Promotional Analysis and Forecasting for Demand Planning:
A Practical Time Series Approach

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Exhibits

This detailed demonstration describes how to use the SAS/ETS ® Time Series Forecasting System (TSFS) to perform promotional analysis and forecasting using intervention models. Though these examples are rather simple and obvious for understandability, much more complex problems and models using interventions can be analyzed with TSFS. The documentation for TSFS contains more detail on how intervention analysis is performed.

Exhibit 1: Promotional Analysis Demonstration

Consider the problem of evaluating a promotion, which starts in January 1996 and continues to the present, say July, 1997. Assume that the promotion deviates the underlying time series process in a step-wise fashion from the starting date until the present. The *time*, *type*, *duration*, and *response* of the intervention are known, but the underlying time series model is unknown.

1. Start the SAS System.
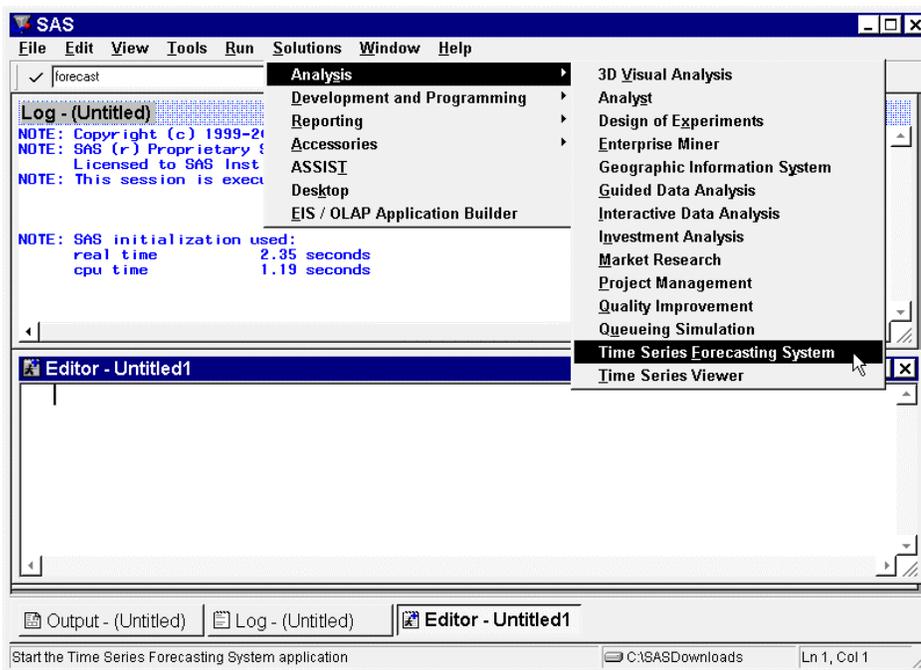
2. Enter "forecast" in the command line or select Solutions -> Analysis -> Time Series Forecasting System from the menu. The **Time Series Forecasting** window will appear.
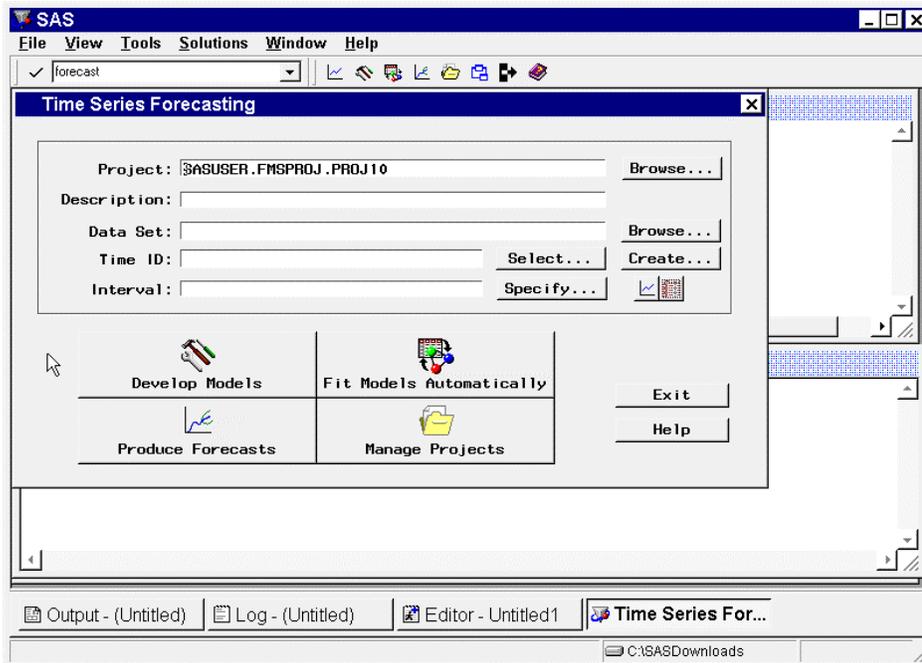
3. In the **Time Series Forecasting** window, click the button **Develop Models**. The **Series Selection** window will appear. The **Series Selection** window is used to select the time series under analysis.
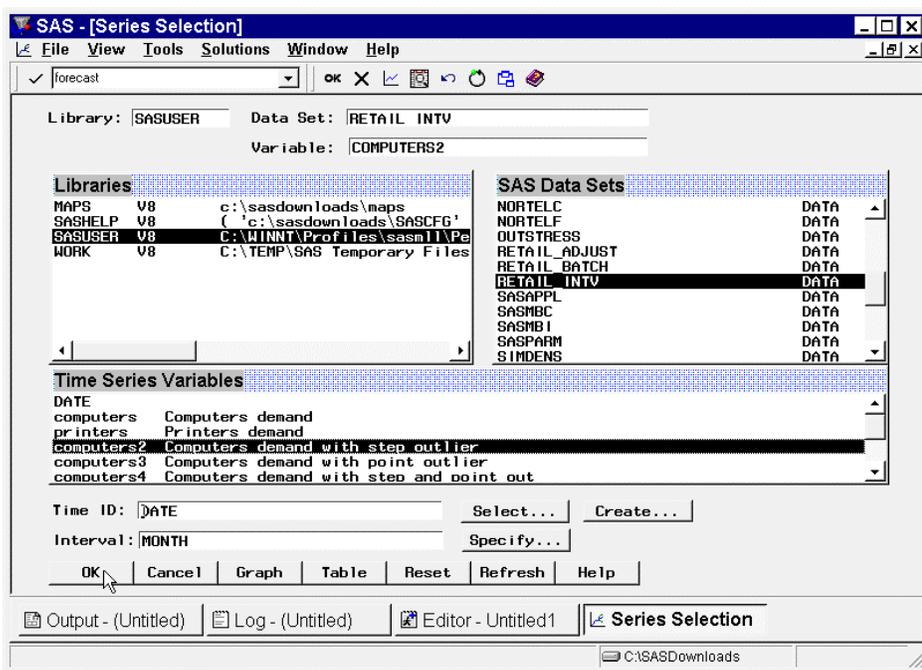

4. From the **Series Selection** window, choose the data set (library and member name), time series variable, time ID variable, and time interval. In this demonstration, SASUSER.RETAIL_INTV, COMPUTERS2, DATE, and MONTH are chosen, respectively. Click the **OK** button. **The Develop Models** window will appear. The **Develop Models** window is used analyze, model, forecast time series on an individual basis.
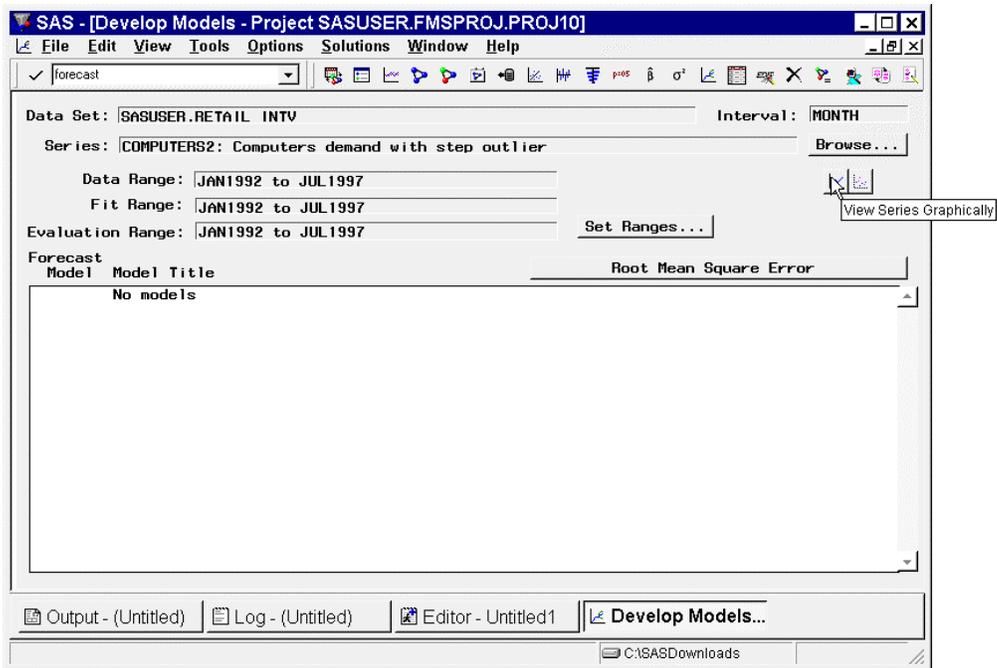
5. In the **Develop Models** window, click the **View Series Graphically** icon. The **Time Series Viewer** will appear. The **Time Series Viewer** is used interactively analyze the properties of a time series.
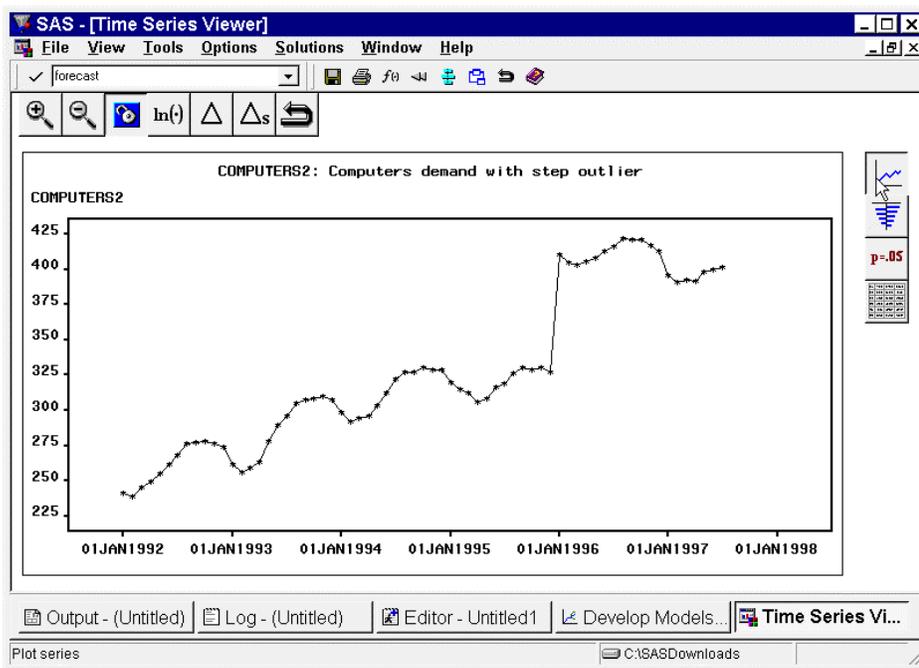

6. Notice that the time series plot contains a large jump at the time period at January 1996 when the promotion occurred. Further analysis of the series could be performed using the **Time Series Viewer** but for now, close the **Time Series Viewer**. The **Develop Models** window will appear.
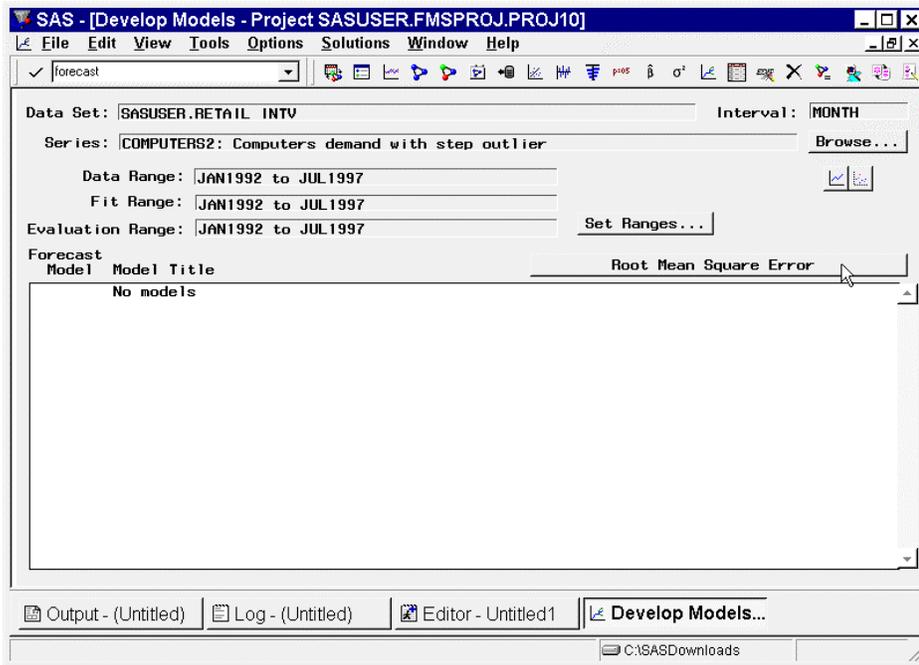
7. In the **Develop Models** window, click the button labeled **Root Mean Square Error**. The **Model Selection Criterion** window will appear. The **Model Selection Criterion** specifies how to select the best fitting model when using automatic fitting.
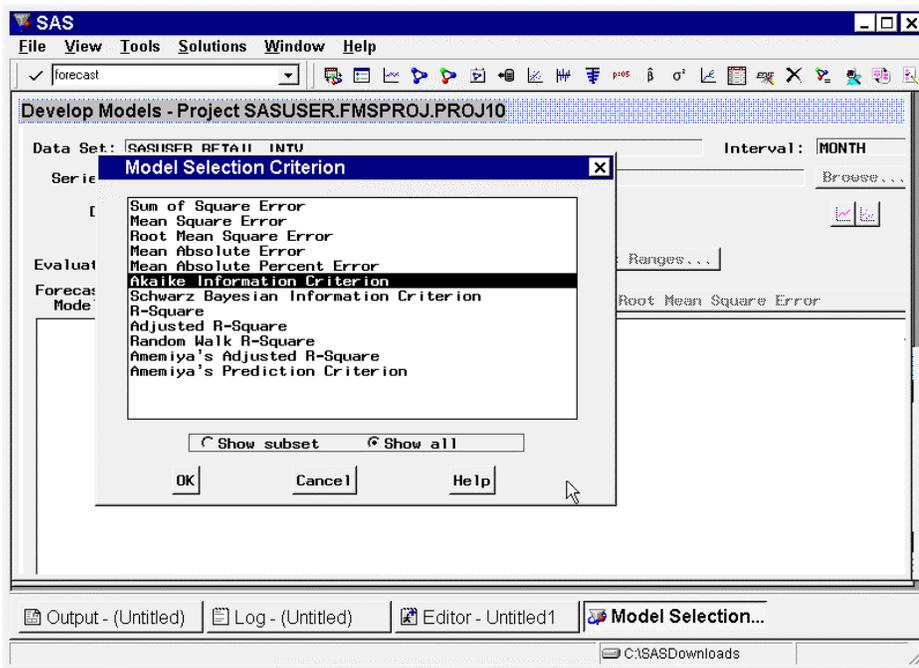

8. In the **Model Selection Criterion** window, select the **Show All** radio button. Since we do not want to over parameterize the underlying time series model, select **Akaike Information** from the list box. **Criterion**. (The Schwarz Bayesian Information Criterion and Anemiya's Prediction Criterion also correct for the number of parameters.) Click the **OK** button. The **Develop Models** window will appear.
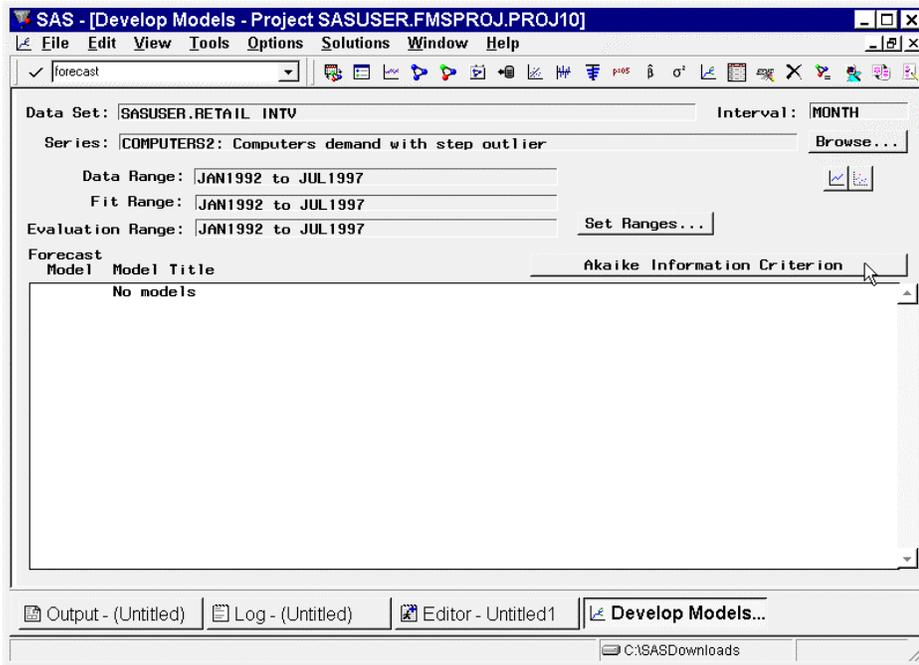
9. Notice that the button previously labeled **Root Mean Square Error** is now labeled **Akaike Information Criterion** (AIC). Time series models will now be automatically selected based on a selection criterion that penalizes for the number of variables.
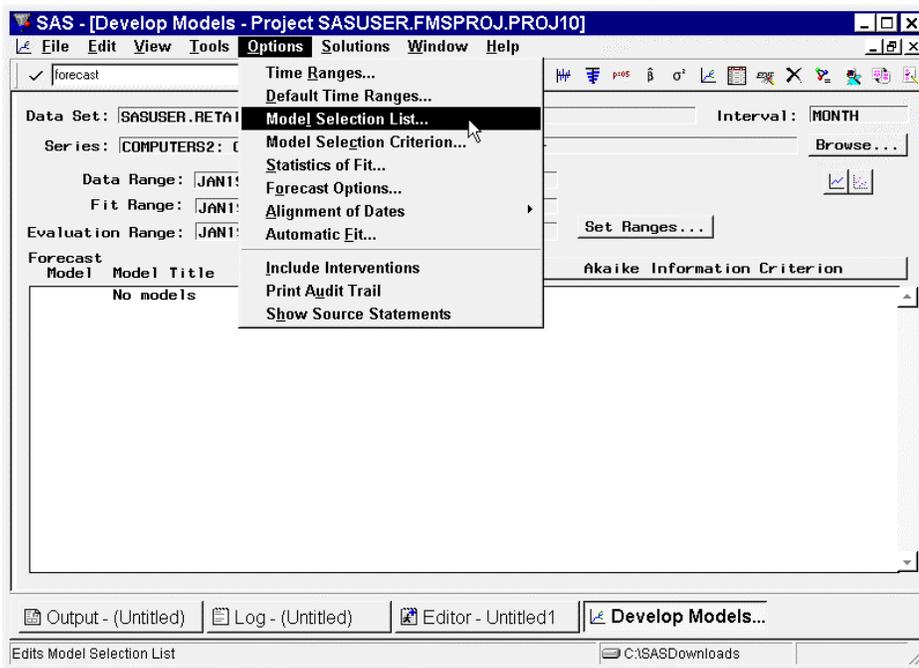

10. From the menu, select Options->Model Selection List. The **Model Selection List** window appears. The **Model Selection List** window specifies the list of candidate models to be used in automatic model fitting. In this window, you can add, delete, and, disable candidate models as needed.
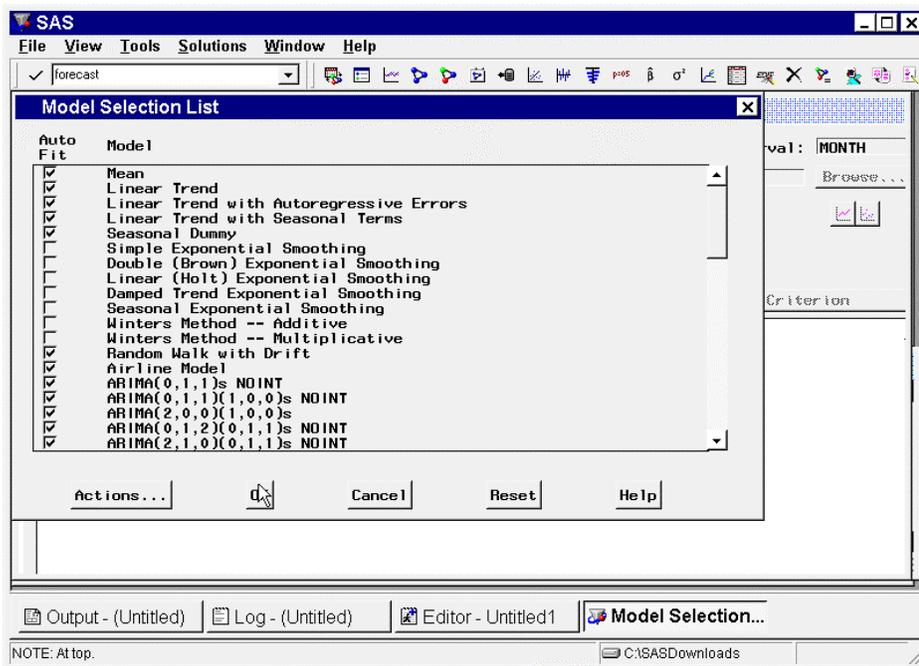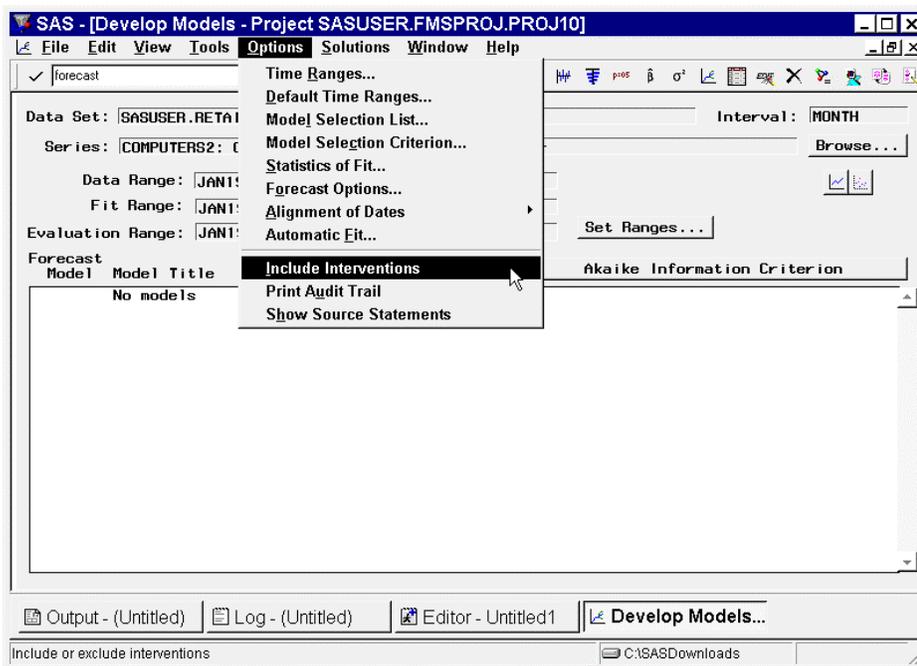
11. In the **Model Selection List** window, disable (de-select) all of the smoothing models and Winters Method for these models do not support interventions. The default model selection list contains 14 of these models. If you do not know how to inverse transform intervention models, de-select all transformed models. Click **OK**. The **Develop Models** window will appear.
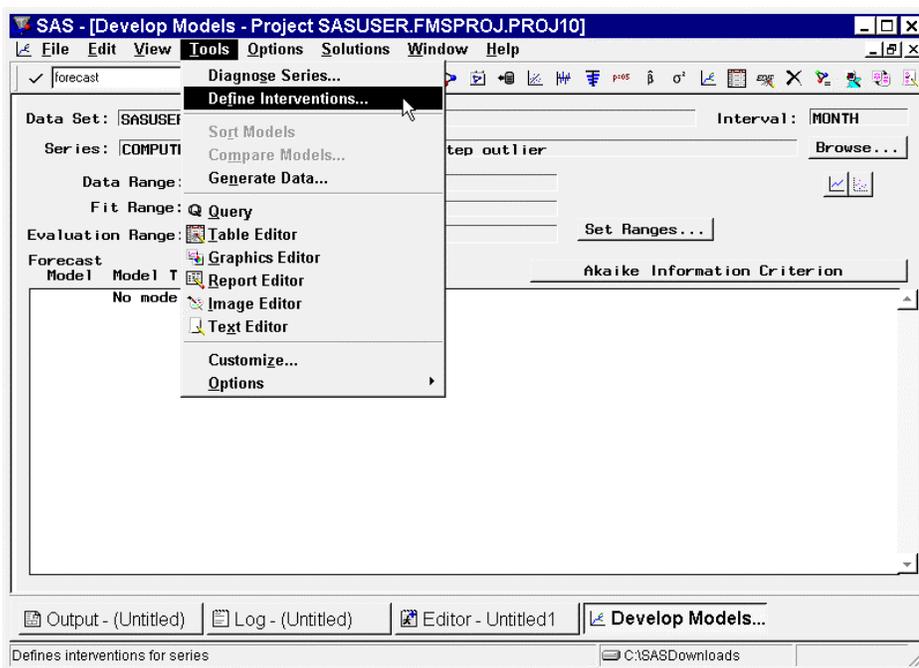

12. From the menu, select Tools->Define Interventions. The **Intervention Specification** window appears. The **Intervention Specification** window specifies the time of the intervention, the type of intervention (Point, Step, and Ramp), the effect time window (number of numerator parameters), and the effect decay pattern (exponential or wave).
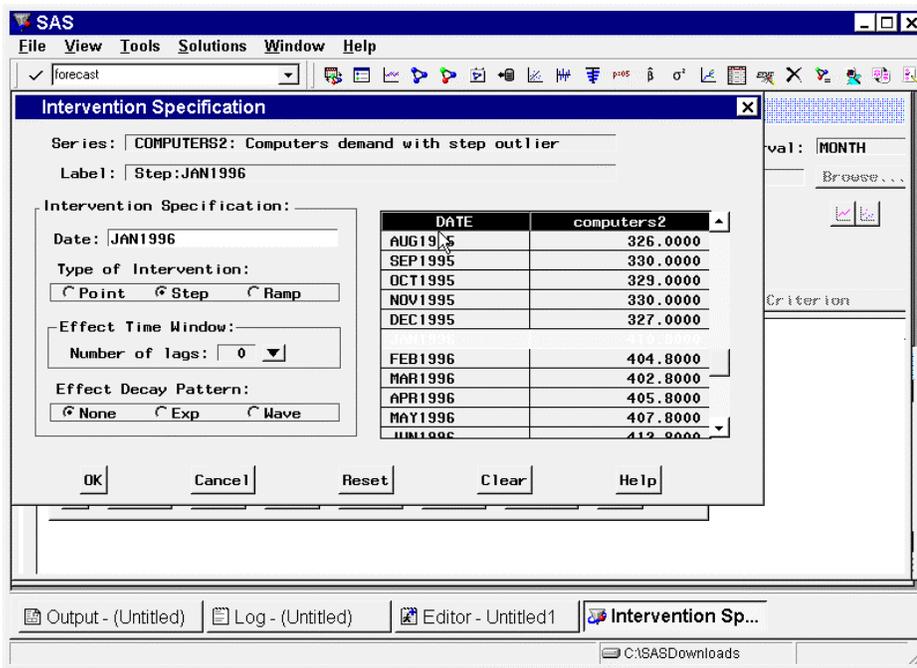
13. In the **Intervention Specification** window, select the time/date of the intervention and the Type of Intervention (other intervention properties could also be selected). In this demonstration, January 1996 and Step are chosen, respectively. Click **OK**. The Interventions for Series window will appear with all specified interventions. Click **OK**. The **Develop Models** window will appear.


14. From the menu, select Options->Include Interventions to include interventions in each candidate model specified in the Model Selection List.
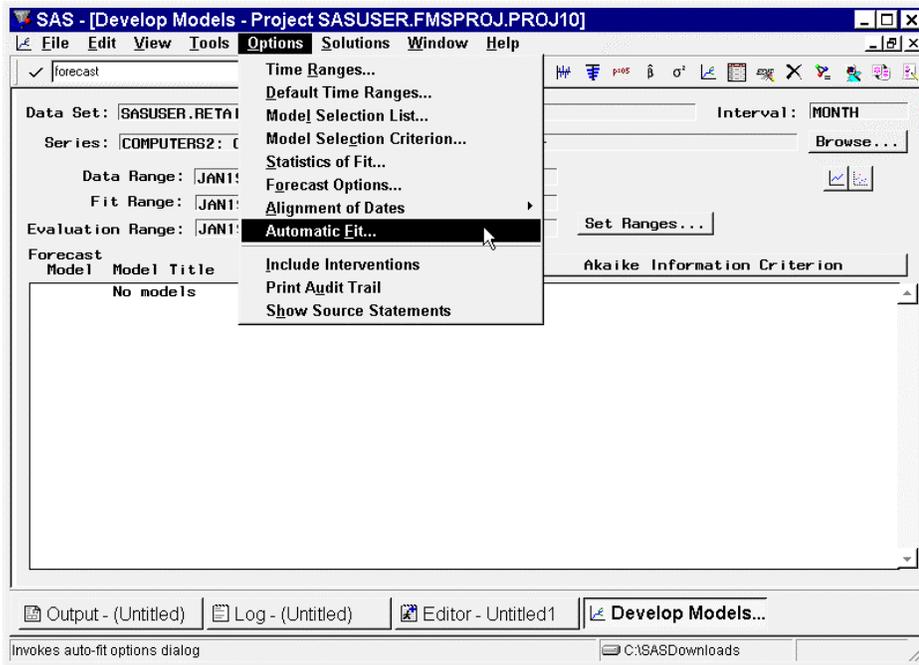
15. From the menu, select Options->Automatic Fit. The **Automatic Model Selection Options** window will appear. The **Automatic Model Selection Options** window specifies how many models will be kept in automatic fitting and also whether the series diagnostics are to be used.
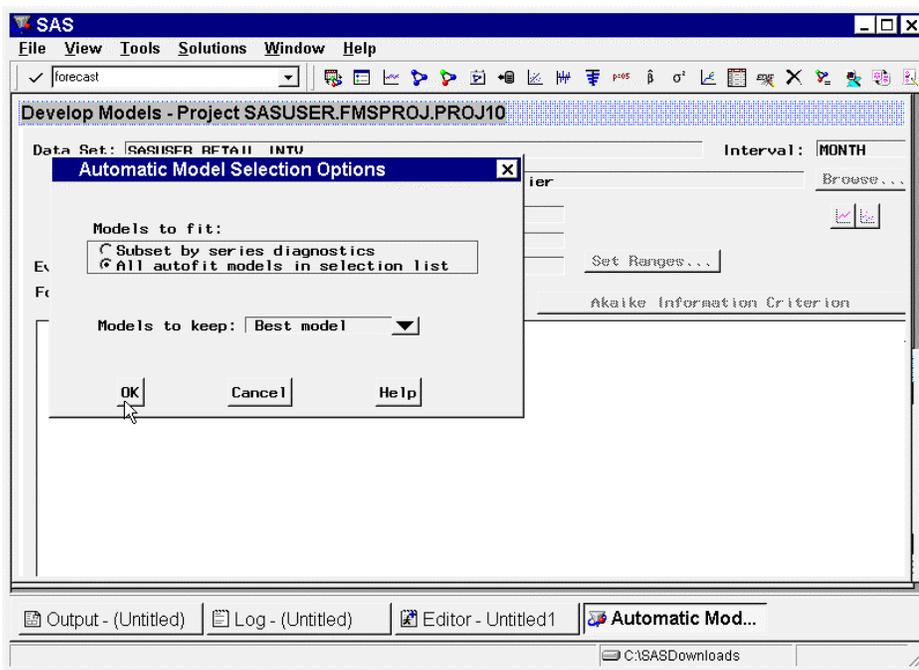
16. Since the large deviations caused by interventions may cause the diagnostics associated with the automatic model fitting to misdiagnose the underlying time series, it is best to turn off this diagnostic. Select the radio button labeled **All autofit models in the selection list**. Since for this demonstration we are only interested in the best fitting model, leave the **Models to Keep** combo box selected to **Best Model**. Click **Ok**. The **Develop Models** window will appear.
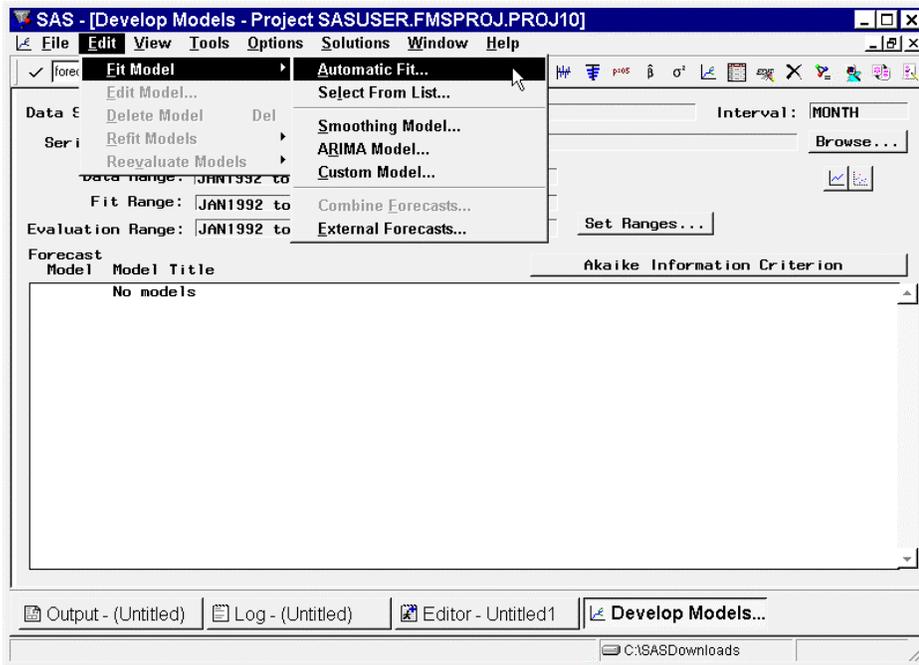
17. From the menu, select Edit->Fit Model->Automatic Fit. The **Automatic Model Selection** window will appear stating the number of candidate models to be fit. Click **OK**. The Time Series Forecasting System will fit all models in the Model Selection List (which can be customized), select the best model based on the chosen Model Selection Criterion (in this case AIC), and keep the best fitting model.
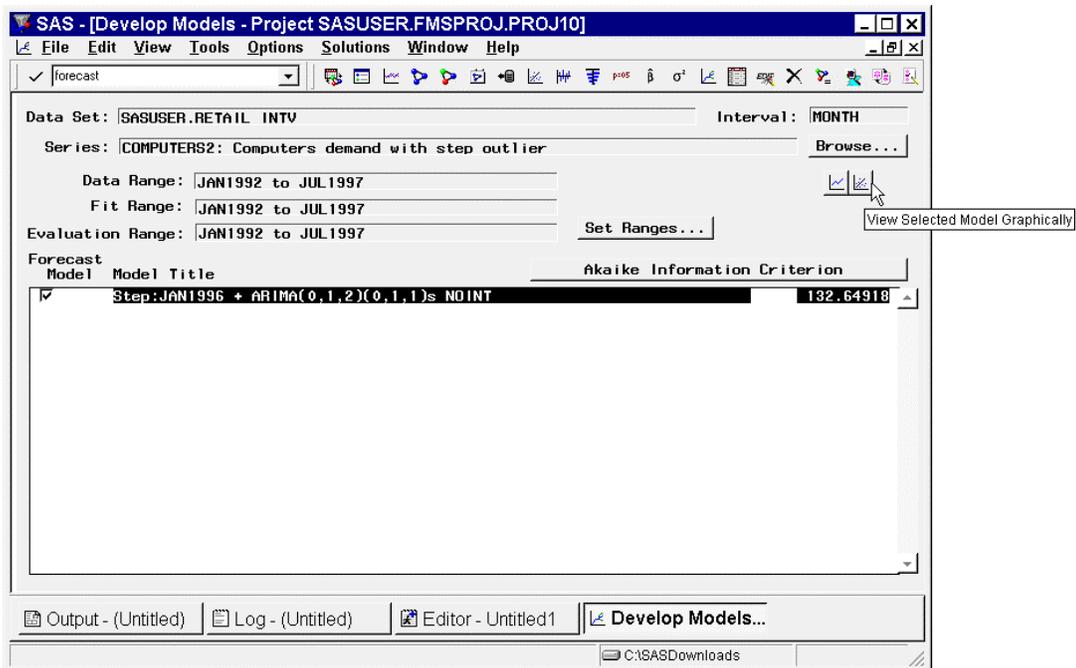

18. After fitting the candidate models, the **Develop Models** window models list will contain the best fitting model. In this demonstration, the model **STEP:Jan1996 + ARIMA(0,1,2)(0,1,1)s NOINT** was chosen as the best model. This *combined model* is a seasonal ARIMA model with no intercept term and a step intervention starting at January 1996.

19. Once the automatically selected model has been chosen, click the **View Selected Model Graphically** icon. The **Model Viewer** will appear. The Model Viewer is used to analyze the properties of a time series model interactively.
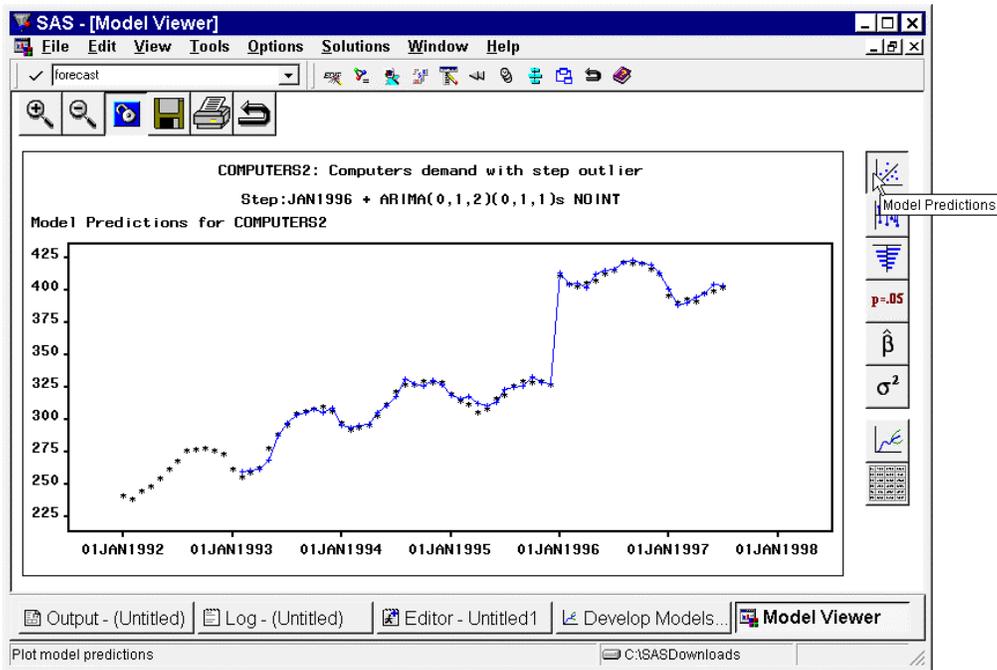

20. When the Model Viewer appears, a plot of the time series and the one-step ahead model predictions is displayed. Notice how closely the model one-step ahead predictions fit the time series.
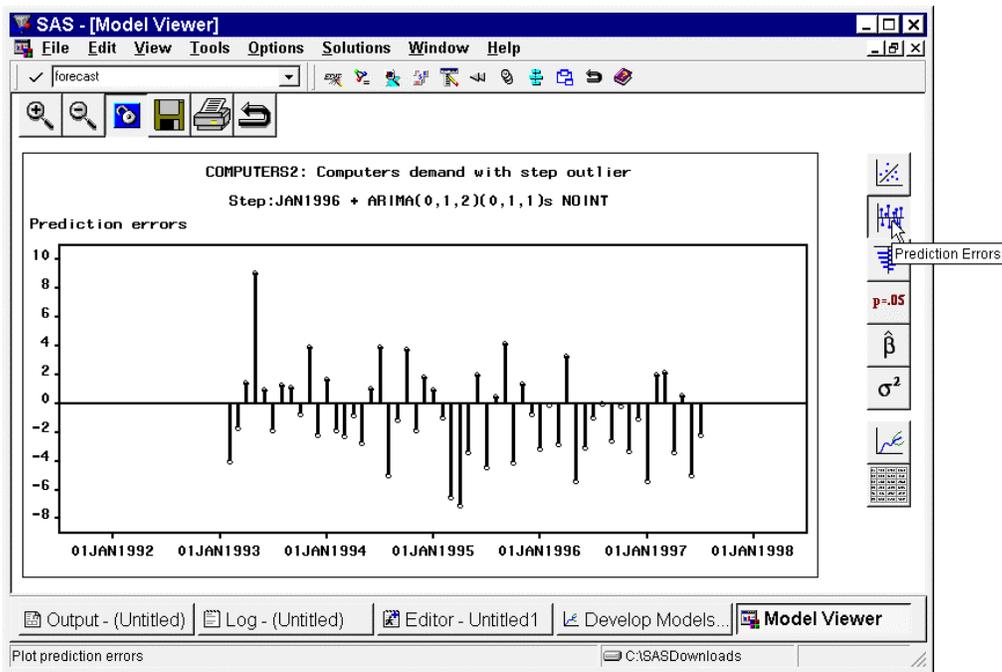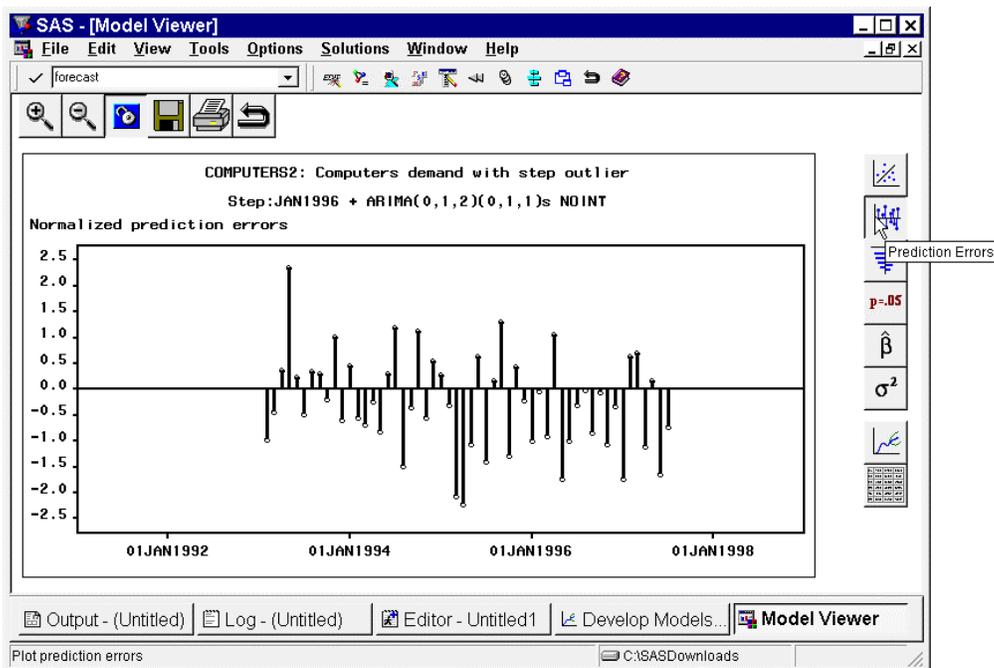

21. Click on the **Prediction Errors** icon. A plot of the prediction errors is displayed. Notice that most of the predicted errors are small in magnitude with respect to the time series.

22. From the menu, select Options -> Residual Plot Options -> Normalized Prediction Errors. A plot of the normalized prediction errors is displayed.
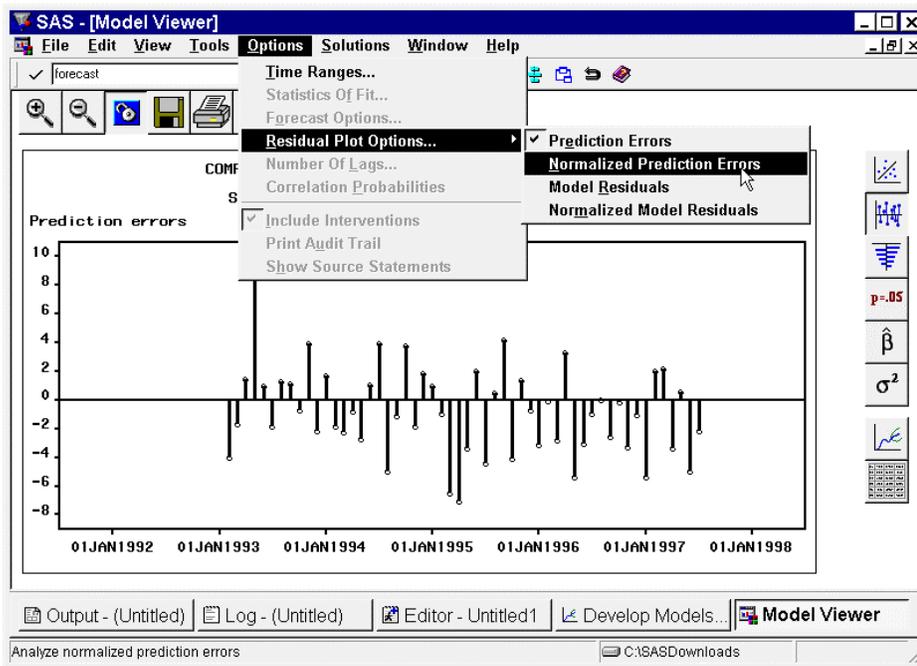

23. Notice that most of the prediction errors are less than two prediction error standard deviations but some are not. This result shows that the model selected by automatic model fitting is pretty good but not perfect.
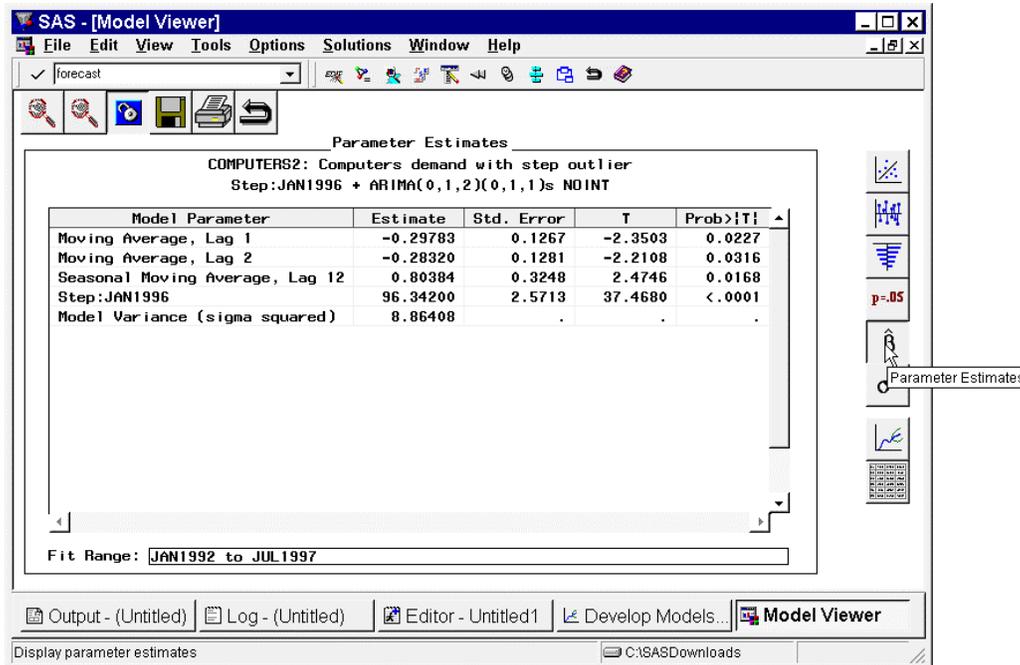
24. Click on the **Prediction Error Autocorrelation** icon. Notice that the prediction error autocorrelation, partial autocorrelation, and inverse autocorrelation are insignificant at all time lags. These statistics indicate that the model prediction errors have no significant patterns that have not been modeled.
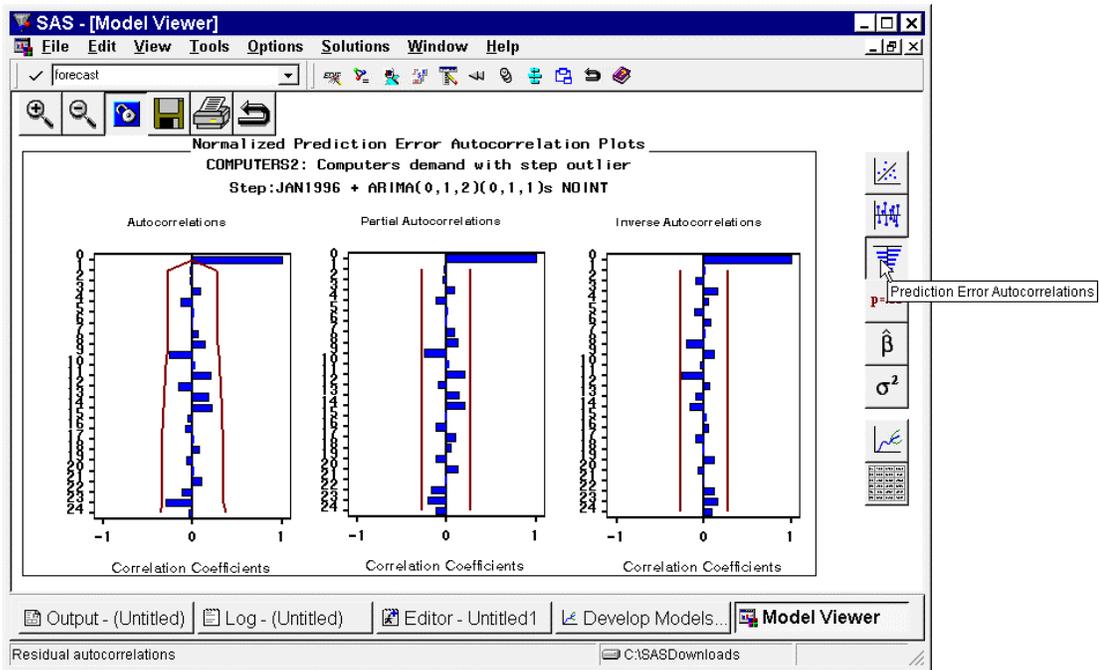
25. Click on the **Prediction Error Tests** icon. Notice that the White Noise Test graphic is nearly completely white, indicating that the model prediction errors represent white noise or that no significant patterns in the model prediction errors exists. Notice also that both unit root and seasonal unit root tests indicate stationarity of the prediction errors.
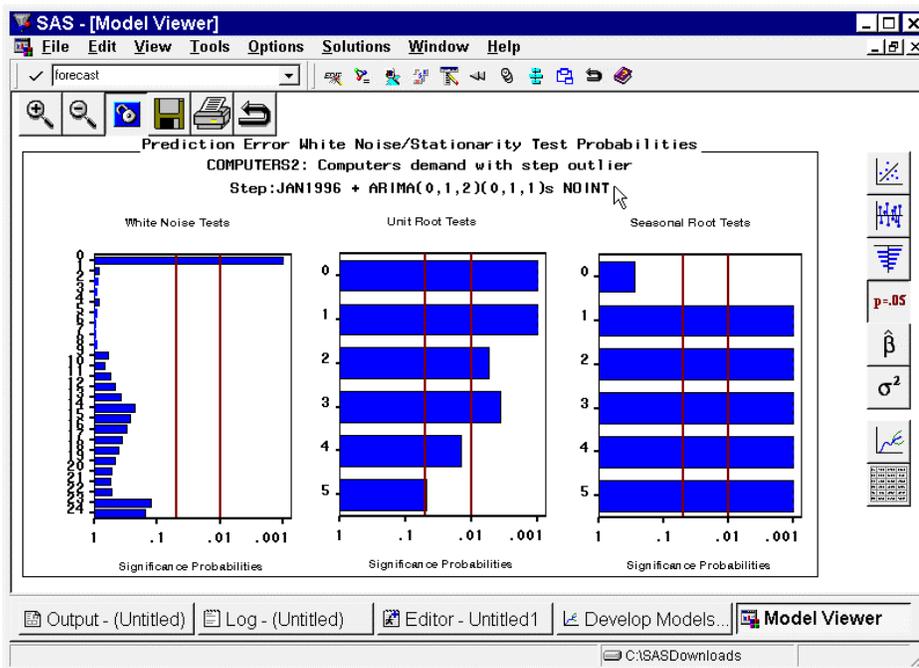
26. Click on the **Parameter Estimates** icon. Notice that all parameter estimates are significant with respect to a 0.05 significance level. Also notice that the parameter estimate associated with the step intervention (STEP:JAN1996) is **96.342** and the standard error is **2.5713**. Remember these two numbers for they provide an estimate of the size of the step intervention.

27. Based on the Prediction Errors, Prediction Error Autocorrelations, Prediction Error Tests, and the Parameter Estimates, the model selected by automatic fitting is pretty good although it may be improved upon with further analysis.

Having fit the *combined model* fairly well one must ask: What was the value of this promotion? Being that the parameter estimate *(response)* for the step intervention was 96.342 with standard error 2.5713, then a good guess is that the value of this promotion is 96.342 plus or minus two standard errors for each period of the duration of the intervention.

This simple demonstration showed how to use the SAS/ETS ® Time Series Forecasting System for promotional analysis.