

# Challenges with Seasonal Adjustment

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FESAC Meeting  
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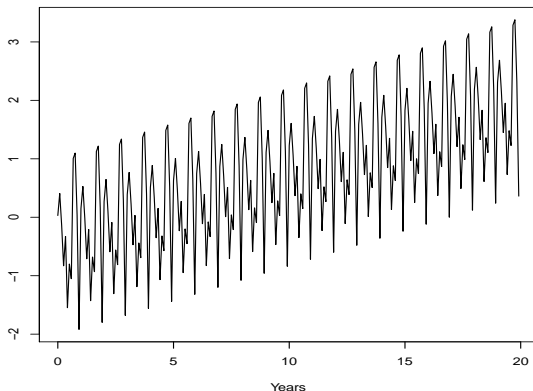
# Disclaimer

This presentation is released to inform interested parties of research and to encourage discussion. The views expressed on statistical issues are those of the authors and not necessarily those of the U.S. Census Bureau.

- Frequency Aggregation
- Cross-sectional Aggregation
- Seasonal Heteroscedasticity
- Improved Methodology?

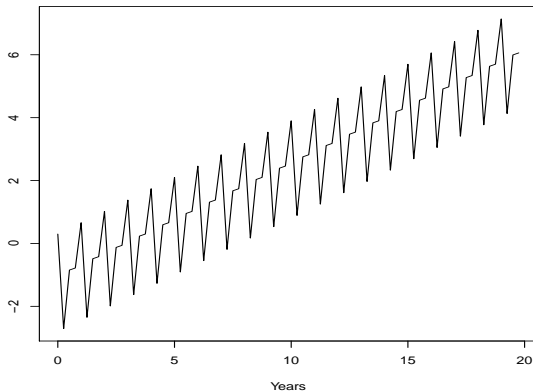
- ▶ Nonseasonal monthly series that become seasonal when aggregated to quarterly frequency
- ▶ Nonseasonal series that whose aggregate across cross-sections (region, industry, etc.) is seasonal
- ▶ Seasonal series deemed nonseasonal by conventional diagnostics

# FREQUENCY AGGREGATION



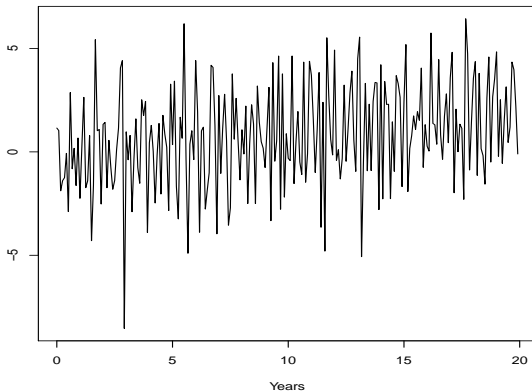
**FIGURE:** Simulated monthly series with salient seasonality (and trend).

# FREQUENCY AGGREGATION



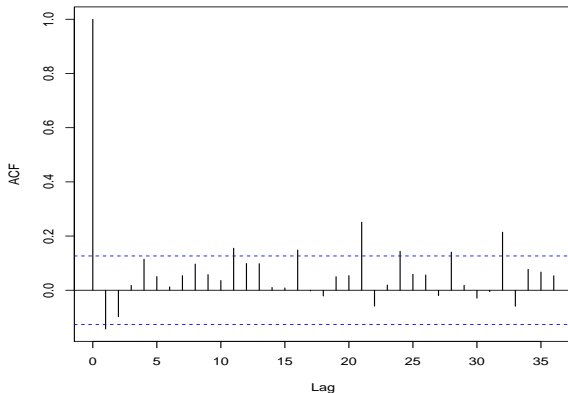
**FIGURE:** Simulated monthly series, which has been quarterly aggregated.

# FREQUENCY AGGREGATION



**FIGURE:** Simulated monthly series, consisting of original series plus noisy “quota” series.

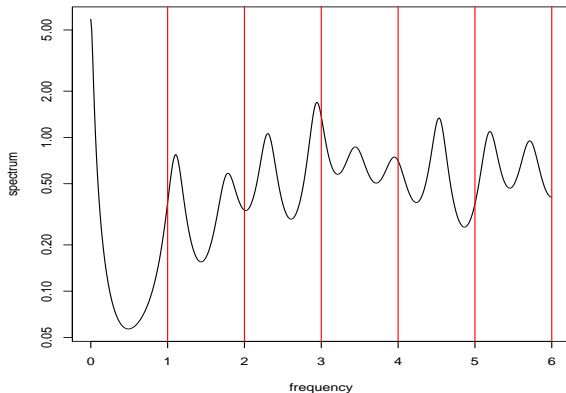
# FREQUENCY AGGREGATION



**FIGURE:** Autocorrelation plot of noisy monthly series. (Big spikes at lags 12, 24, and 36 would indicate seasonality.)

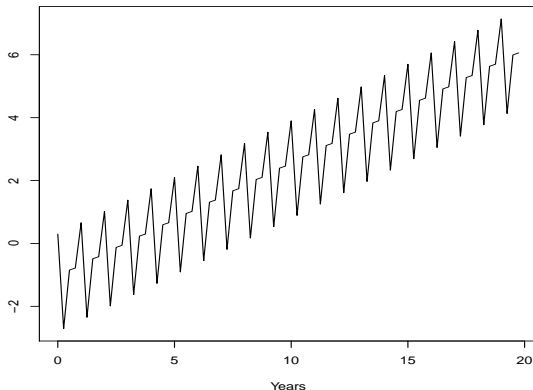


# FREQUENCY AGGREGATION



**FIGURE:** Spectral density plot of noisy monthly series. (Big spikes at seasonal frequencies 1, 2, 3, 4, 5, 6 in red would indicate seasonality.)

# FREQUENCY AGGREGATION

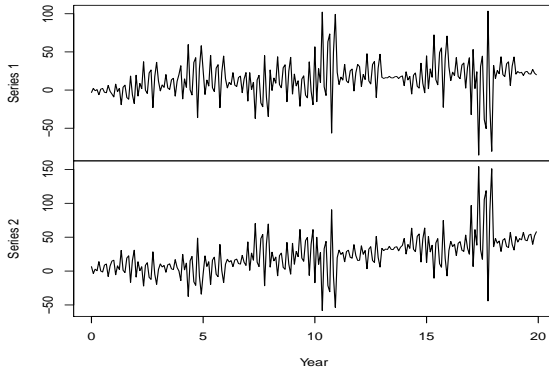


**FIGURE:** Quarterly aggregation of nonseasonal noisy monthly series.

## Summary:

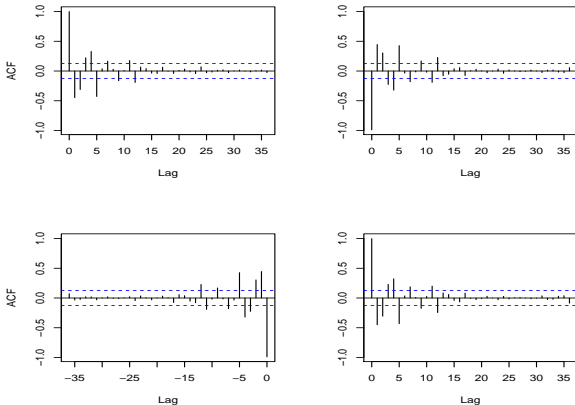
- ▶ “Quota” series generated by random values of first two months of each quarter, but with third month equal to negative of sum of other two months
- ▶ Exhibit noisy monthly series with NO apparent seasonality (by conventional diagnostics)
- ▶ This noisy monthly series aggregates to a quarterly series with strong seasonality
- ▶ How can we detect such features in the monthly data, before quarterly aggregation?

# CROSS-SECTIONAL AGGREGATION



**FIGURE:** Simulated bivariate monthly series without salient seasonality (but mild trend).

# CROSS-SECTIONAL AGGREGATION



**FIGURE:** Acf plot of differenced bivariate monthly series. (Big spikes at lags 12, 24, and 36 would indicate seasonality.)

# CROSS-SECTIONAL AGGREGATION

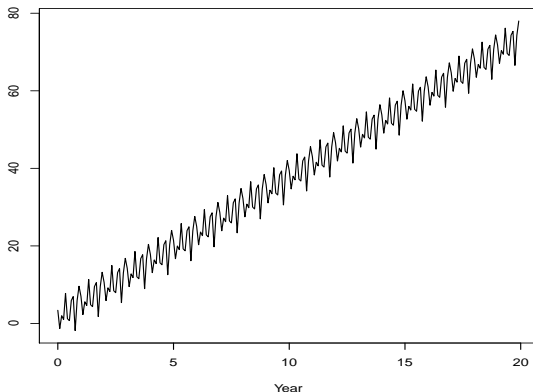
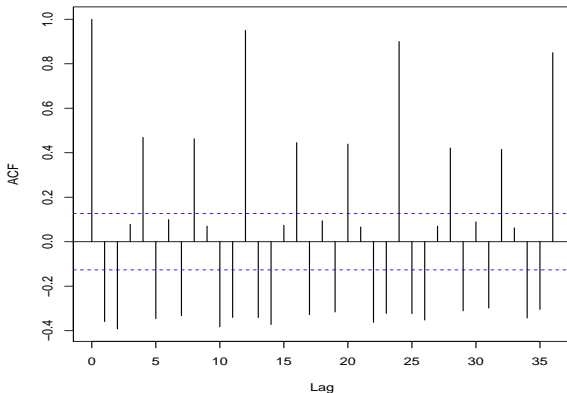


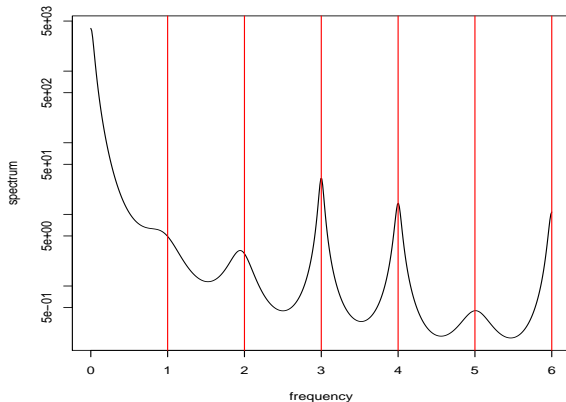
FIGURE: Plot of sum of nonseasonal bivariate monthly series.

# CROSS-SECTIONAL AGGREGATION



**FIGURE:** Acf plot of differenced aggregate monthly series. (Big spikes at lags 12, 24, and 36 indicate seasonality.)

# CROSS-SECTIONAL AGGREGATION



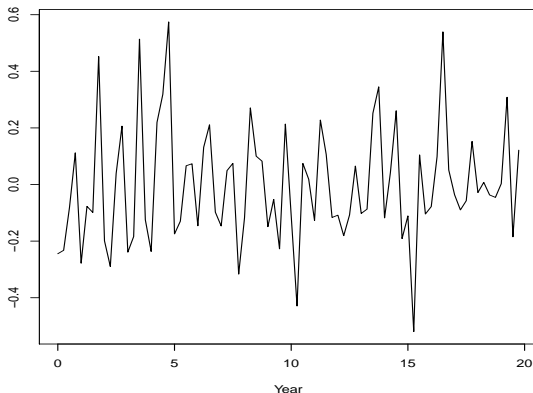
**FIGURE:** Spectral density plot of aggregate monthly series. (Big spikes at seasonal frequencies 1, 2, 3, 4, 5, 6 in red indicate seasonality.)



## Summary:

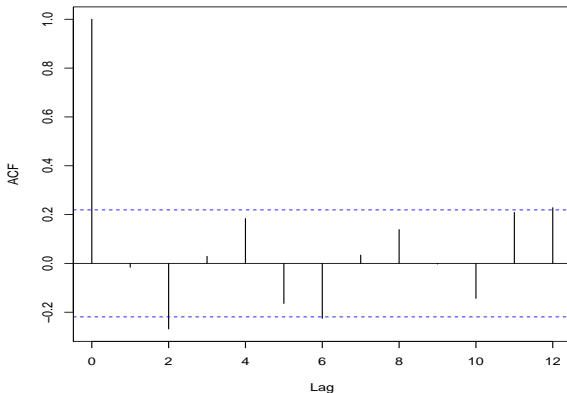
- ▶ Construction proceeds by adding and subtracting the same white noise to seasonal persistency of each series
- ▶ Exhibit two monthly series with NO apparent seasonality (by conventional diagnostics)
- ▶ These monthly series aggregate to a monthly series with strong seasonality
- ▶ How can we detect such features in the monthly data, via a bivariate analysis?

# SEASONAL HETEROSCEDASTICITY



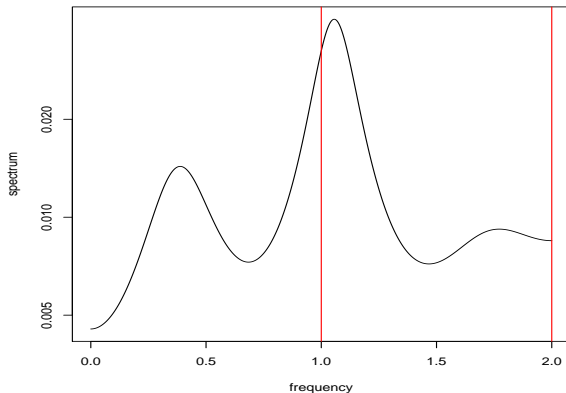
**FIGURE:** Simulated quarterly series. Is it even seasonal?

# SEASONAL HETEROSCEDASTICITY



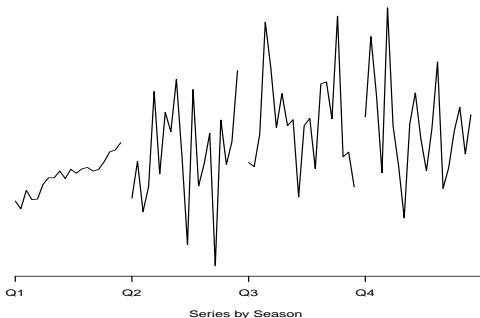
**FIGURE:** Acf plot of simulated quarterly series. (Big spikes at lags 4, 8, and 12 would indicate seasonality.)

# SEASONAL HETEROSCEDASTICITY



**FIGURE:** Acf plot of simulated quarterly series. (Big spikes at seasonal frequencies 1 and 2 in red would indicate seasonality.)

# SEASONAL HETEROSCEDASTICITY



**FIGURE:** Annual series for each quarter. Q1 is persistent, indicating seasonality, whereas other quarters are non-persistent, and hence non-seasonal.

## Summary:

- ▶ Construction proceeds by making persistent Q1 effect, and composing with noisy series for other quarters
- ▶ Composition appears to have some dynamic seasonality, but diagnostics are ambiguous
- ▶ Isolating individual quarters' series makes Q1 persistence clear

# CRITERIA FOR IMPROVED METHODOLOGY

1. **Simplicity** (non model-based)
2. **Continuum** (non-seasonal to seasonal)
3. **Idempotent** (sa same as non-seasonal)
4. **Generality** (includes classical methods as special cases, and explains their failure)
5. **Measure** (defines seasonality)
6. **Diagnostic** (tools for assessing seasonality)
7. **Uncertainty** (quantifies error in adjusting)
8. **Flexibility** (explains stable, dynamic, seasonal break, changing amplitude, seasonal hetero, frequency agg, cross agg, et al)

**Seasonal Vector Form:** series  $\{X_t\}$  with  $p$  seasons per cycle is embedded as  $p$ -variate vector time series

$$\mathbf{X}_n = U y_n$$

where  $U$  is  $p \times r$  (seasonal patterns),  $y_n$  is  $r \times 1$  (seasonal persistence). This can be adapted when trend structures are present.  $U$  and  $y_n$  can be computed by SVD of data matrix (Lin, Huang, and McElroy).

**Useful?:** helped me construct the counter-examples of this talk – therefore useful, at a minimum, conceptually



- ▶ Fixed effects in  $y_n$  (e.g., linear trend) correspond to deterministic (predictable) seasonality
- ▶ Stochastic portion of  $y_n$  with high autocorrelation (spectral mass at frequency zero) corresponds to persistent dynamic seasonal phenomena
- ▶ White noise portion of  $y_n$  corresponds to nonseasonal component

**Seasonal Adjustment:** whitening the seasonal persistence

# QUESTIONS AND DISCUSSION POINTS

1. Which agencies have data exhibiting some of these problems?  
(Can you share)
2. How are the issues resolved now, using software of the classical approaches (e.g., X-12-ARIMA, SEATS, STAMP)?
3. How do we communicate these issues to “man on the street”?

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