To Adjust or Not to Adjust? An Empirical Evaluation of Time Series with Unstable Seasonal Patterns

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The problem

- Should time series with weak seasonal autocorrelation be seasonally adjusted?
- Weak seasonal autocorrelation → quickly changing annual pattern.
  - For example, for a series following a seasonal (1 0 0) model with Phi = 0.4 the autocorrelation between values one year apart is 0.4; between values two years apart is 0.16
  - Some seasonality diagnostics in X-13ARIMA-SEATS will find the series to be seasonal, but the seasonal pattern may change too quickly for accurate identification

This study investigates…

- Whether X-13ARIMA-SEATS's seasonality diagnostics find the weakly seasonal series to be seasonal
- How accurate the adjustments are, compared to adjustments of similar series with more stable seasonal patterns
- Whether the seasonal adjustments are stable

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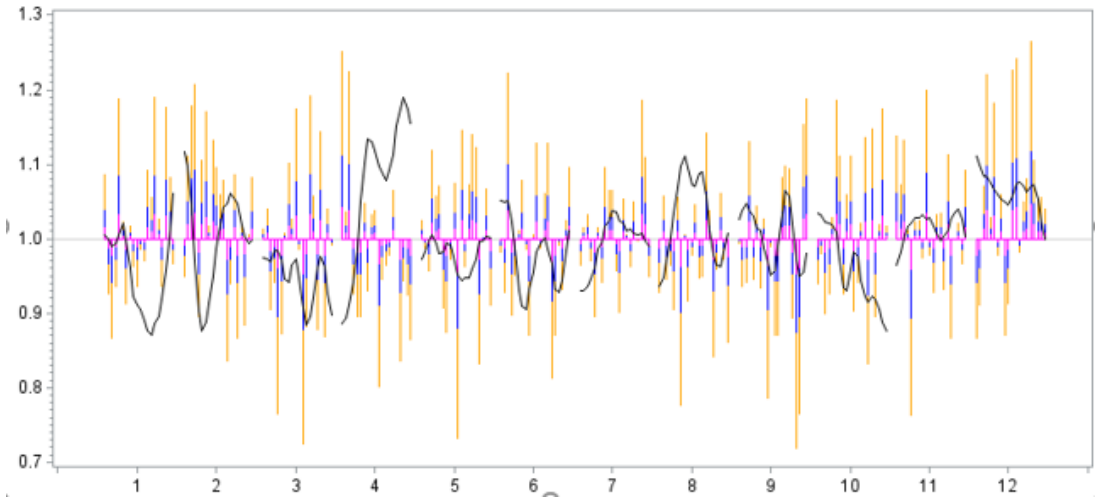
Simulating the time series

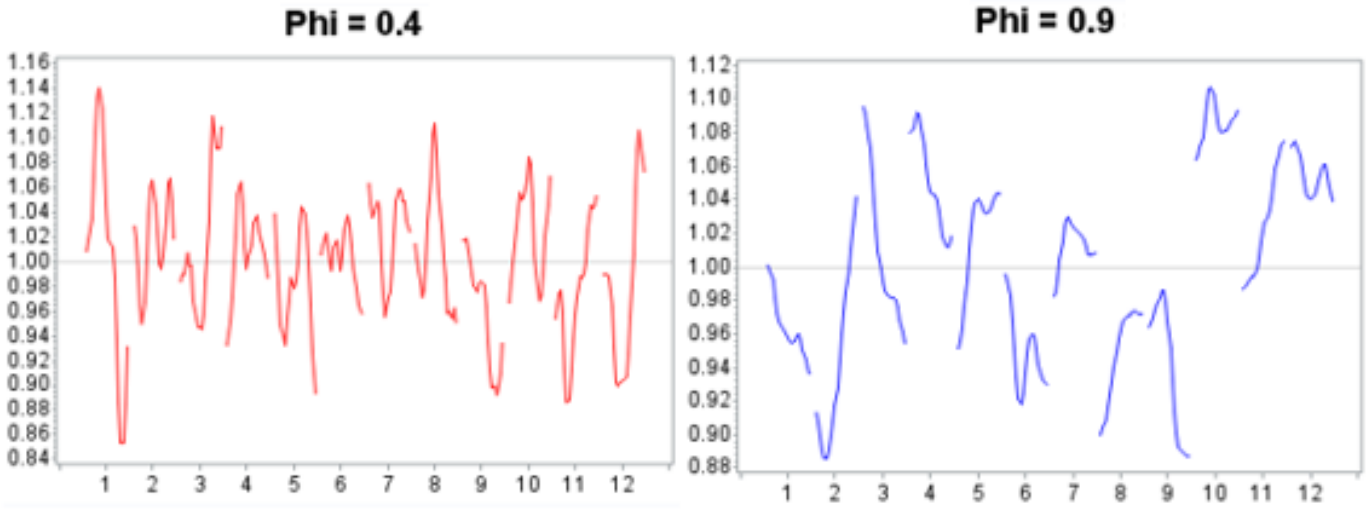
- Create simulated monthly time series using:
  - 10 trends from real time series (monthly manufacturing series)
  - 5 irregular patterns (simulated white noise) spread out so that the irregular is small (Group A), similar to (Group B), or large (Group C) compared to the seasonal factors
  - 10 seasonal patterns each from an X-11 adjustment of simulated (1 0 0)12 series with Phi = 0.4 and Phi = 0.9
- In total, there are 1500 Phi = 0.4 (weakly seasonal) series, 1500 Phi = 0.9 (fairly strongly seasonal) series, and 150 nonseasonal series

An example of one of the Phi = 0.4 seasonal patterns, overlaid with one of the irregular patterns at the three levels



Comparison of the Phi = 0.4 and Phi = 0.9 factors

Seasonal factors from one of the Phi = 0.4 and Phi = 0.9 series



Descriptive summary statistics of the Phi = 0.4 and Phi = 0.9 monthly seasonal factor series

For each monthly seasonal factor series…	Phi = 0.4	Phi = 0.9
Average number of times they cross one	2.08	0.86
Average changes in direction	4.03	2.65
Average spread	0.16	0.09
Average year-to-year change	0.018	0.008

Proportion of series in each group indicating seasonality

Irregular Group	M7 < 1	D8F > 7	Spectrum Peak (v.s. peak at S1 - S4)	QS Original (p < 0.01)	QS Prior Adj (p < 0.01)	QS Original (Last 8 yr) (p < 0.01)	QS Prior Adj (Last 8 yr) (p < 0.01)	Seasonal Regs (p < 0.05)
Phi = 0.4								
A	0.60	0.53	0.88	1.00	1.00	1.00	1.00	0.99
B	0.46	0.22	0.77	1.00	1.00	1.00	0.99	0.81
C	0.02	0.00	0.24	0.81	0.81	0.37	0.36	0.53
Phi = 0.9								
A	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
B	1.00	1.00	0.97	1.00	1.00	0.98	0.98	1.00
C	0.67	0.29	0.53	0.70	0.70	0.38	0.38	0.98
Nonseas								
A	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

- Diagnostics differ greatly as to whether weakly seasonal series are seasonal, with QS (which directly measures positive seasonal autocorrelation) most likely to consider the series seasonal.
- Strongly seasonal series are always found to be seasonal when the irregular is small, and less likely to be when the irregular is large.
- Nonseasonal series are not identified as seasonal.

Residual seasonality in the adjusted simulated series

- For the Phi = 0.9 and the nonseasonal series, almost no diagnostics found residual seasonality
- For the Phi = 0.4 series, residual seasonality was identified by the QS diagnostic for the seasonally adjusted series and the irregular (but not for the extreme-value adjusted versions of these series) only for the series with the small irregular:

Irregular Group	Seas Adj Spectrum	Irregular Spectrum	QS Seas Adj	QS Extreme Adj Seas Adj	QS Irregular	QS Extreme Adj Irregular	Seasonal Regs (Last 8 yrs)
A	1.2	3.0	59.4	0.6	63.2	0.0	2.4
B	0.0	0.6	0.0	0.0	0.0	0.0	0.0
C	0.4	0.4	0.0	0.0	0.0	0.0	0.0

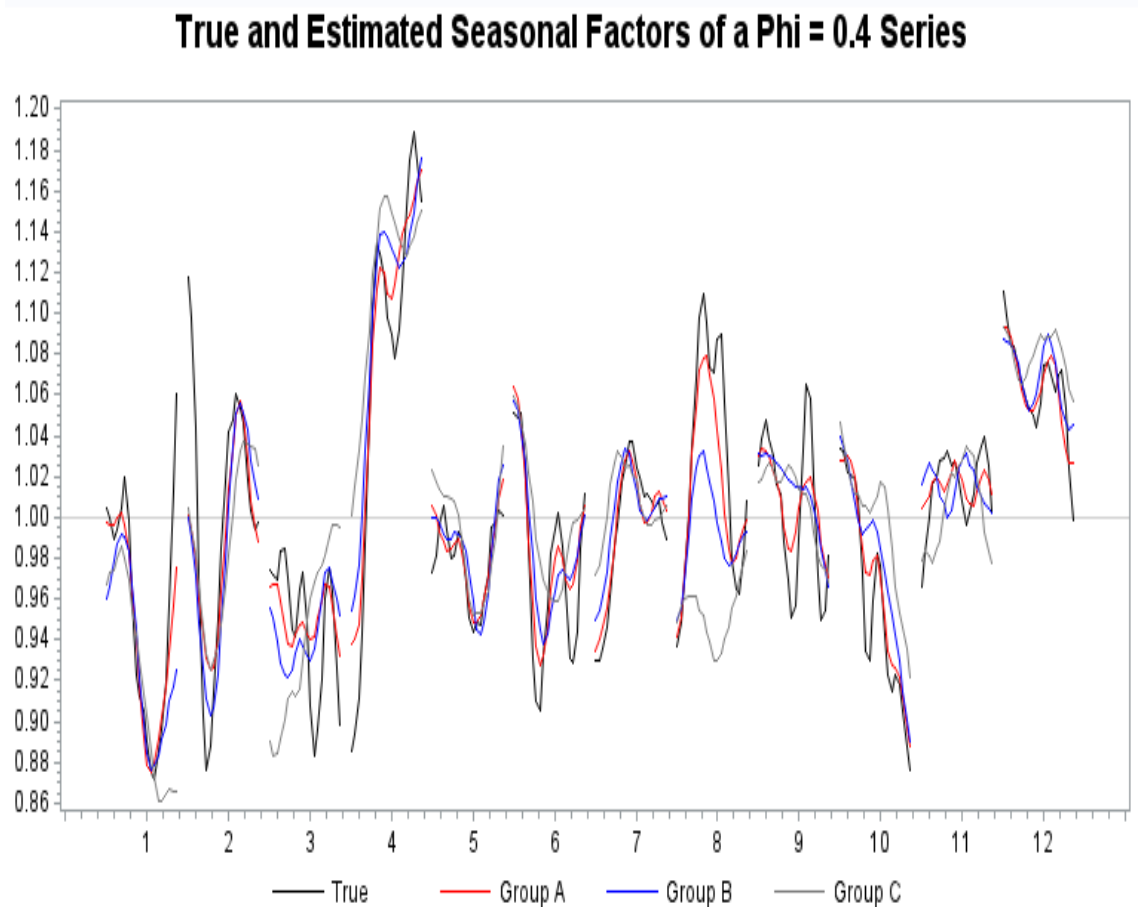
Accuracy of the adjustments

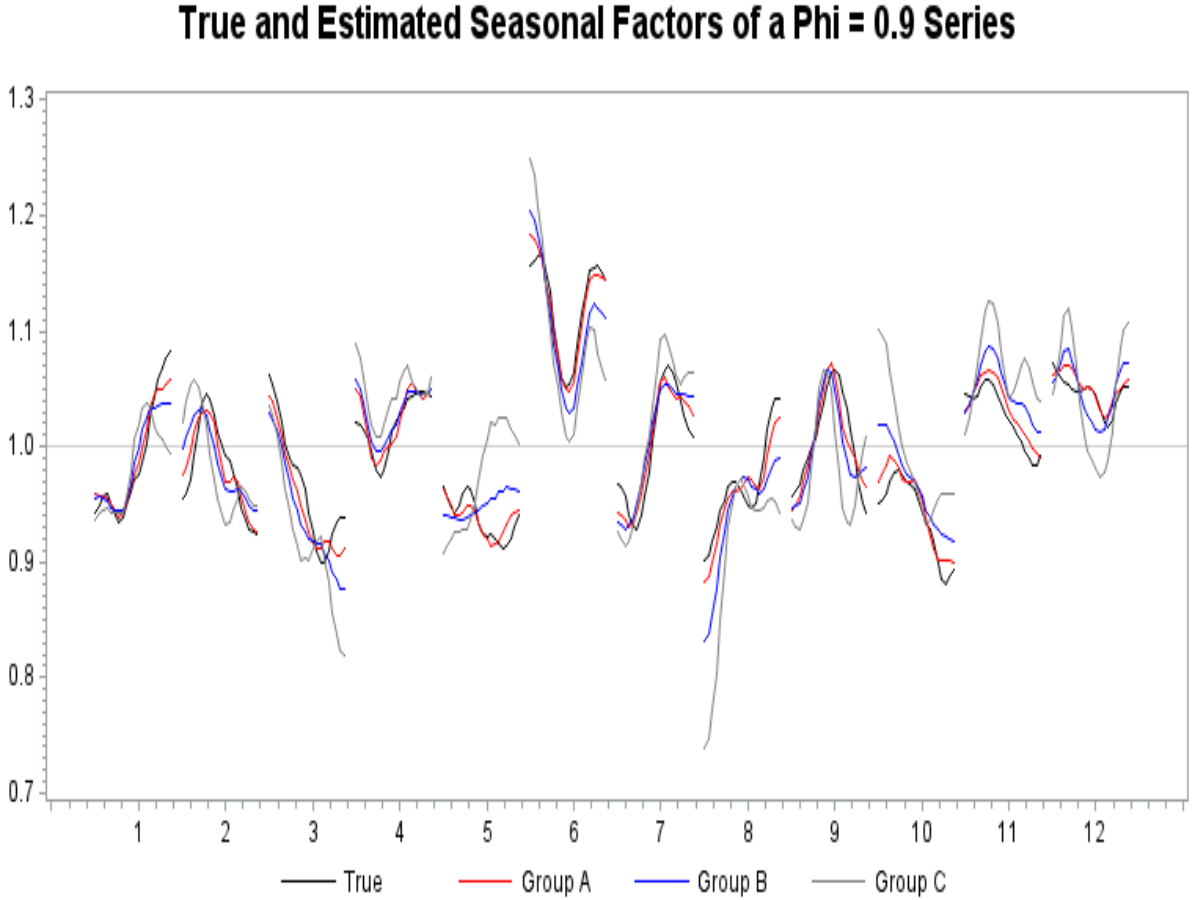
Means of average absolute percent differences between the true unadjusted series and the estimated seasonally adjusted series, along with the standard error

Seasonal Pattern	Group A aapd (s.e.)	Group B aapd (s.e.)	Group C aapd (s.e.)
Phi = 0.4	1.4812 (0.0057)	2.3443 (0.0066)	4.0857 (0.0128)
Phi = 0.9	0.9083 (0.0041)	1.8292 (0.0074)	3.7121 (0.0206)
None	0.6245 (0.0109)	1.5666 (0.0329)	3.4466 (0.0743)

- The error in the estimated adjustment was larger for the weakly seasonal series than for the strongly seasonal series. In Group A, it's about 50% bigger. The difference in error is less pronounced when the irregular is larger.
- The adjustments become less accurate as the irregular gets larger.

Comparison of the estimated seasonal factors from one Phi = 0.4 and one Phi = 0.9 series





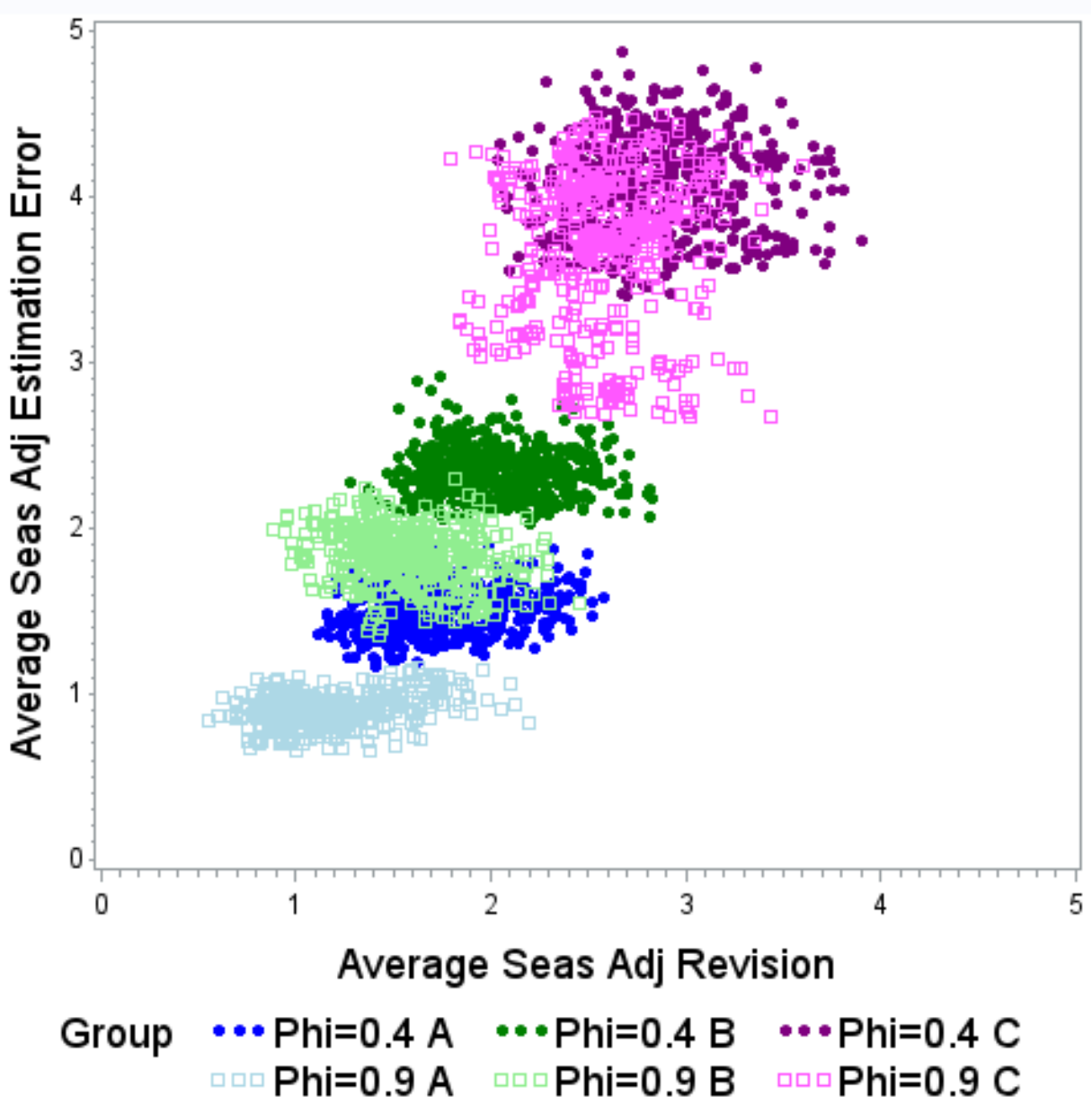
Stability of the adjustments

Average absolute percent difference between the initial and the final seasonal adjustment (SA) and month-to-month change in the seasonal adjustment (MM)

		Phi = 0.4				Phi = 0.9			
Group		Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max
A	SA	1.71	0.30	1.11	2.58	1.16	0.29	0.56	2.21
	MM	1.90	0.27	1.18	2.64	1.21	0.20	0.62	2.04
B	SA	2.00	0.29	1.29	2.82	1.58	0.28	0.89	2.46
	MM	2.60	0.33	1.74	3.41	2.04	0.36	1.14	3.12
C	SA	2.86	0.36	2.04	3.91	2.60	0.31	1.80	3.60
	MM	3.97	0.62	2.62	5.78	3.58	0.56	2.32	5.53

- The weakly seasonal series have larger revisions than the more strongly seasonal series.

The average absolute percent differences between the true and estimated seasonal adjustments vs the average revision between the initial and final estimate of each value.



Conclusions

- X-11 seasonal adjustment of these weakly seasonal series is generally successful, in that it removes evidence of seasonality from the series.
  - The reason for the significant QS diagnostics still needs investigation.
- However, the error in these adjustments is greater than the error from adjusting more strongly seasonal series.
- Determining whether these series are seasonal is difficult, as seasonality diagnostics give contrasting decisions.

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