Time Series Edits for the Electric Power EIA-906
Friday Oct 29 at 8:40 am

Abstract: Simple time series models have provided useful edits for EIA's weekly petroleum surveys and for monthly petroleum marketing surveys. This project examines the use of simple time series models for editing the EIA-906 Electric Power Plant Report, that collects monthly data from a sample of regulated and unregulated generators (excluding combined heat and power plants.) The data varies in complexity among the 1600 responding plants, with some consuming only one type of fuel, but others having several types of equipment utilizing a variety of fuels. We will describe our progress to date on developing simple exponential smoothing models for generation, fuel consumption, stocks, and the ratio of generation to consumption. Our initial efforts have focused on only the regulated respondents with complete data. We will have examples of cases where the simple non-seasonal model fits well, and examples where it does not.

Background: The EIA-906 survey collects data on generation, fuel consumption, and stocks for regulated and non-regulated power plants. The survey form is available on our website at http://www.eia.doe.gov/cneaf/electricity/forms/eia900/eia906.pdf. Prior to 2004, the 906 collected data from combined heat and power plants (CHP), but those are now collected on our 920 survey and not addressed in this study. The work for this study was conducted by AdSTM Inc. under contract to EIA.

Current Edits: Starting in 2004, respondents are asked to key in their data using our Internet Data Collection system. Edits based on the respondent's past data are run when the data is submitted, and messages displayed to the respondent. Edits here check for new fuels, improbable combinations, or Btu values out of range. We also have a comparison to same month in prior year, where we flag if change > 50%. We also compute the mean and standard deviation for the prior 12 months, and flag if current data outside of mean +/- 1.5 times standard deviation. These are applied to generation, consumption, and the ratio of total Btu consumption/generation.

Time series edits: The question we are attempting to address is whether our editing can be improved by using time series edits. We wanted models that can be easily programmed, and we used here the simple non-seasonal exponential smoothing model, namely

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

where F_{t+1} is the prediction for time $t+1$ (using data through time *t*),

Y_t is time *t*'s actual value,

F_t is the prediction for time t (using data through time *t*-1),

α is the smoothing constant, a number between 0 and 1.

Twenty four months of data from January 2002 through December 2003 were used in SAS PROC ARIMA to estimate the parameter in an ARIMA(0,1,1) model for each plant and variable to forecast January 2004. Data from January 2002 through January 2004 were used to forecast February 2004, and through February to forecast March. The moving average parameter in this model, θ, is related to the exponential smoothing parameter via the following equation $\alpha = 1 - \theta$. In some cases this resulted in a value of $\alpha > 1$, in which case it was set equal to .99. Forecasts were one-month ahead for January, February, and March of 2004. We used the confidence intervals provided, which assume normal distributions. Models were evaluated by calculating the MAPE (mean absolute percent error) and by looking at the stability of the alpha when updated over the 3 forecast months. Stability is estimated as the percent change in the estimated value of alpha due to adding the data from one more month.

Data: We obtained monthly data from January 2002 through about March 2004 for all respondents to the EIA-906. To begin the project, we examined the 867 regulated plants. Selecting only plants with complete data brought us down to 835 plants to model. Of these, 353 plants used only one fuel and 482 used multiple fuels. Of the single fuel plants, hydroelectric accounted for 243.

Modeling Ratio: We first modeled the ratio of generation over total Btu consumption, which, is the inverse of the variable used in the current edits. Since many plants have no consumption (hydro being the largest) and many others are mostly zero, we only modeled the ratio for 480 plants. Of these, 80% had MAPE of under 10%, and 92% of had MAPE of under 50%.

We looked at the percent change in the alpha over the three months, and over half showed greater than 10% change in the alpha parameter. However, since many of the alpha values were small, this may not be a good indicator of stability. Most of the alpha values were close to zero, and there were no obvious patterns among fuels or prime mover equipment types for the alpha parameter. An alpha value close to zero indicates that the mean is not changing over time, and that the current method of flagging deviations from the mean may be close to optimal.

The confidence intervals calculated by SAS under the normal distribution corresponded approximately to the percent inside or outside of the intervals for our data, with about 13% to 14% of the data outside of the 85% confidence interval. In most cases, only one of the three months was out of range for a plant, and only two plants were outside of the bounds for all three months. Applying the existing edit of +/- 1.5 times the standard deviation, we got 24% out of bounds. This might indicate that a time-series model would flag fewer data points. However, this simplistic comparison ignores whether or not the data should have been flagged. This also ignores how well the model is fitting, namely, we did not have a separate comparison for models with acceptable MAPE values. And, we are using the inverse of the usual ratio.

We also modeled the ratio on a subset of data excluding all plants with zero generation or consumption for any month. This is probably too drastic, but does eliminate the peaking plants. The model fit is slightly improved, with 89% having a MAPE of under 10%. The alpha values show even more near-zero values. Similarly to above, the confidence interval bounds flag slightly fewer observations than the +/- 1.5 times the standard deviation.

Modeling Consumption: We calculated the total Btu of fuel consumed, and we only looked at the 369 regulated plants with nonzero generation and consumption for all months. Of these, 55% to 65% had MAPE of under 10%, and at least 80% had MAPE of under 50%. Just over half showed a stable alpha value (< 10% change) for the three forecast months. The distribution of the fitted alpha values is strongly bimodal, with large spikes near zero and near 1. We did not have time to explore these further. Using an 85% confidence interval would generate approximately the same number of edit flags as the current method.

Modeling Generation: Similar to above, we only modeled the generation for the 369 regulated plants with nonzero generation and consumption for all months. Of these, 15% had MAPE of under 10%, and 80% had a MAPE of under 50%. The alpha varied by under 10% in about half of the cases. The distribution of the alpha values is again strongly bimodal with almost 25% of the plants at each of the two extremes. Using an 85% confidence interval would flag 2% to 4% less plants than the current approach, with some variations over the three months. The same limitations mentioned under modeling the ratio also apply to generation and consumption.

Modeling Stocks: We modeled the Btu's in stock for the 292 plants with nonzero values for stocks, generation, and consumption. 45% of the plants had a MAPE of under 10%, and 98% were under 50%. The alphas were generally stable, with 80% of the plants having less than 10% variation in the alpha values. The alpha values had a different distribution here, with only a few near zero, and a large percentage (60%) between .9 and 1. Using an 85% confidence interval resulted in about 10% fewer edit flags than just the mean +/- 1.5 times the standard deviation, however, other edits are also currently applied to the stocks, including change from prior months, and we did not compare to all that would have been flagged.

Conclusions and Limitations: So far, there are only slight differences in the number of edit flags between the proposed time-series model and one of the current edits. This may indicate that the current edits are performing well. However, the work is still preliminary and there are some limitations.

- Models were estimated using short time series (24 months),
- We only looked at the regulated plants.
- We only looked at one-step ahead forecasts.
- We only looked at the three months of January through March, and much of this data is seasonal.
- We excluded plants with zero generation or consumption.
- We have not conducted more detailed examinations of the company level data and model fit.
- At this point we have not tried to integrate the tests for consumption, generation, and ratio to come up with one flag.

- The data we used has been edited, however we suspect that not all errors have been removed from the data. To date, we have not discussed data that appear questionable by our work with CNEAF to evaluate performance of the flags.
- We have not yet done a careful comparison of the units with data that are flagged by the two methods.

EIA's Plans for the Future – what are we going to do next?
So far, we do not have conclusive results. We want to determine for which types of plants and which data series the proposed time series edits would be an improvement. Our current thoughts are to:

- Look at plants based on the fitted alpha values. Many plants have an alpha near zero, which implies a fairly constant mean, and the current edit comparisons may be fine. We will also look at the plants with low MAPE but alpha near 1.
- Look at plants based on fit of the model. So far, we are just looking at the MAPE. We will look at the fuel and other plant characteristics for those where the model doesn't fit.
- Form logical groupings for the plants, such as those without conventional fuel (hydro, wind, nuclear), those with one fuel, and those that switch between fuels. We do have peaking plants which may be zero for days or months. We may also have outliers.
- We do plan to compare current edits to proposed edits at the company level, and group and summarize those comparisons.

Committee is invited to provide advice concerning any phase of this project, and how we might bring it to a successful conclusion. Specific questions include:

- Should we use other measures of model fit besides MAPE?
- We have about 800 respondents for the regulated plants, and another 800 independent power producers. Other than to produce plots for 800 or 1600 plants, what else could we do to decide if model is appropriate?

Attachments

- Plot of alpha and table of alpha vs. MAPE for modeling ratio of generation over consumption.
- Example of good fit for modeling consumption, with residual plot and actual data, forecasted values, and upper and lower confidence bounds.
- Example of poor fit for modeling consumption.
- Plot of alpha and table of alpha vs. MAPE for modeling consumption.

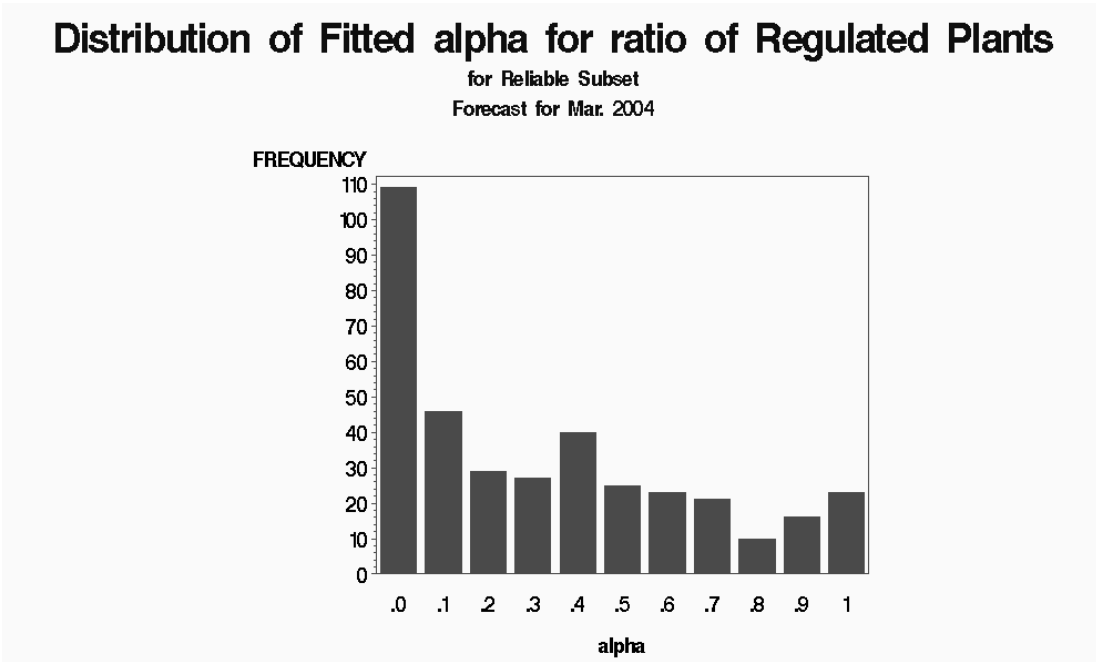
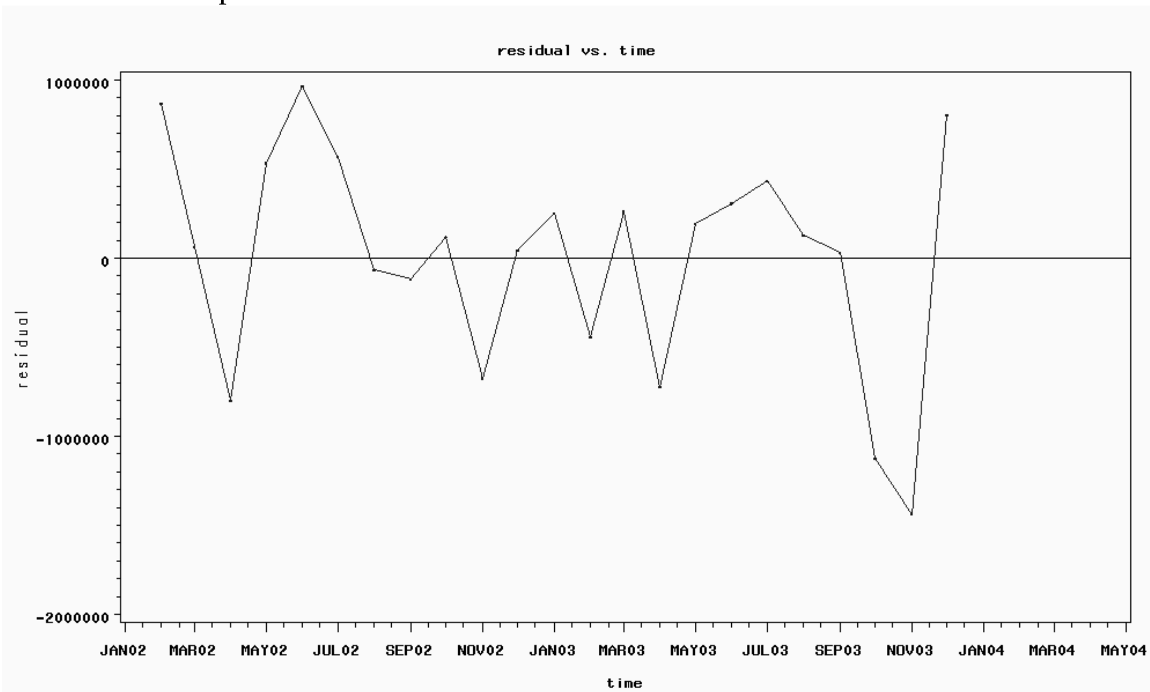


Table of Fitted alpha vs. MAPE for Ratio of generation/Btu consumption

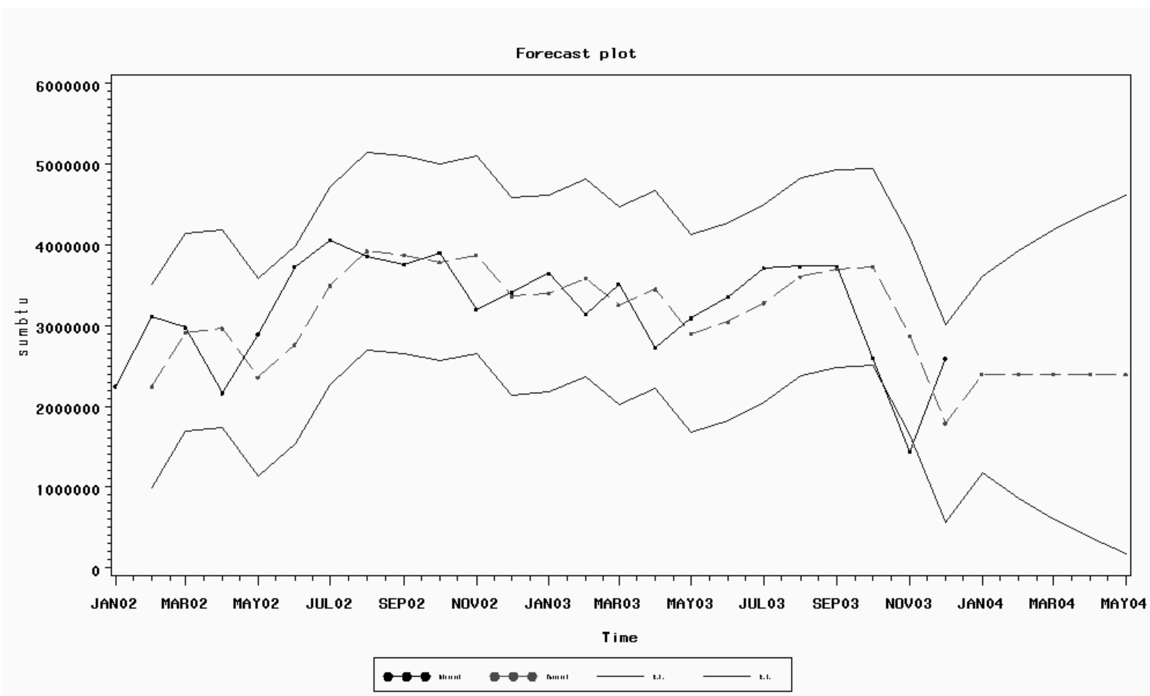
α	MAPE				Total/percent
	[0,10%]	(10%,50%]	(50%,100%]	(100%, ∞)	
.0	90	11	4	3	108/30%
.1	26	6	1	3	36/10%
.2	35	1	1	0	37/10%
.3	28	2	1	0	31/8%
.4	36	1	0	0	37/10%
.5	29	1	0	0	30/8%
.6	21	2	0	0	23/6%
.7	10	1	0	0	11/3%
.8	14	0	0	0	14/4%
.9	19	0	0	0	19/5%
1.	19	3	1	0	23/6%
Total/percent	327/90%	28/8%	8/2%	6/2%	369/100%

Example of good fit for Consumption: α=0.76, MAPE=15.43%

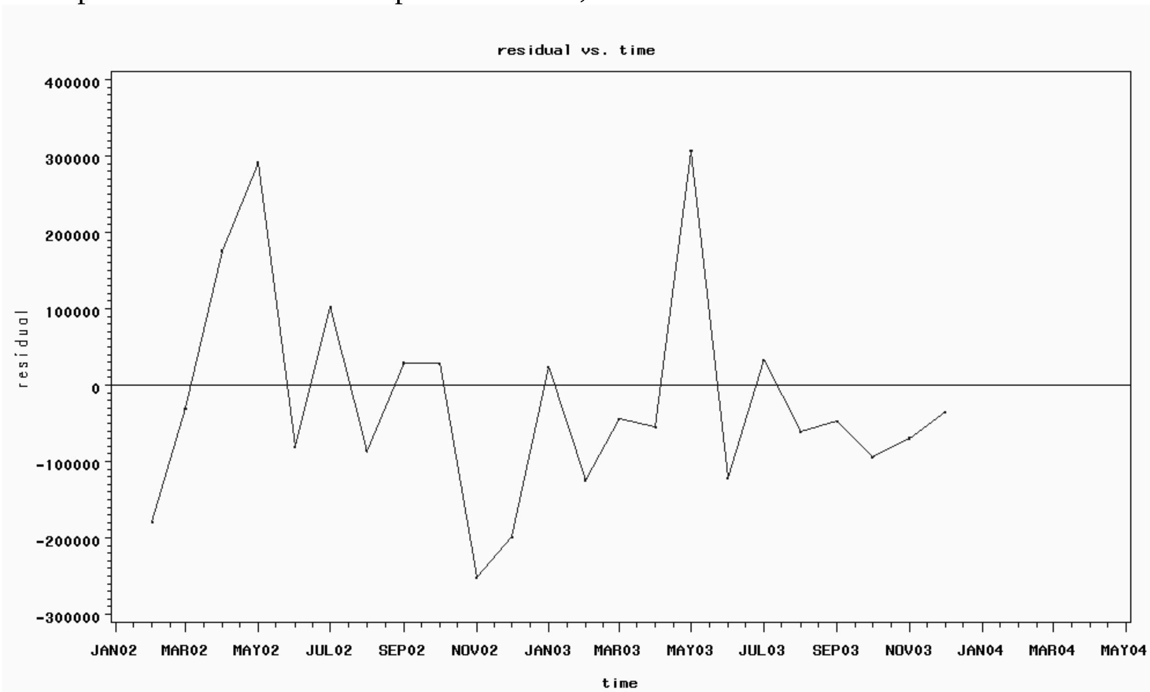
Residual plot



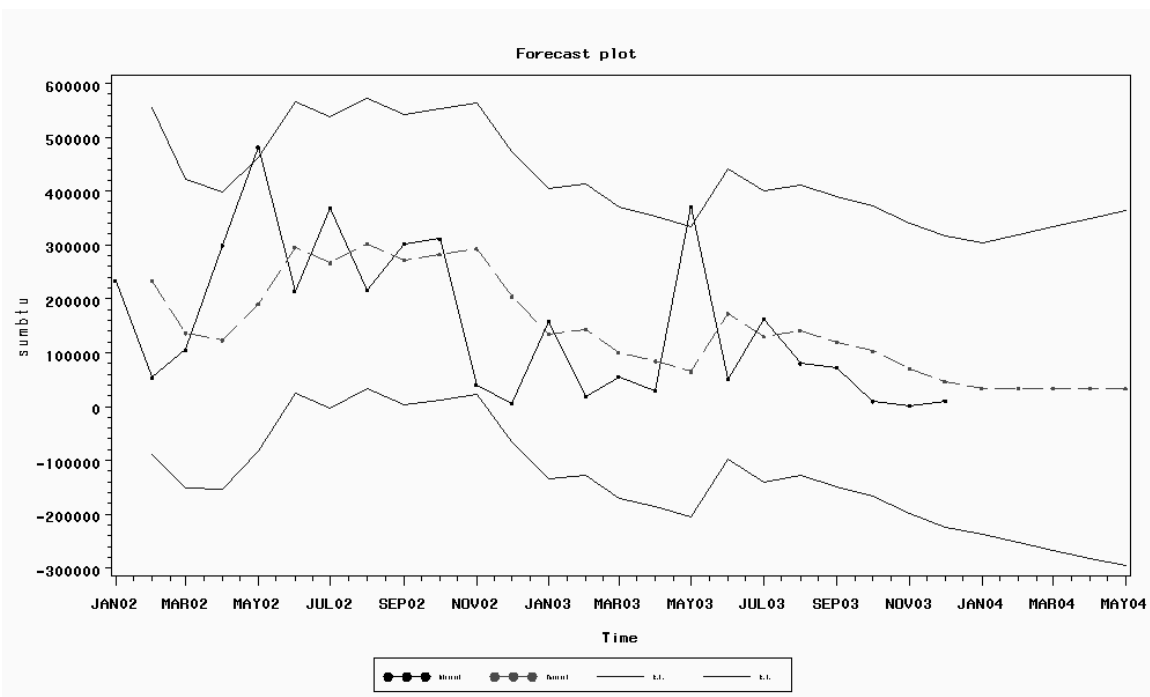
Actual, forecasted (dashed line) and confidence intervals.

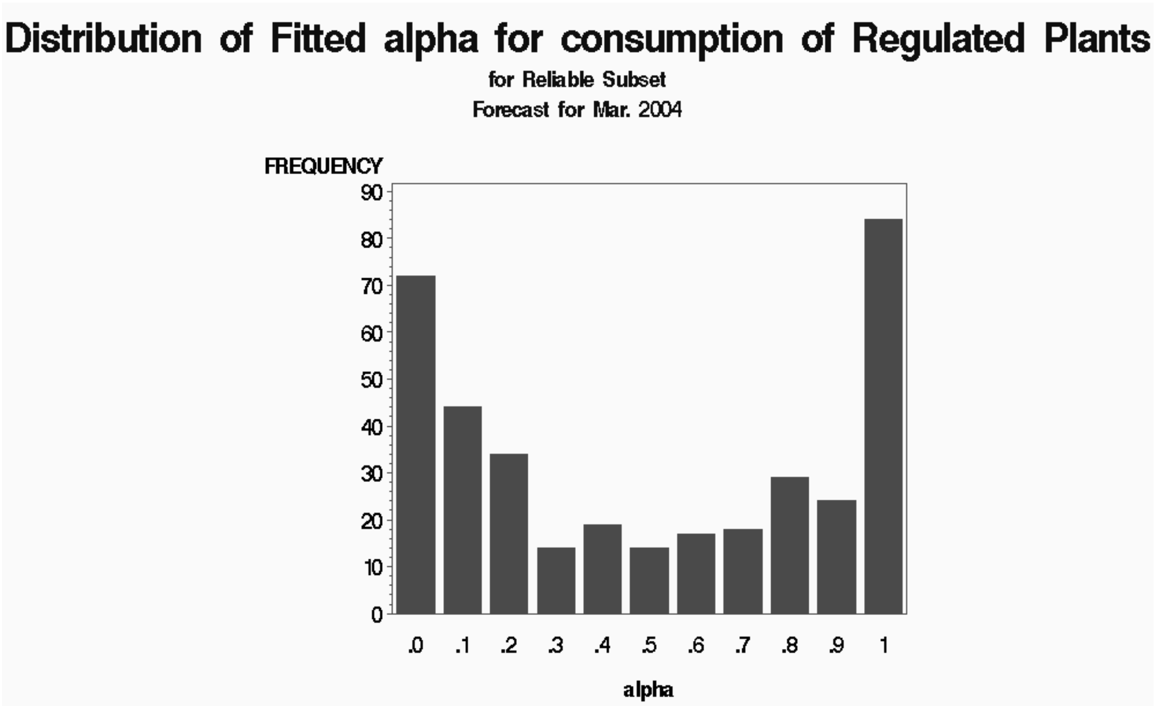


Example of bad fit for consumption: α=0.35, MAPE=515.59%



Actual, forecasted (dashed line) and confidence intervals





Fitted α vs. MAPE for Consumption

α	MAPE				Total/percent
	[0,10%]	(10%,50%]	(50%,100%]	(100%, ∞)	
.0	15	57	5	7	84/23%
.1	11	18	1	3	33/9%
.2	12	12	2	2	28/7.5%
.3	3	5	0	4	12/3%
.4	4	15	0	2	21/6%
.5	0	9	1	2	12/3%
.6	4	11	1	1	17/5%
.7	4	15	1	3	23/6%
.8	3	16	0	2	21/6%
.9	2	23	0	3	28/7.5%
1.	7	57	7	19	90/24%
Total/percent	65/18%	238/64%	18/5%	48/13%	369/100%