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A PRELIMINARY ASSESSMENT OF THE ALBACORE TUNA (*THUNNUS ALALUNGA*) STOCK IN THE SOUTHERN ATLANTIC OCEAN USING A NON-EQUILIBRIUM PRODUCTION MODEL

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SUMMARY

Catch and catch per unit effort are used to fit a biomass dynamic stock assessment model. A variety of residual diagnostics, are then given to check for violations of the model assumptions and to explore the information in the data. Potential problems are identified and ways to overcome or avoid them discussed.

RÉSUMÉ

La capture et la capture par unité d'effort sont utilisées pour ajuster un modèle d'évaluation des stocks dynamique de la biomasse. Divers diagnostics de valeurs résiduelles sont ensuite présentés afin de détecter le non-respect des postulats du modèle et d'explorer les informations dans les données. Les problèmes potentiels sont identifiés et les façons de les surmonter sont discutées.

RESUMEN

La captura y la captura por unidad de esfuerzo se usan para ajustar un modelo de evaluación de stock de dinámica de biomasa. Se presentan posteriormente diversos diagnósticos residuales para comprobar las infracciones de los supuestos del modelo y explorar la información de los datos. Se identifican posibles problemas y se discuten formas de superarlos o evitarlos.

KEYWORDS

Albacore, ASPIC, Assessment, Biomass Dynamic,
Diagnostics, Residuals, South Atlantic, Likelihood Profiles, Surplus Production, R, FLR

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1. Introduction

In order to investigate the northern albacore stock we run a non-equilibrium production model with the input data agreed at the last Data Preparatory meeting held in Madrid (April 2013). At the last assessment four scenarios were run as part of the ASPIC assessment Prager (1992), i.e. 1 factor with 2 levels for the form of the surplus production function and another factor with 2 levels for the relative weight (based on catch) given to the indices of abundance. A set of common diagnostics were presented in at the working group on stock assessment (SCRS/2013/036) that can be used for different stock assessment models. In this paper we apply these diagnostics as part of the South Atlantic albacore biomass dynamic Prager (1992) assessment. Similar diagnostics were also used for the Northern Stock (SCRS/2013/036) and the Northern and Southern stocks of swordfish. A range of stock assessment models are used by the SCRS, from biomass dynamic models using catch biomass and effort data with only a few parameters to statistical catch-at-size models with over a 1000 parameters. Despite these differences they are being used for the same purpose i.e. to estimate population parameters from fisheries dependent data. The stock assessment process assumes that the input data can be evaluated and fits compared ensuring some consistency when decisions are being made about model choices.

This paper is not intended to be used as a check list but an example of what to look at, how to do it, potential problems, consequences and how to overcome, but even better to avoid them, i.e. the intention is not to provide strict guidelines but to look at some methods that can be used for a range of stock assessment models that use indices of abundance such as Catch per Unit Effort (CPUE) for fitting.

2. Materials and Methods

A Stock Production Model Incorporating Covariates (ASPIC) is a non-equilibrium implementation of a biomass dynamic model based on surplus production model. ASPIC uses time series of indices of abundance and catch biomass to estimate stock status and uses bootsrapping to construct sampling distribution for a statistic of interest, e.g. stock status, the biomass that would provide the maximum sustainable yield (B_{MSY} and MSY).

The model was fit to five time series of catch and catch per unit of effort (CPUE) fisheries data covering 15 distinct fishing fleets.

2.1 Stock Assessment Assumptions

The main assumptions of ASPIC are that the biomass of a stock next year (B_{t+1}) are the sum of the biomass this year B_t less the catch (C_t) plus the surplus production (P_t) i.e. $B_{t+1} = B_t - C_t + P_t$

In the case of the Southern Albacore assessment, two production functions were considered, i.e. the logistic (or Schaeffer) and the Fox. It is also assumed that catches and catch per unit effort (CPUE) are from a single homogeneous stock and that the CPUE represent stock trends in abundance. If there are zero or negative correlations between the indices, then this means that a basic assumption of ASPIC is violated, either because factors other than stock abundance are determining catch rates or that the indices are fishing different stock components.

2.2 Software

Software used was a biomass production model implemented as a package in R, this allows it to be used with a variety of other packages for plotting, summarizing results and to be simulation tested, e.g. as part of the FLR tools for management strategy evaluation (Kell *et al.*, 2007).

3. Results

We compare the residuals from the four scenarios ran in the last assessment. The standardised CPUE series (points) are plotted in **Figure 1**, the blue line is a less fitted to the points by index and the red line is a GAM fitted to year as a smooth term and fleet as a factor. I.e. the red line shows a common trend and the blue line the trend suggested by an individual index. The differences between an index and the average trend can be seen by comparing the blue and red lines. Correlations between indices and groups of indices are evaluated in **Figure 2** by plotting the indices against each other. The correlation matrix is then plotted in **Figure 3**, the colours shows the correlation between the indices (i.e. red negative and blue positive correlations) while the size of bubbles and depth of colour show the strength of the correlation. The order of the indices and the rectangular boxes are chosen based on a hierarchical cluster analysis using a set of dissimilarities for the indices being clustered. However sometimes even indices overlap for only a few years, and there may be negative correlations due to chance. The Chinese-Taipei and Japanese I show a negative correlation but there are only three overlapping points.

3.1 Fits

The observed values are plotted against the fitted values in **Figure 4**, ASPIC assumes that an index is proportional to the stock so the points should fall around the y = x line. If this does not occur it suggests that the indices are not following the fitted stock trend. In no scenario are the fits appreciably improved.

3.2 Residuals

Looking for patterns in the residuals allows a check for violation of models assumptions. The residuals are plotted against year in **Figure 5**, a lowess smoother is also fitted to help identify patterns. This confirmed the problems identified in **Figure 4**. ASPIC assumes residuals are normally distributed and that there is no autocorrelation between them, these assumptions are evaluated in **Figures 6 and 7**. The Q-Q plots in **Figures 6** compare a sample of data on the vertical axis to a statistical population on the horizontal axis, in this case a normal distribution. If the points follow a strongly nonlinear pattern this will suggest that the data are not distributed as a standard normal i.e. X N(0; 1). Any systematic departure from a straight line may indicate skewness or over or under dispersion. For example in the panel showing the Taiwanese longline suggests that the negative residuals are much greater in magnitude than expected.

Figure 7 plots the residuals against each other with a lag of 1 to identify autocorrelation. There are significant autocorrelations particularly for the Japanese and Taiwanese longlines, this could be due to an increase in catchability with time. This may result in a more optimistic estimate of current stock status as any decline in the stock is masked by an increase in catchability. It is also assumed that variance does not vary with the mean, this assumption is evaluated in **Figure 8** where the residuals are plotted against the fitted values. Violation of the assumptions about the may result in biased estimates of estimated parameters, reference points and stock trends. In addition variance estimates obtained from bootstrapping assume that residuals are Independently and Identically Distributed (i.i.d.).

4. Discussion and Conclusions

This paper presents some diagnostics for CPUE time series. The software is available as an R package (diags). Although the results are from ASPIC, the same plots can be generated for any stock assessment methods that uses fits to CPUE series for calibration. The paper was not intended to be used as a check list but an example of what to look at, how to do it, potential problems, consequences and how to overcome, but even better to avoid them, i.e. the intention is not to provide strict guidelines but to look at some methods that can be used for a range of stock assessment models that use indices of abundance such as Catch per Unit Effort (CPUE) for fitting.

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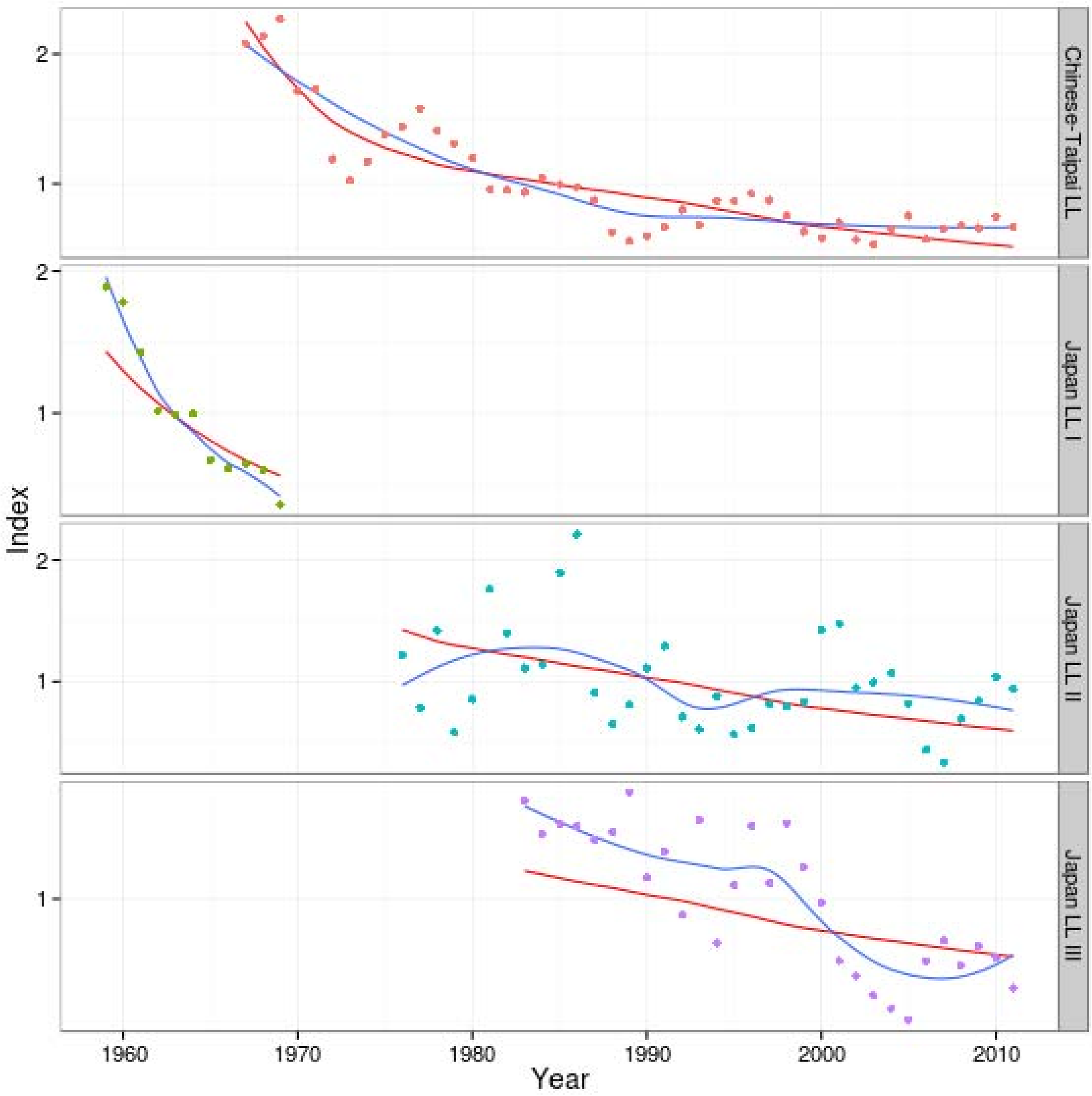

Figure 1. Plot of indices of abundance, points are the observed index values and the blue a lowest fit to the points by index. The red line is GAM fitted to lo(year) and fleet.

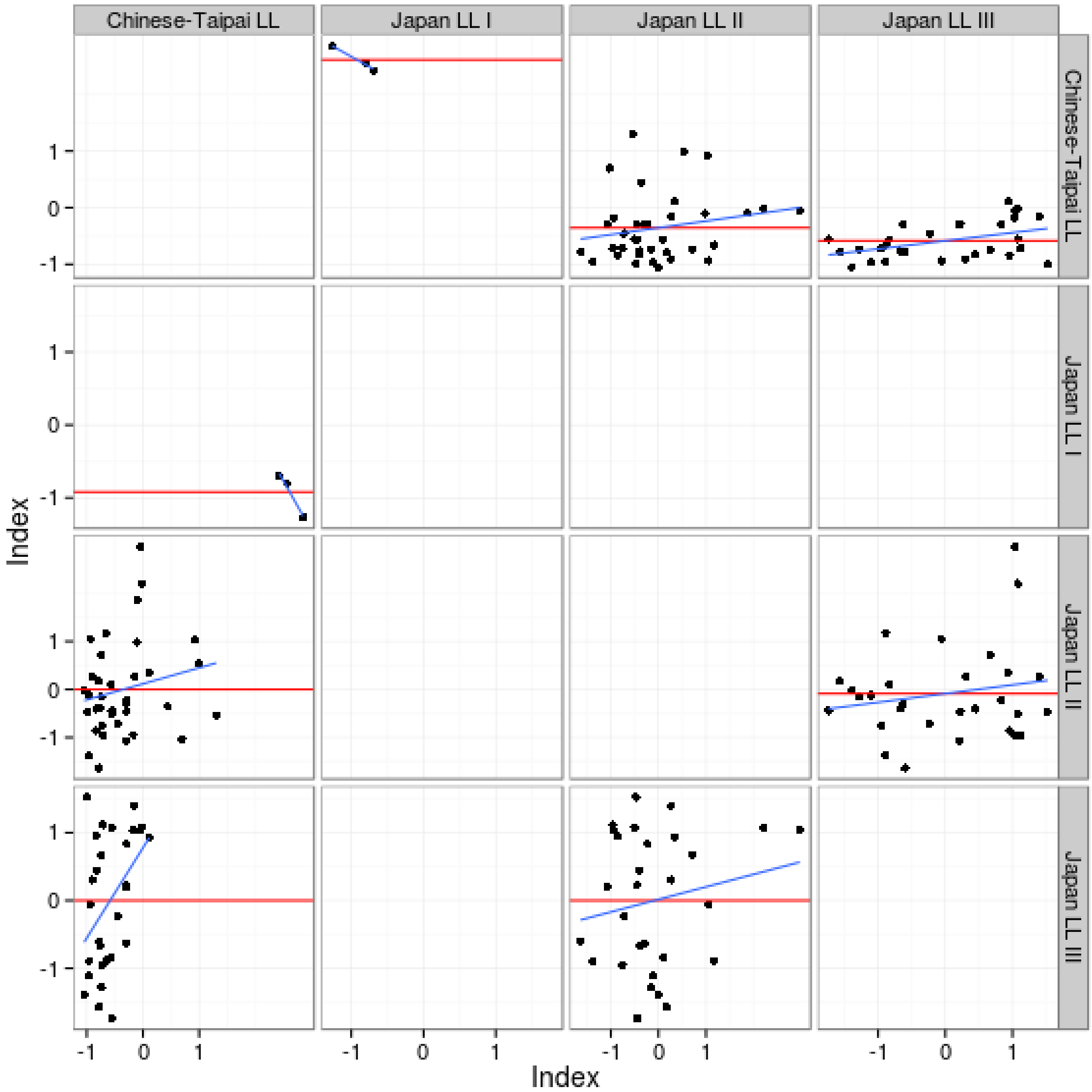

Figure 2. Pairwise scatter plots of the indices of abundance, blue lines are linear regressions fitted to the points, the shade area is the standard error of predicted means and the red line is the mean of the points on the y-axis.

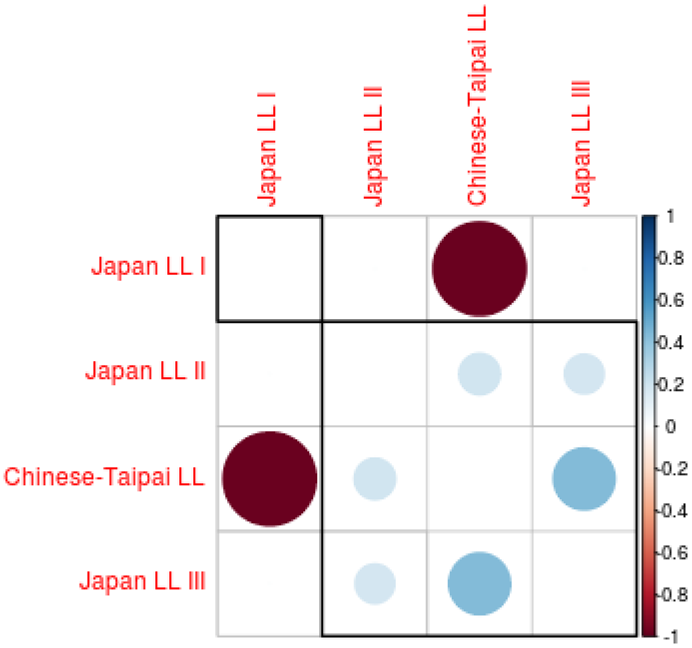

Figure 3. A plot of the correlation matrix for the indices, blue indicate a positive correlation and red negative. the order of the indices and the rectangular boxes are chosen based on a hierarchical cluster analysis using a set of dissimilarities for the indices being clustered.

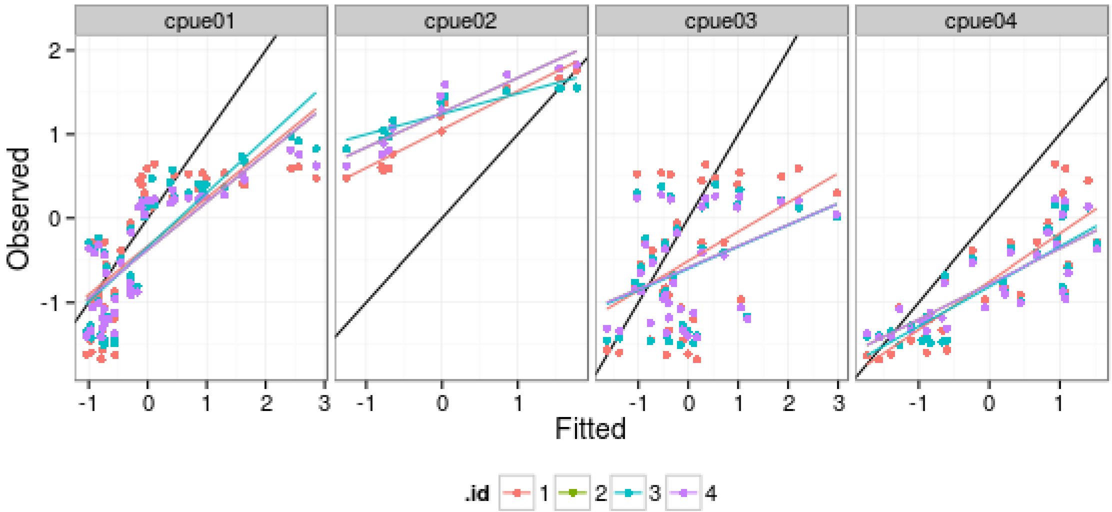

Figure 4. Observed CPUE verses fitted, blue line is a linear regression fitted to points, black the y=x line.

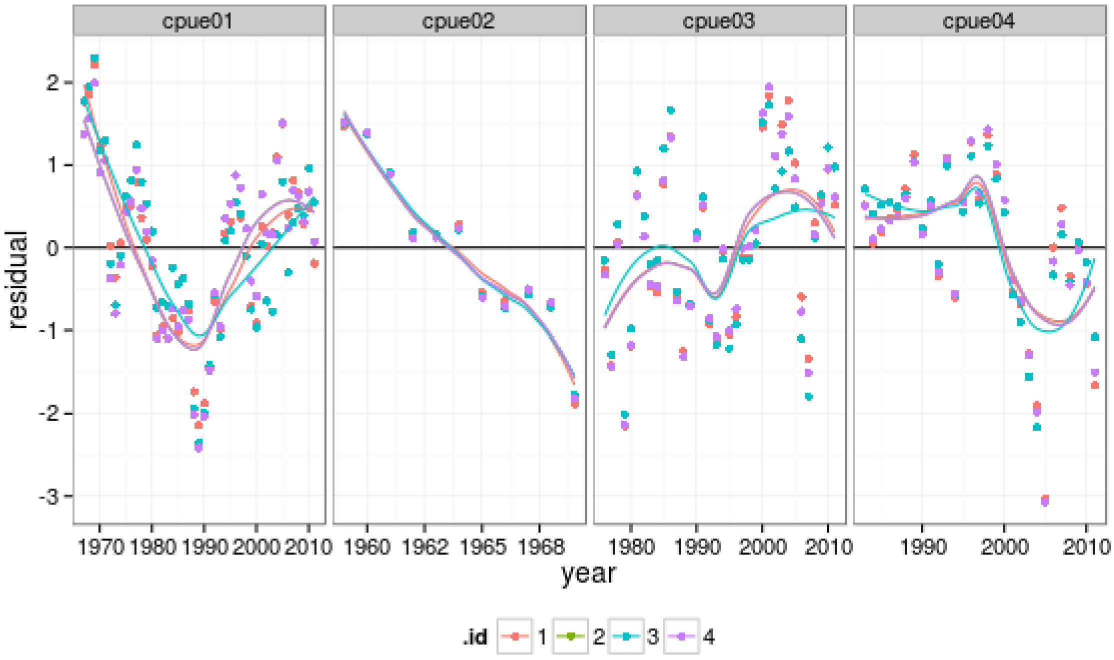

Figure 5. Residuals by year, with lowest smoother and SEs.

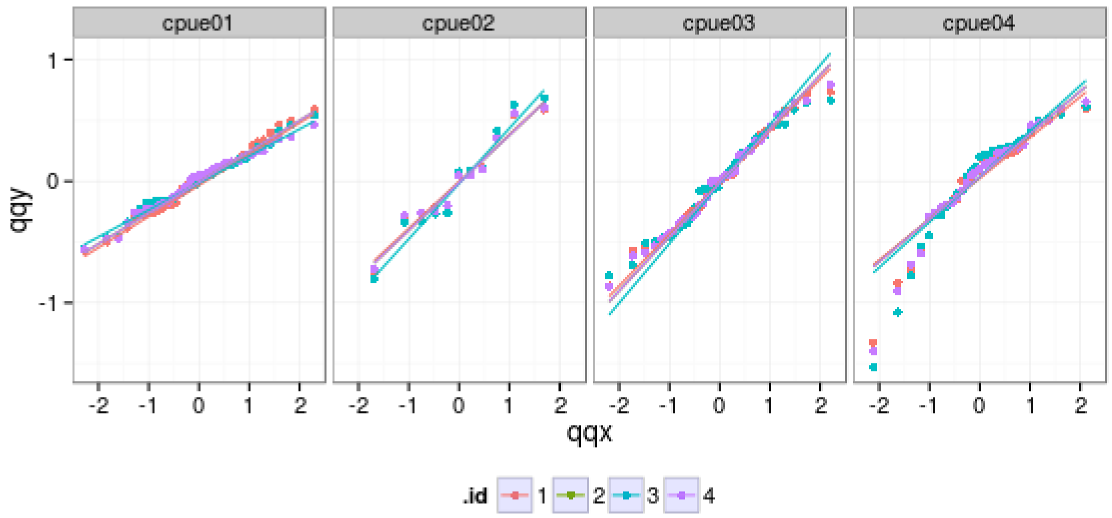

Figure 6. Quantile-quantile plot to compare residual distribution with the normal distribution.

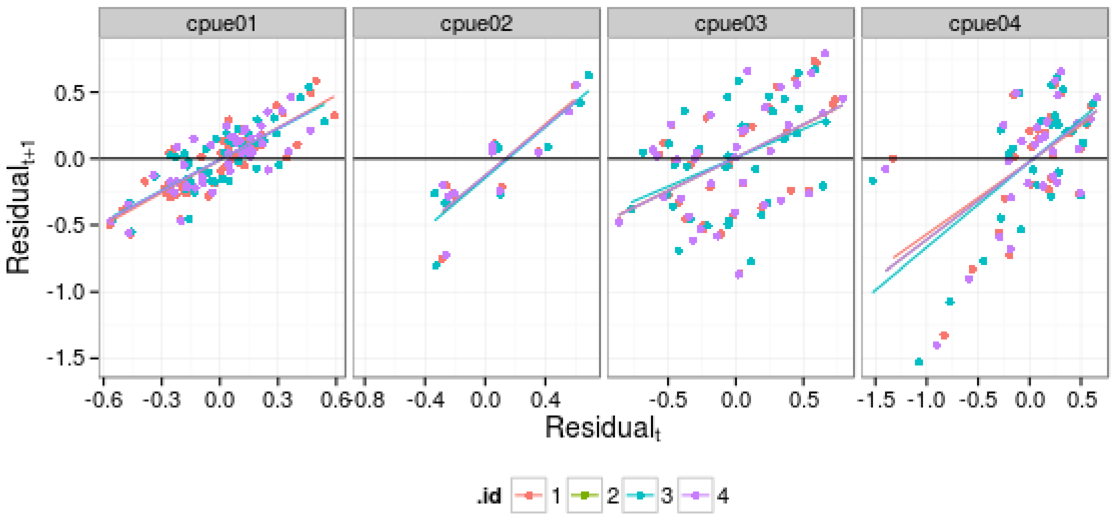

Figure 7. Plot of autocorrelation, i.e. residualt+1 verses residuals.

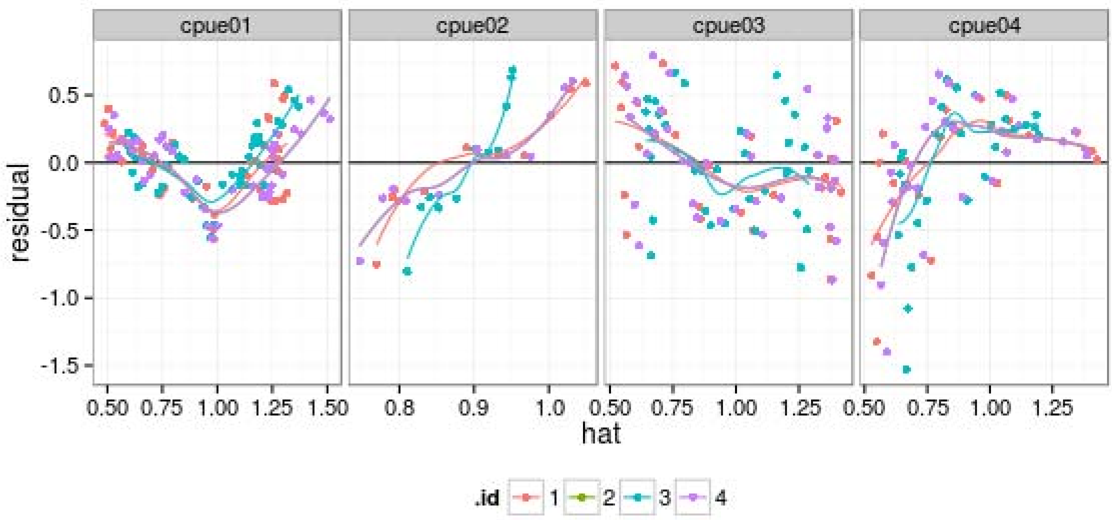

Figure 8. Plot of residuals against fitted value, to check variance relationship.