1/acc=AVG setmiss=AVG;
var x2/acc=AVG setmiss=FIRST;
```

2. The %vf_addXTSMODEL macro generates an addX function call of the Time Series Data Frame (TSDF) object from the Automatic Time Series Modeling (ATSM) package for all the independent variables. The following example shows the use of the %vf_addXTSMODEL macro:

```
declare object dataFrame(tsdf);
%if "&vf_indepVars" ne "" %then %do;
%vf_addXTSMODEL(dataFrame);
%end;
```

3. The %vf_addEvents macro adds event specifications of the TSDF object and the event object from the ATSM package. The following example shows the use of the %vf_addEvents macro:

```
declare object dataFrame(tsdf);
%if "&vf_inEventObj" ne "" or "&vf_events" ne "" %then %do;
declare object ev1(event);
rc = ev1.Initialize();
%vf_addEvents(dataframe, ev1);
%end;
```

4. The %vf_promoteCASTable macro promotes a local CAS table to the global level. If you want to make any table other than the system-defined output tables available for further use, you need to use the %vf_promoteCASTable macro to promote them.

CONTACT INFORMATION

Your comments and questions are valued and encouraged. Contact the author:

Iman Vasheghani Farahani
SAS Institute Inc
Iman.VasheghaniFarahani@sas.com