Case Study: Fixing Residual Trading Day Effects in the Seasonally Adjusted Series

Catherine C. H. Hood, Catherine Hood Consulting

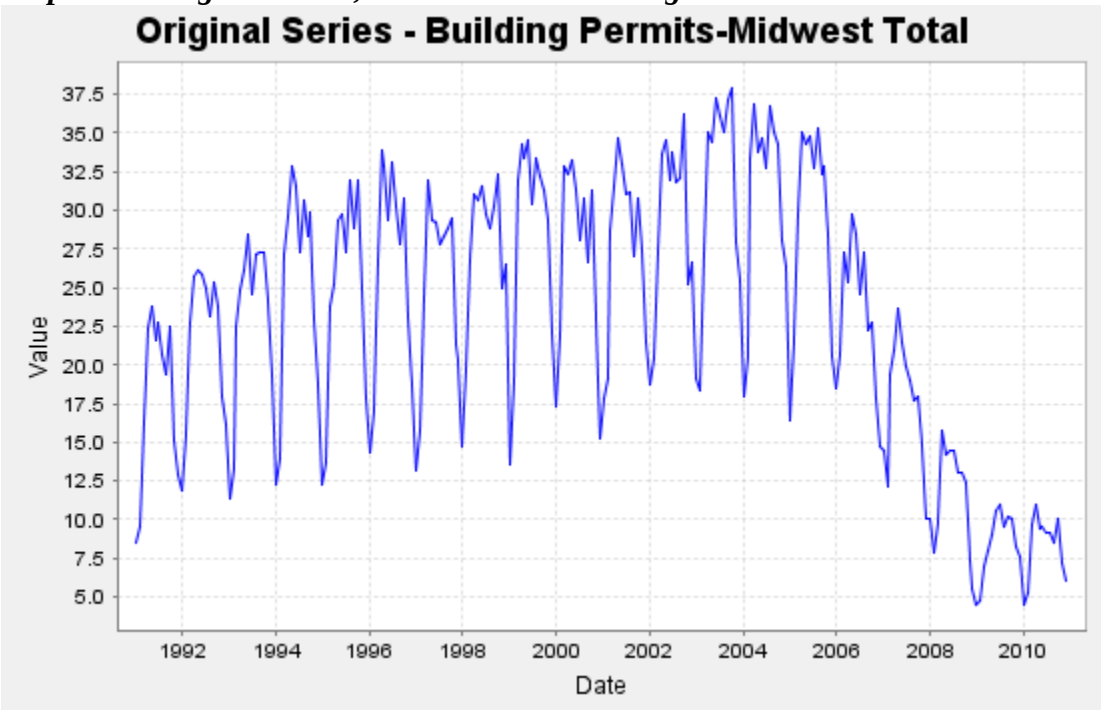
Spectral graphs are one of the most useful diagnostics we have. It's through spectral graphs that we can see residual seasonality and trading day effects. One of the most common issues with the spectral diagnostics is having a trading day peak in the spectral graph when we've already specified a trading day effect in the regression model. For some background information on spectral graphs, please see the section on spectral diagnostics in the paper "Getting Started with X-12-ARIMA Diagnostics."

First Run of Midwest Total Building Permits

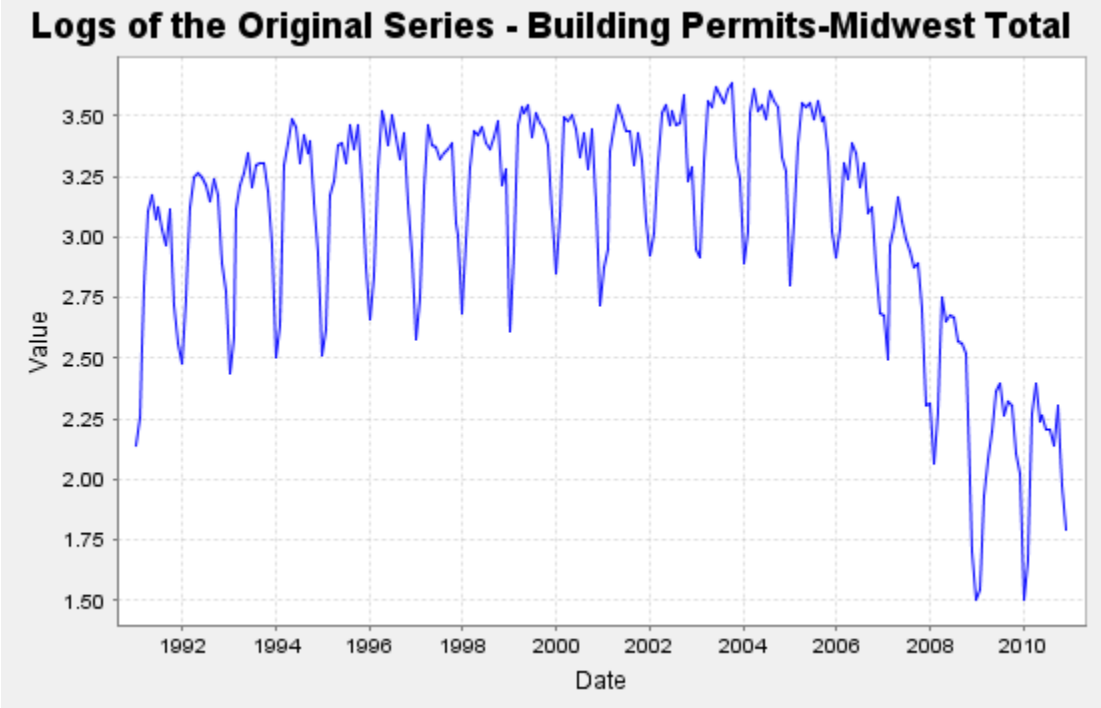
We will look at trading day and trading day spectral peaks in the series Midwest Building Permits. This series is published by the U.S. Census Bureau, and their seasonal adjustment procedure begins in 1991. This series records the number of new housing units authorized by building permits. Because permit offices are not open every day of the week, we would expect this series to have a trading day effect.

Below are graphs of the original series and a logarithmic transformation of the original series.

Graph 1 — Original Series, Midwest Total Building Permits



Graph 2 — Logs of Original Series, Midwest Total Building Permits

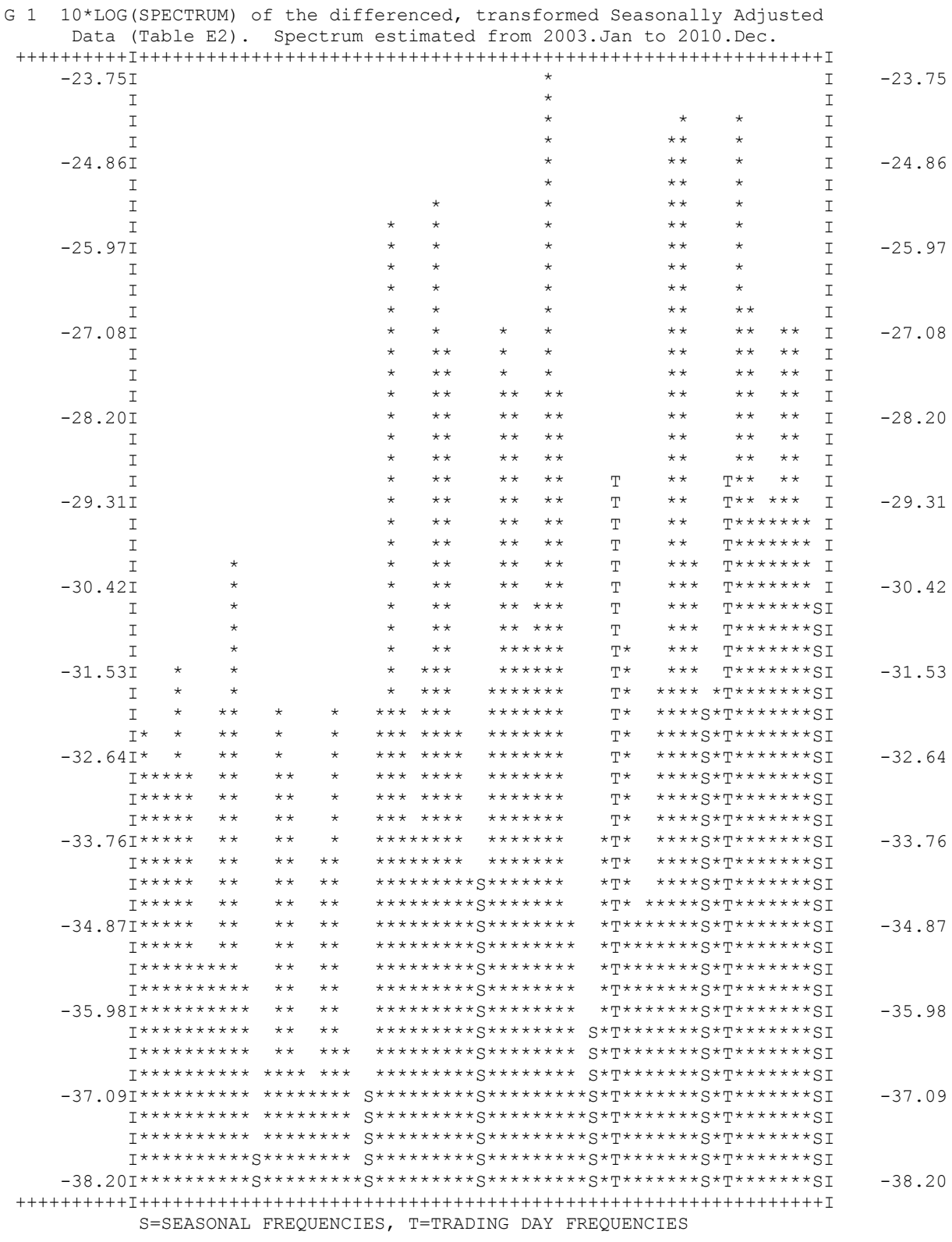


The X-12 input specification file that I used for this series is in the box below. For more information on X-12-ARIMA input files, please see the X-12-ARIMA Users Manual.

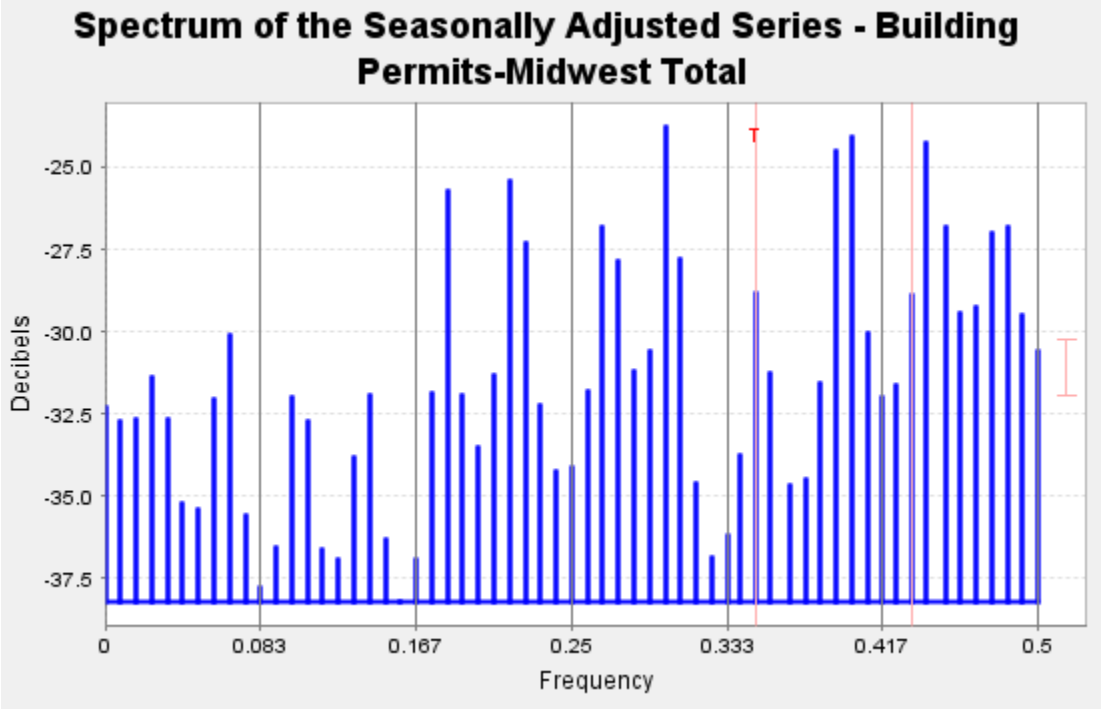
```
series {
  span=(1991.1, )
  title='Building Permits-Midwest Total'
  file='bpmwtot.dat' format="datevalue"
  savelog=spk
}
transform {function=log}
regression {variables=( td ao2000.12 ls2008.11)}
arima {model=(0 1 1)(0 1 1)}
outlier {critical=4.5 span=(2009.10, )}
check {print=all savelog=lbq}
forecast {maxlead=60}
x11 {sigmalim=(1.5 3.0)
     seasonalma=s3x5
     savelog=all
}
```

When I run the above specification file, X-12-ARIMA sends warning messages to the screen that there is a residual trading day peak in the seasonally adjusted series. The spectral graph from the output and the spectral graph from the X-12 Windows interface are on the following pages. In the graph from the output file, we can see that the first trading day peak is more than six stars above its nearest neighbor. In the graph from the interface, the trading peak is marked with a red "T". Notice also that the spectral graph uses data from 2003 to 2010 — only eight years of data, the default for X-12-ARIMA.

Graph 3 — Seasonally Adjusted Series Spectrum from the Output File



Graph 4 — Seasonally Adjusted Series Spectrum from the X-12-ARIMA Windows Interface



Also in the output file, we will find the results of the trading day regression. We can see by the regression results, given below in Table 1, that Tuesday has a significant positive regression coefficients (more people get permits on Tuesday) while Saturday and Sunday have significant negative regression coefficients. This makes sense because most permit offices are closed on Sundays, and either closed or have limited hours on Saturdays. The Chi-squared test for the trading day effect tells us that this effect is significant.

Table 1. Trading Day Regression Results for the Full Series (beginning in 1991)

Variable	Parameter Estimate	Standard Error	t-value
Trading Day			
Mon	-0.0042	0.01011	-0.41
Tue	0.0429	0.00995	4.31
Wed	0.0050	0.00997	0.50
Thu	0.0072	0.01002	0.72
Fri	0.0076	0.01001	0.76
Sat	-0.0320	0.01008	-3.18
*Sun (derived)	-0.0265	0.01002	-2.65

Chi-squared Tests for Groups of Regressors

Regression Effect	df	Chi-Square	P-Value
Trading Day	6	119.63	0.00

Options for Fixing Residual Trading Day

What sometimes happens is that a seasonal or trading day pattern changes over time so that regression coefficients that are estimated from the entire span do not adequately account for the effect. Because, generally, we are most interested in the data at the end of the series, it's best to use the data at the end of the series to generate the regression coefficients. Therefore, one solution is to use the "modelspan" argument to limit the data used in the regression. Another solution is to use different trading day coefficients for two different parts of the series.

A disadvantage to using a shorter span for the modeling is that it will also affect other parts of the model, such as outliers. In this series, there are two outliers: a point outlier in December 2000 and a level shift in November 2008. So, for example, if we shorten the series for modeling back to 2003, then we would not be able to estimate the point outlier in 2000.

The Change-of-regime Trading Day Variable

A change-of-regime trading day variable will estimate a trading day effect separately for two different parts of a series. This solution can be particularly useful if we can't use the modelspan argument because of outliers or other regression effects. An example of a regression spec with a change-of-regime trading day variable with a split in the series in January 2006 is shown in the box below.

```
regression {variables=( td/2006.jan/  ao2000.12  LS2008.11 ) }
```

If we use the change-of-regime trading day regression list above, we get the coefficients given in Table 2. The second Chi-squared test (on the next page) for the change between the coefficients before January 2006 and after January 2006 shows that the change isn't significant. However, this change-of-regime trading day variable does eliminate the residual trading day in the seasonally adjusted series as seen in Graph 5 on the next page.

Table 2. Trading Day Regression Results with td/2006.1/ Variable

Variable	Parameter Estimate	Standard Error	t-value
Trading Day (after 2006.Jan)			
Mon	-0.0362	0.01983	-1.82
Tue	0.0775	0.01952	3.97
Wed	-0.0125	0.01977	-0.63
Thu	0.0161	0.02012	0.80
Fri	0.0124	0.01918	0.65
Sat	-0.0359	0.02055	-1.75
*Sun (derived)	-0.0214	0.02059	-1.04

Table 2, Continued. Trading Day Regression Results with td/2006.1/ Variable

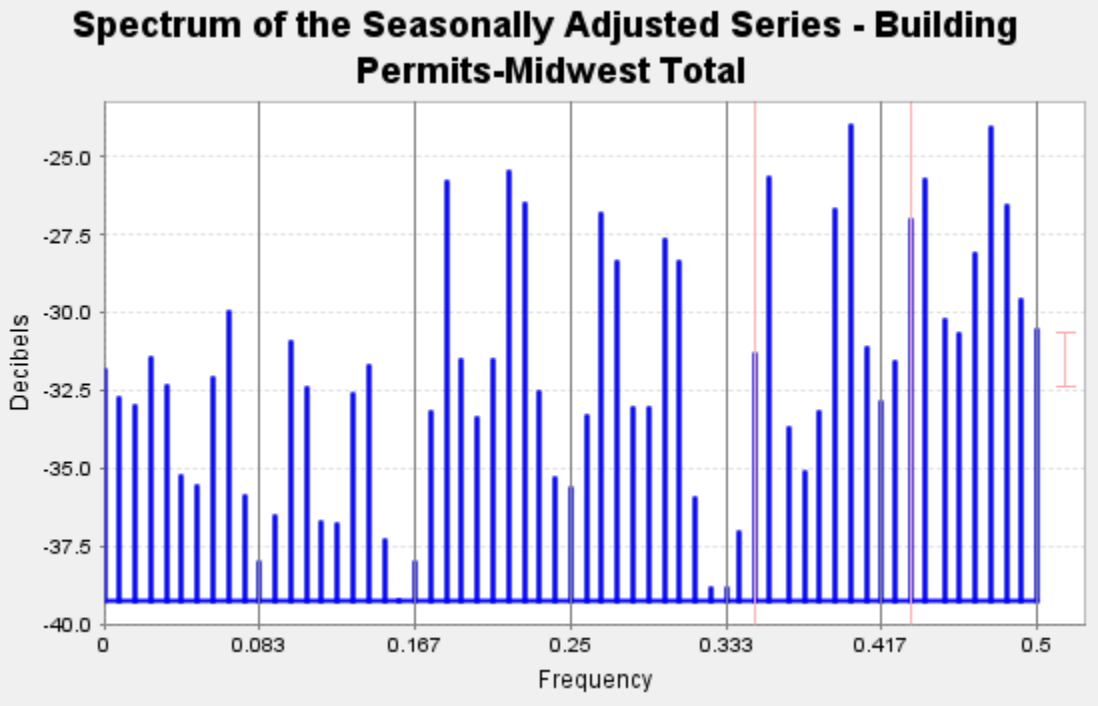
Variable	Parameter Estimate	Standard Error	t-value
&&Trading Day (change for before 2006.Jan)			
Mon I	0.0429	0.02294	1.87
Tue I	-0.0468	0.02263	-2.07
Wed I	0.0240	0.02273	1.06
Thu I	-0.0123	0.02314	-0.53
Fri I	-0.0063	0.02239	-0.28
Sat I	0.0052	0.02356	0.22
*Sun I (derived)	-0.0067	0.02353	-0.29

&&The I values estimate how much the early trading day coefficients differ from those estimated for the span of data starting at the change date.

Chi-squared Tests for Groups of Regressors

Regression Effect	df	Chi-Square	P-Value
Trading Day (after 2006.Jan)	6	48.09	0.00
Trading Day (change for before 2006.Jan)	6	6.68	0.35
Combined Trading Day Regressors	12	133.61	0.00

Graph 5 — Seasonally Adjusted Series Spectrum with td/2006.1/ Variable



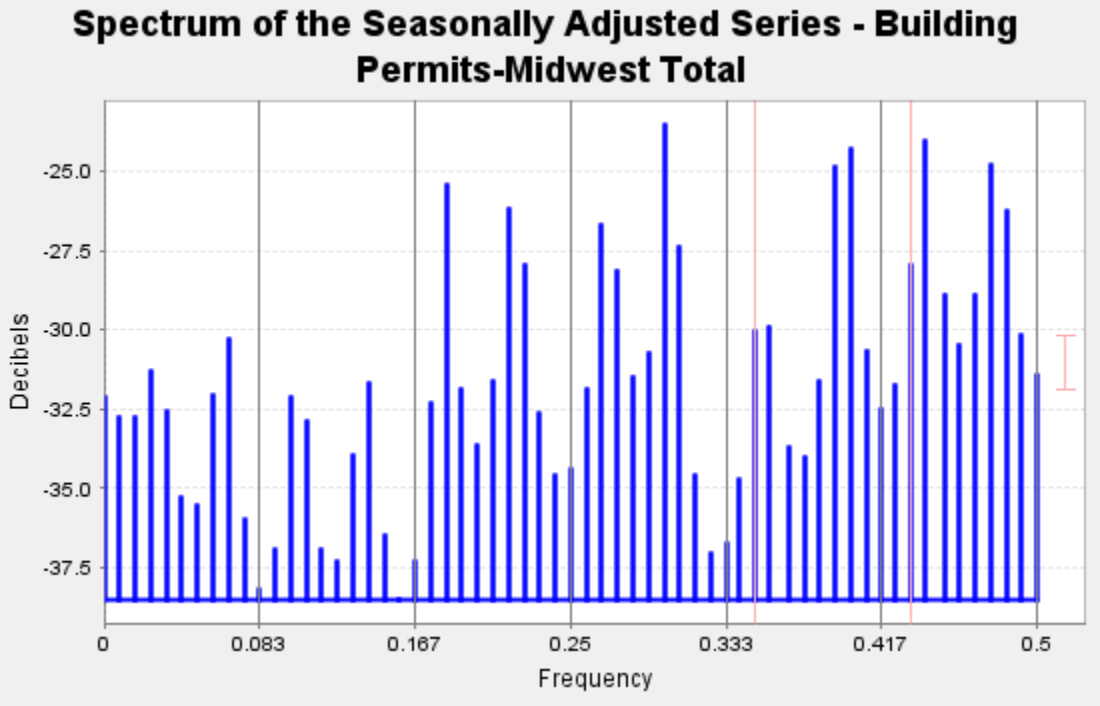
The Modelspan Argument

Let's look at using a modelspan argument instead of the change-of-regime trading day. Because of the outlier in 2000, let's begin the modelspan a few years before that. The new series spec with the span used for modeling beginning in 1998 is shown in the box below.

```
series {
  span=(1991.1, )
  modelspan = (1998.1, )
  title='Building Permits-Midwest Total'
  file='bpmwtot.dat' format="datevalue"
  savelog=spk
}
```

With the modelspan set to begin in January 1998, there are now no warnings about residual trading day peaks in the spectrum of the seasonally adjusted series. The spectral graph is shown below.

Graph 6 — Seasonally Adjusted Series Spectrum with modelspan=(1998.1,)



The new trading day regression coefficients are in Table 3 below. We can see slight changes to the coefficients, particularly in Tuesday with a corresponding change to the derived coefficient for Sunday.

Table 3. Trading Day Regression Results with modelspan=(1998.1,)

Variable	Parameter Estimate	Standard Error	t-value
Trading Day			
Mon	-0.0077	0.01384	-0.56
Tue	0.0491	0.01348	3.64
Wed	-0.0031	0.01365	-0.23
Thu	0.0148	0.01403	1.06
Fri	0.0095	0.01380	0.69
Sat	-0.0458	0.01396	-3.28
*Sun (derived)	-0.0168	0.01378	-1.22

Conclusion

For this series, I use the modelspan argument to limit the data for modeling to start in January 1998. This is a simpler solution, in my mind, then the change-of-regime trading day.

References

Hood, C.C.H. (2011), "Getting Started with X-12-ARIMA Diagnostics—Spectral Diagnostics." http://www.catherinechhood.net/papers/gsspectraldiags.pdf

U.S. Census Bureau (2009), *X-12-ARIMA Reference Manual, Version 0.3*, Washington, DC: U.S. Census Bureau, U.S. Department of Commerce. http://www.census.gov/ts/x12a/v03/x12adocV03.pdf