Seasonal Adjustment Diagnostics

Seasonal Adjustment With X-13ARIMA-SEATS

2019

Economic Statistical Methods Division

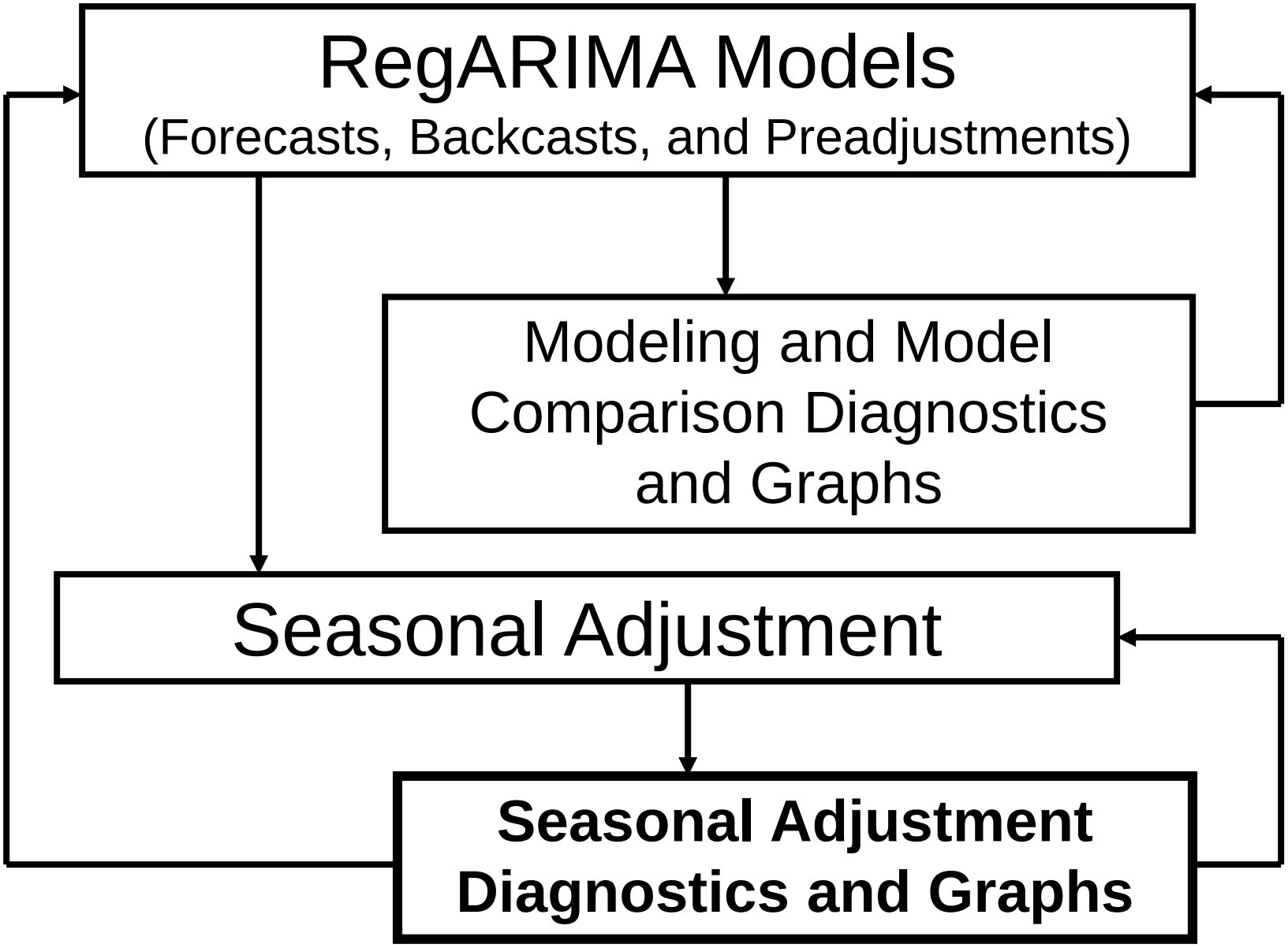
U.S. Census Bureau

United States Census Bureau

U.S. Department of Commerce
Economics and Statistics Administration
U.S. CENSUS BUREAU
census.gov

Objectives

- **At the end of this unit, you should understand**
  - What types of diagnostics are available and what they mean


RegARIMA Models
(Forecasts, Backcasts, and Preadjustments)
Modeling and Model Comparison Diagnostics and Graphs
Seasonal Adjustment
Seasonal Adjustment Diagnostics and Graphs

Why Are Diagnostics Important?

- They help us make decisions about
  - Whether or not the series is seasonal
    - Should the series be adjusted?
  - Overall quality of the seasonal adjustment
  - Choices for the X-11 options, such as seasonal filter lengths, sigma limits, etc.

Outline

- Spectral graphs
- Stability diagnostics
  - Sliding spans
  - Revisions history
- Monitoring and Quality diagnostics

What Makes an Acceptable Adjustment?

- Critical – No residual seasonality or calendar effects
  - Fit seasonal regressors to a subspan of the seasonally adjusted series then check the F test for significance (additional run)
  - QS diagnostics
  - Monthly series only: check spectral diagnostics for seasonal and trading day effects

www.census.gov/srd/www/sapaper/rrs2017-03_abs.html

Detecting Seasonality in Seasonally Adjusted Monthly Time Series by Findley, Lytras, McElroy (2017)

What Makes a Quality Adjustment?

- Adequate stability (large revisions indicate lack of usefulness)
  - Sliding spans and revision histories detect instability
- Adequate smoothness (for interpretability, especially turning points)
  - Revision histories give information about smoothness

Spectral Graph Uses

- Does the seasonally adjusted series or the irregular component have residual seasonality or trading day effects?
  - Must attempt to correct the problem
- Do the regARIMA model residuals show seasonal or trading day effects?
  - May need to change the model
- Is the original series seasonal?

Time and Frequency Domain

- Two complementary ways to analyze a time series
  - Time domain: sequence of values with regard to the time interval
  - Frequency domain: values represented as a combination of sine and cosine waves

Analysis in the Frequency Domain

Different frequencies of a time series have different strengths

- Measure those strengths (amplitude)
- Graph the squared amplitudes versus the frequencies

periodogram or spectrum

Analogies

- Prism
- Orchestra
- String wrapped around 2 pencils with space between
  - How much string is left over?

Spectral Graphs in X-13ARIMA-SEATS

- The graph marks the seasonal and trading day frequencies
  - Trading day frequencies from Cleveland and Devlin (1980)

- X-13ARIMA-SEATS does not produce spectral diagnostics for quarterly series

Seasonal Frequencies

Something that happens every

- 12 months ➔ 1/12 cycles per month
- 6 months ➔ 1/6 (2/12) cycles per month
- 3 months (every quarter) ➔ 1/3 (4/12) cycles per month

Seasonal frequencies marked at

1/12, 2/12, 3/12, 4/12, 5/12

Also called

S1, S2, S3, S4, S5

Seasonal Frequencies (continued)

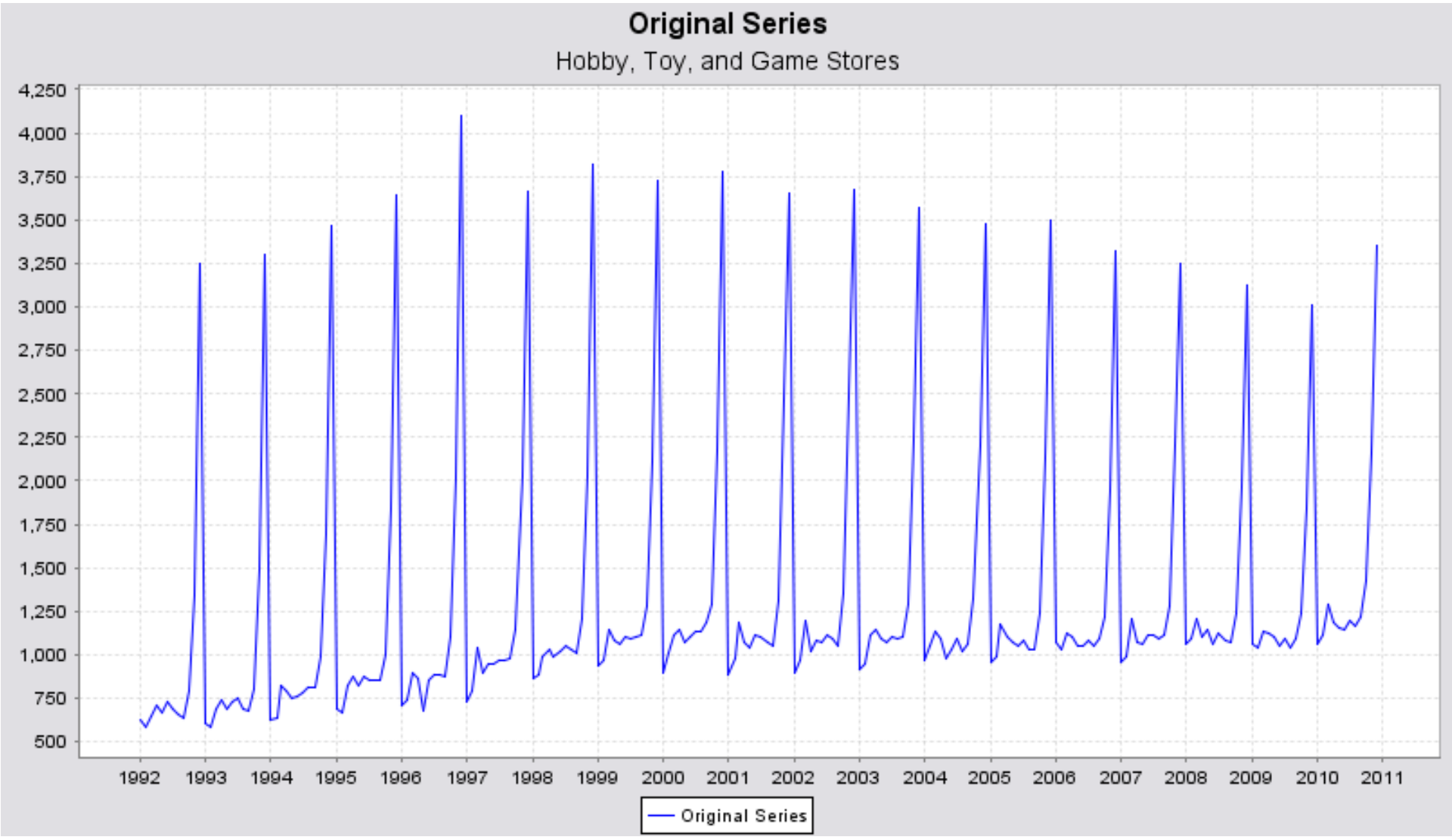
- A prominent spectral peak at 1/12, 2/12, 3/12, or 4/12 usually indicates that seasonal effects are present
  - Discount peaks at 6/12 because of spurious results, other concerns
  - In practice, we discount peaks at 5/12; 5/12 is not a natural division of the year unlike the lower frequencies, but X-13A-S warns for these peaks

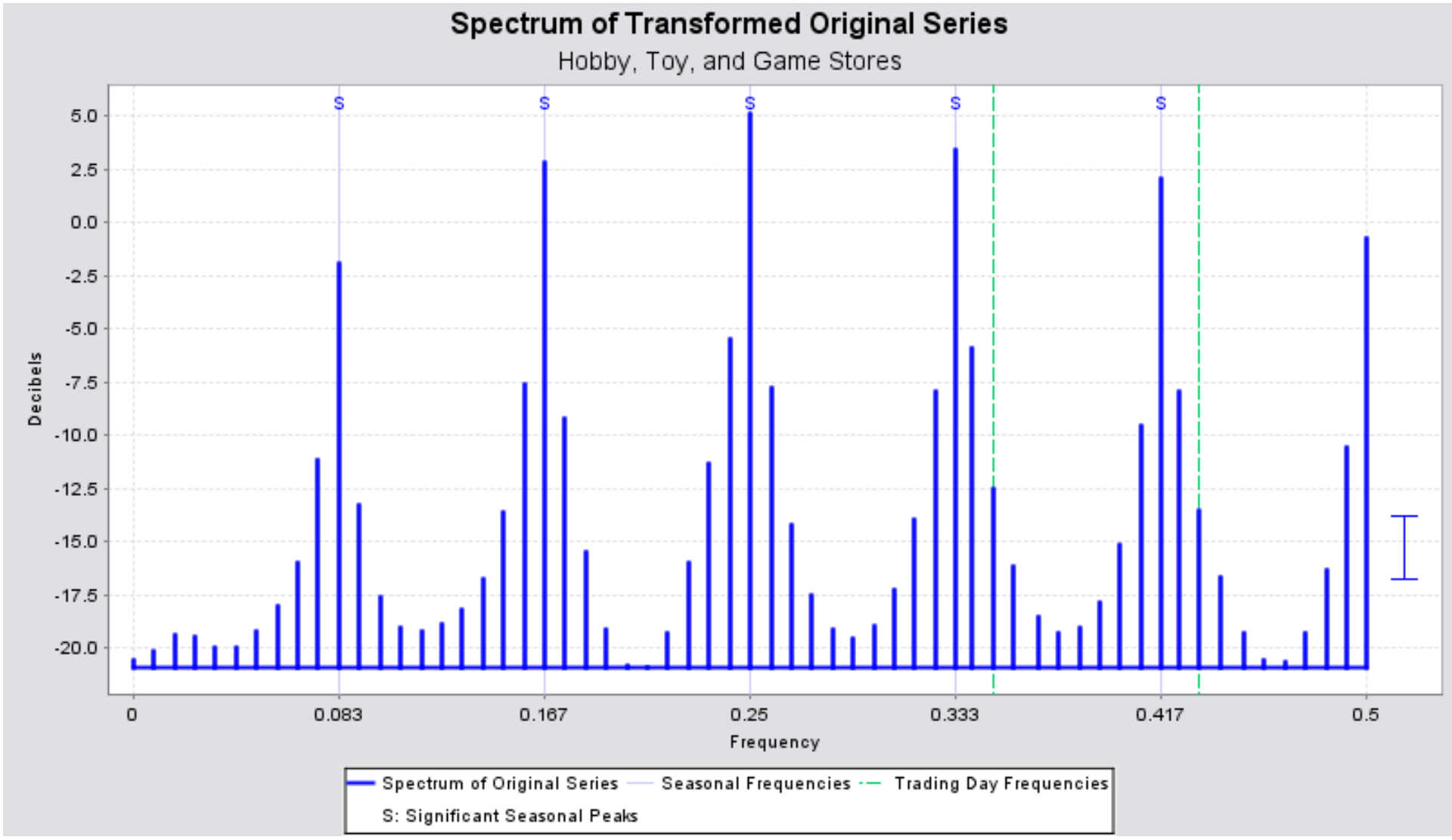
Trading Day Frequencies

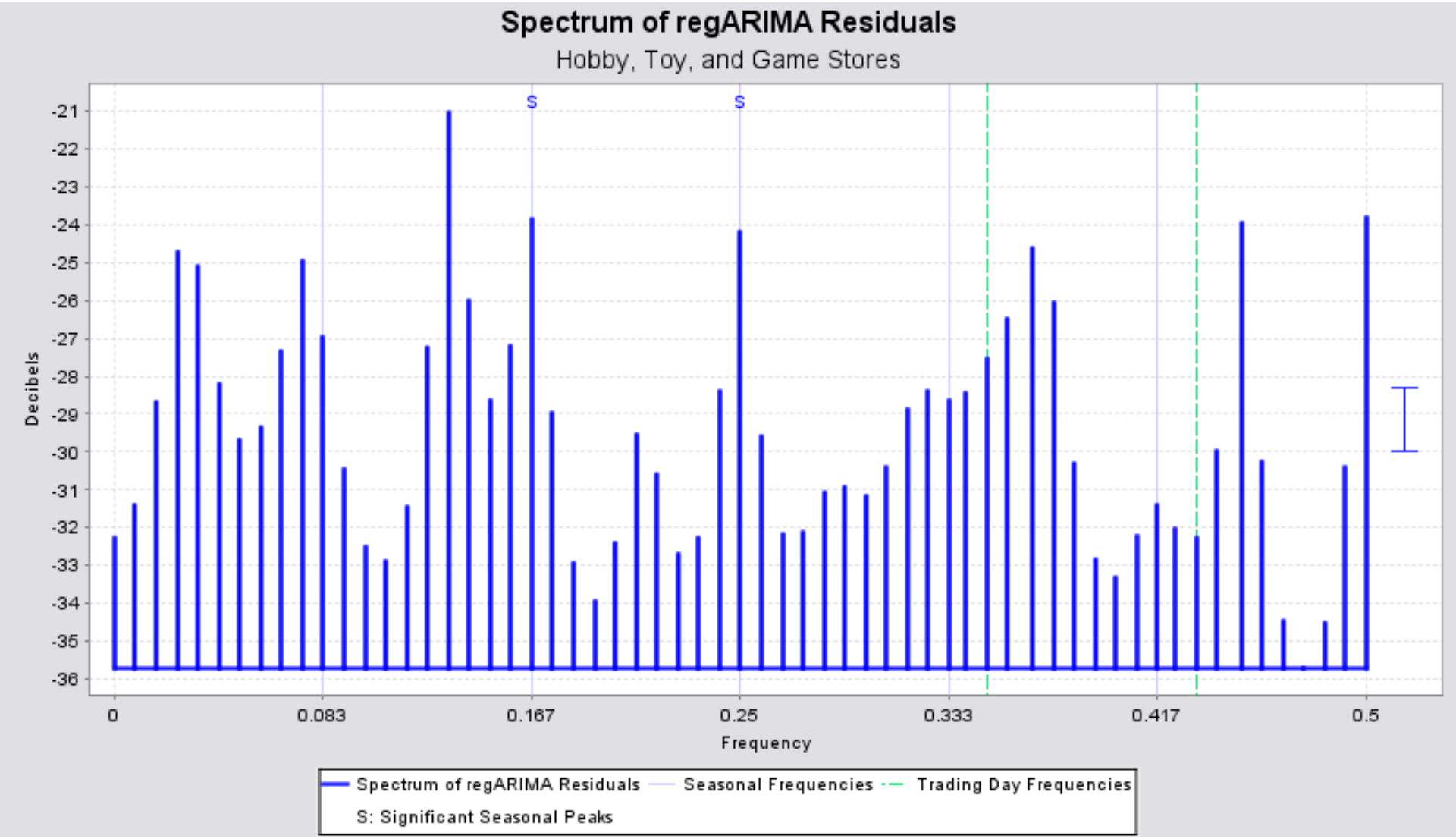
- To see a daily effect with a period of seven days
  - 365.25 / 12 = 30.4375
  - 30.4375 / 7 = 4.348
- Trading day peaks are marked at 0.348 (and also 0.432)
- Prominent spectral peak at 0.348 usually indicates that trading day effects are present
  - “T1” is 0.348
  - “T2” is 0.432

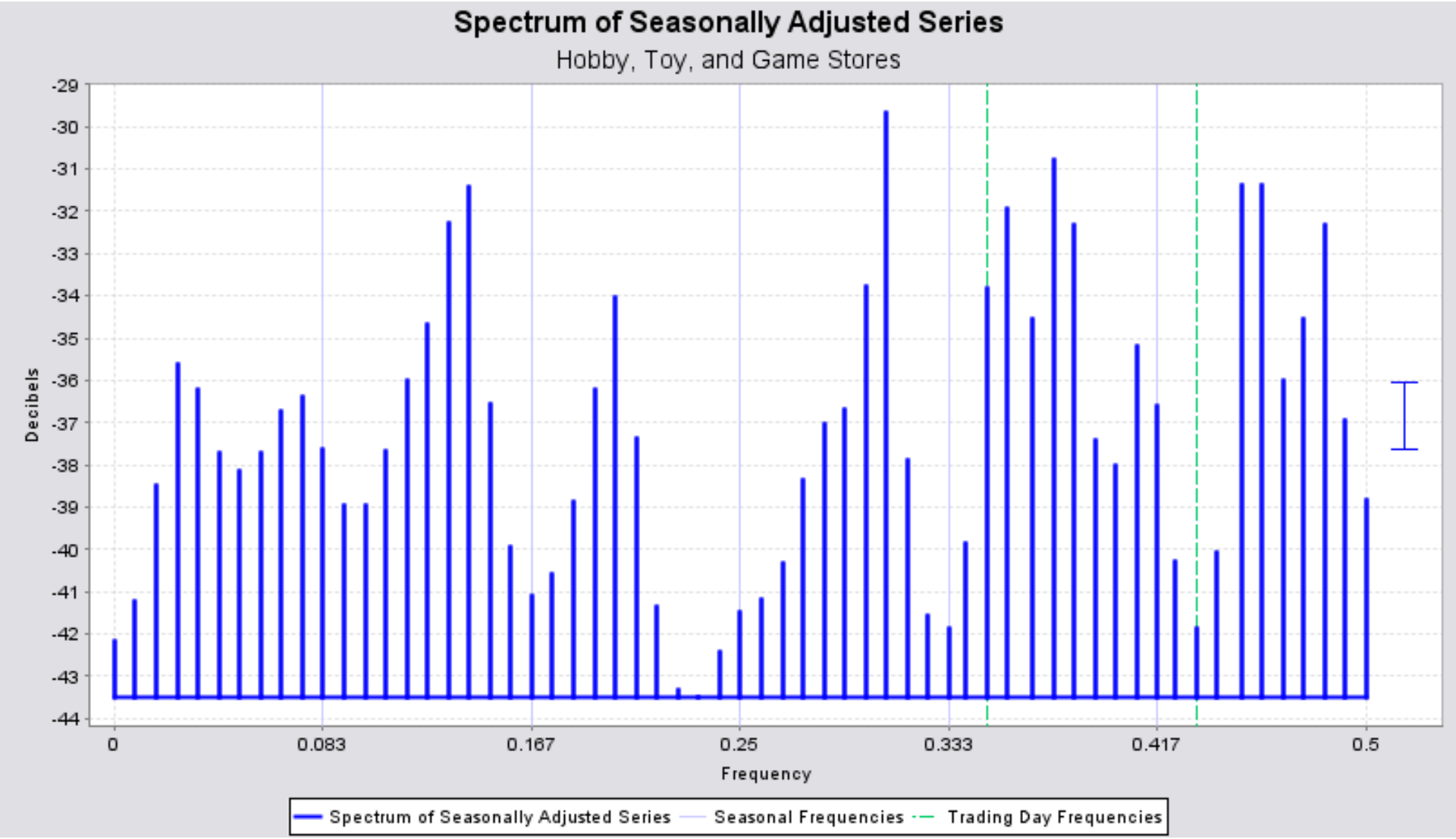
Visually Significant Peaks

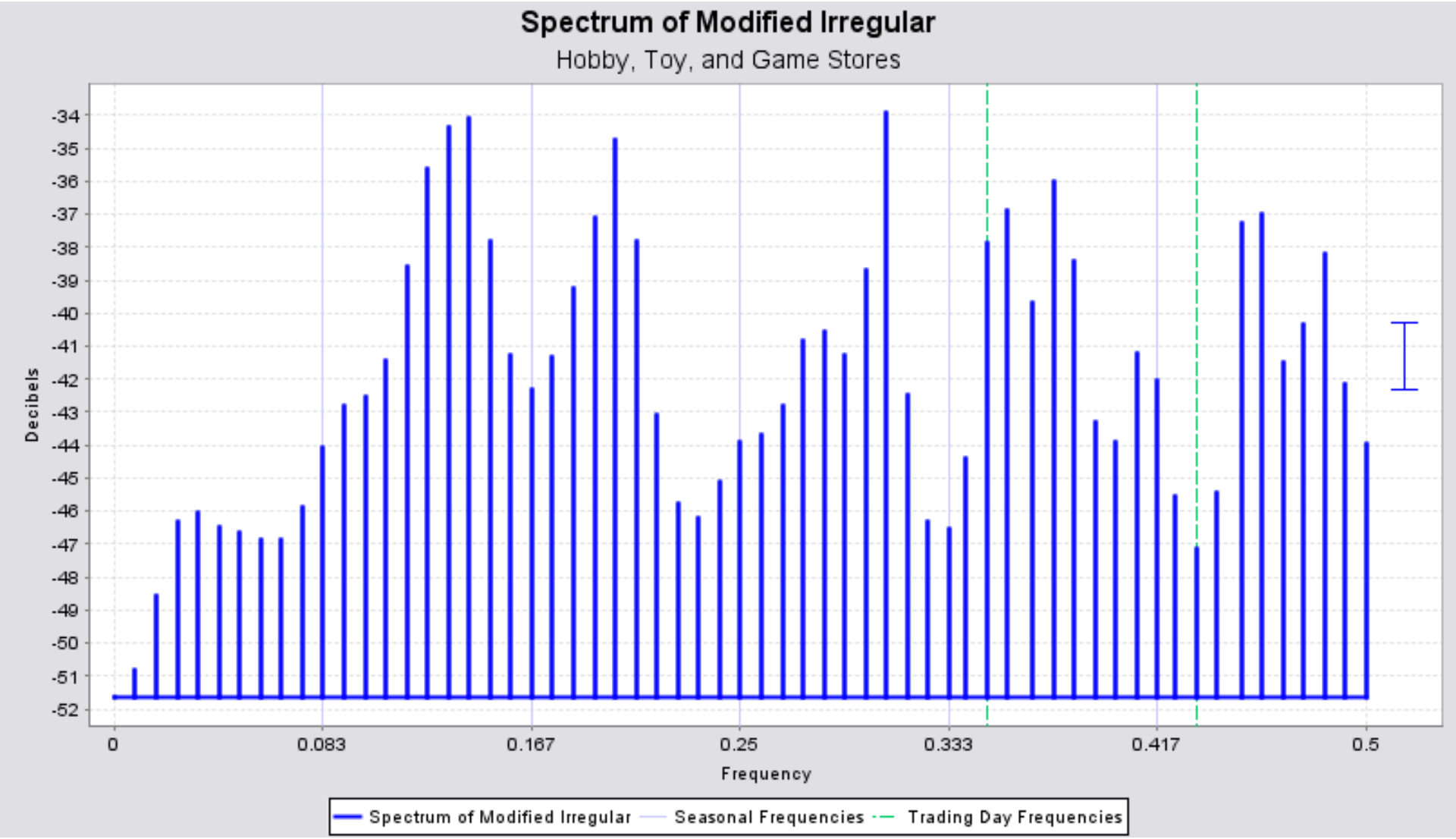
- Look for peaks that are “visually” significant (v.s.) or six or more “stars”
- A v.s. peak is greater than the median and taller than 6/52nds of the spectrum max-min
  - One star = 1/52nd of the range; in the output file, spectral plots are drawn with stars (asterisks)


Original Series
Hobby, Toy, and Game Stores
4,250
4,000
3,750
3,500
3,250
3,000
2,750
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Original Series


Spectrum of Transformed Original Series
Hobby, Toy, and Game Stores
S
S
S
S
S
5.0
2.5
0.0
-2.5
-5.0
-7.5
-10.0
-12.5
-15.0
-17.5
-20.0
Decibels
0
0.083
0.167
0.25
0.333
0.417
0.5
Frequency
Spectrum of Original Series
Seasonal Frequencies
Trading Day Frequencies
S: Significant Seasonal Peaks


Spectrum of regARIMA Residuals
Hobby, Toy, and Game Stores
S
S
-21
-22
-23
-24
-25
-26
-27
-28
-29
-30
-31
-32
-33
-34
-35
-36
Decibels
0
0.083
0.167
0.25
0.333
0.417
0.5
Frequency
Spectrum of regARIMA Residuals
Seasonal Frequencies
Trading Day Frequencies
S: Significant Seasonal Peaks


Spectrum of Seasonally Adjusted Series
Hobby, Toy, and Game Stores
-29
-30
-31
-32
-33
-34
-35
-36
-37
-38
-39
-40
-41
-42
-43
-44
Decibels
0
0.083
0.167
0.25
0.333
0.417
0.5
Frequency
Spectrum of Seasonally Adjusted Series
Seasonal Frequencies
Trading Day Frequencies


Spectrum of Modified Irregular
Hobby, Toy, and Game Stores
Decibels
-34
-35
-36
-37
-38
-39
-40
-41
-42
-43
-44
-45
-46
-47
-48
-49
-50
-51
-52
0
0.083
0.167
0.25
0.333
0.417
0.5
Frequency
Spectrum of Modified Irregular
Seasonal Frequencies
Trading Day Frequencies

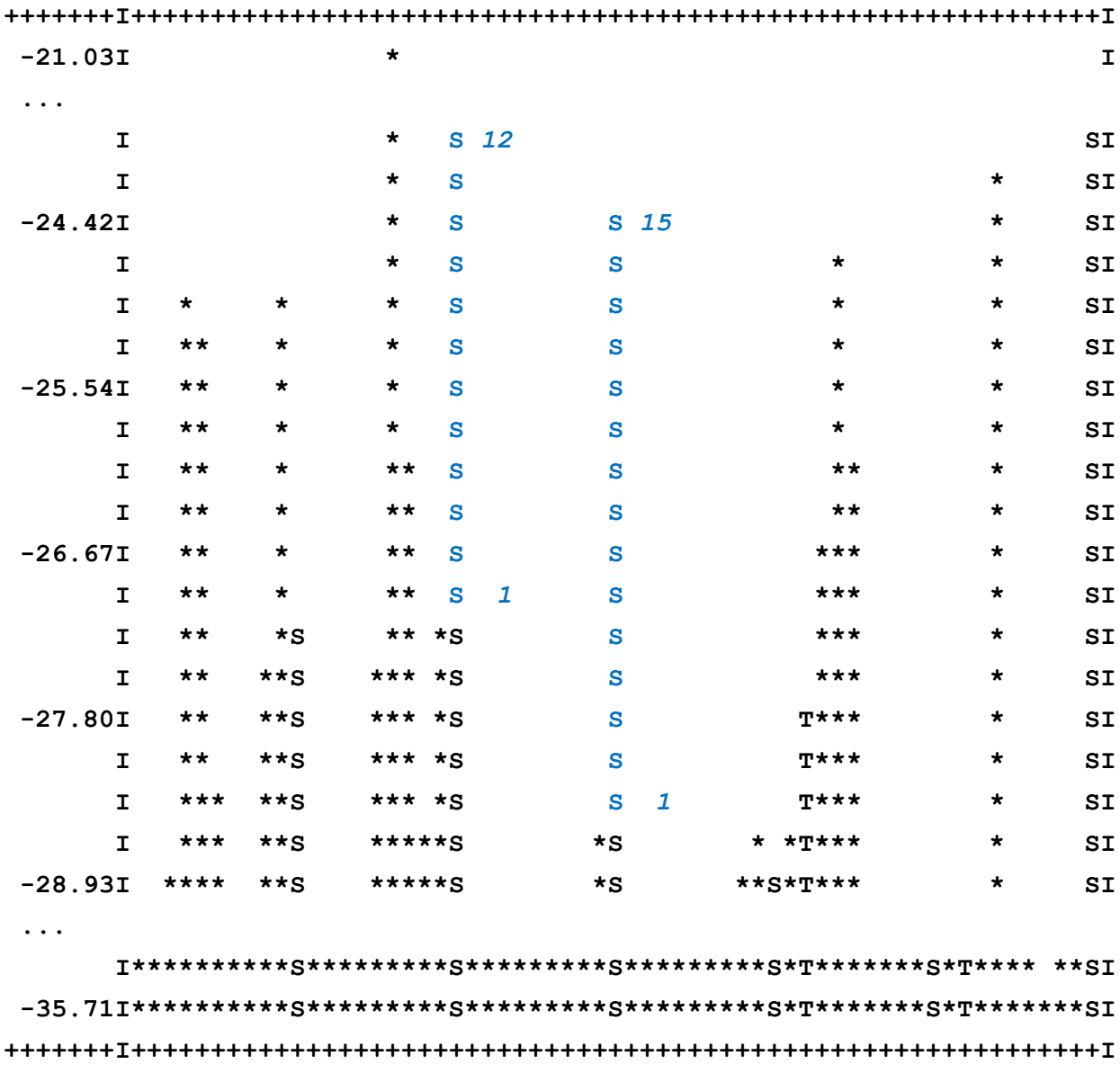
Other Places to Find Spectral Diagnostic

- Spectral results are so important, if a residual effect exists in the model residuals, seasonally-adjusted series, or irregular component, X-13A-S writes screen warnings when it runs
  - We don’t always see the screen any more
- Warnings also appear in output and log
- Win X-13 shows graphs, significant and nonsignificant peaks in Spectrum & QS tab

Hobby, Toy, and Game Stores

G Rs 10*LOG(SPECTRUM) of the regARIMA model residuals

Spectrum estimated from 2003.Jan to 2010.Dec.



S=SEASONAL FREQUENCIES, T=TRADING DAY FREQUENCIES

Spectral Information in the Log

```
spectrum{ . . .
    savelog = peaks
#    savelog = all
}


. . .
 Seasonal Spectral Peaks : rsd
       TD Spectral Peaks : none
```

Spectral Information in Win X-13

Sig SAdj Peaks	Sig Irr Peaks	Sig Ori Peaks	Nonsig Seasonal Peaks	Nonsig TD Peaks
		s1 s3 s4	*rsd [4.8]*	
s2 t2	*t2*	s1 s3 s4 s5	*irr rsd [5.3]*	
		s2 s3 s4 s5	irr [2.2]	
t1 t2	**t1 t2**	s1 s3 s4 s5		
t2	*t2*	s2		
		s1 s3 t1	rsd [2.5]	rsd [2.7]

Nonsig Peaks columns list which series have a non-v.s. peak in the spectrum, along with the height of the tallest peak.

Persistent Peaks

- Try changing model span or full span, especially when evidence of change in patterns
- Look for missed outliers
  - Review "almost" outliers
- Check the seasonal filters and sigma limits (X-11) or model (SEATS)
- Look at different estimation of the spectrum
  - Additional options in X-13ARIMA-SEATS
  - Sometimes these are spurious peaks, but it can be hard to determine if they are meaningful or not!

Our Opinion

- For X-11 seasonal adjustment, peaks in the spectrum of the seasonally adjusted series or irregular component outweigh peaks in the spectrum of the model residuals
  - For indirect adjustments, focus on the seasonally adjusted series result
- Always try to eliminate peaks at 1/12, 2/12, 3/12, 4/12, or TD 0.348 but realize not every situation has a solution

Other Diagnostics for Residual Seasonality

- Since we cannot look for residual seasonality in quarterly series with a spectrum, we need new diagnostics for this
- Research by Lytras (2015)

Residual Seasonality Diagnostics: F Test for Seasonal Regressors

- Create a new spec file, with the seasonally adjusted series (the *series*.d11) as the input series
- Limit the span to a *subspan* of the series – for example, the last 8 years for a 15 year series
- Include the seasonal regressors

Spec File for the F Test

```
series{file = "series.d11"
  format = "x13save"
  span = (2008.1,)}
transform{ function = auto }
regression{ variables=seasonal }
arima{ model = (0 1 1) }
outlier{. . .}
```

F Test for Residual Seasonality

- If the F test for the seasonal regressors indicates seasonality, there may be residual seasonality in the series
- **`arima{ model = (0 1 1) }`** may not be the best choice for model. You can use

```
automdl{ maxdiff=(1 0) }
```

but research shows this is more likely to lead to significant regressors when the selected model includes a seasonal (1 0 0) or (0 0 1).

Residual Seasonality Diagnostics: QS

- Agustín Maravall (Bank of Spain, now retired) devised the QS diagnostics
- These check for positive autocorrelation at seasonal lags
- They test the hypothesis that there is no seasonality in the series

QS Series

- The QS is found for the following series
  - Original (A1)
  - Original, adjusted for extreme values (B1 – misnamed)
  - Model residuals
  - Seasonally adjusted (D11)
  - Seasonally adjusted, adjusted for extremes (E2)
  - Irregular (outlier-adjusted D13)
  - Irregular, adjusted for extremes (E3)

QS Series Span

- For each of the seven series, find the QS for the full series span and again for the span corresponding to the spectrum (96 observations by default)
  - For monthly series, 8 years
  - For quarterly series, generally the full span by default
- **`spectrum{ start = yyyy.q }`** to change

Calculating the QS Statistic

- First, for the original and seasonally adjusted, apply either 1 or 2 nonseasonal differences (see manual for details)
- Find the autocorrelations r_t of the [differenced] series

Calculating the QS

- For $i = s$ and $2s$ (where s is the period), let

$$R_t = \begin{cases} r_t & if\ r_t > 0 \\ 0 & if\ r_t \leq 0 \end{cases}$$

- Let n = (length of series) – (order of differencing)

Calculating the QS (continued)

- If $R_s = 0$ then QS = 0 (and p value = 1)
- Else

$$QS = n(n+2)\left\{\frac{{R_s}^2}{n-s} + \frac{{R_{2s}}^2}{n-2s}\right\}$$

- The QS distribution is approximately chi-squared with 2 degrees of freedom

QS Output

- The 14 QS statistics are in the output file after the F tables, right before the spectral results.

- For a series with a purposely bad adjustment so that we expect to see residual seasonality **(`seasonalma = stable`)**, the QS table might look like

QS output showing residual seasonality

```
QS statistic for seasonality:
 Original Series                          463.58 (P-Value= 0.0000)
 Original Series (EV adj)                 479.07 (P-Value= 0.0000)
 Residuals                                  0.00 (P-Value= 0.9977)
 Seasonally Adjusted Series               183.55 (P-Value= 0.0000)
 Seasonally Adjusted Series (EV adj)       51.77 (P-Value= 0.0000)
 Irregular Series                         179.97 (P-Value= 0.0000)
 Irregular Series (EV adj)                 87.19 (P-Value= 0.0000)

QS statistic for seasonality (starting 2005.Nov):
 Original Series                          137.30 (P-Value= 0.0000)
 Original Series (EV adj)                 146.23 (P-Value= 0.0000)
 Residuals                                  2.43 (P-Value= 0.2960)
 Seasonally Adjusted Series                98.66 (P-Value= 0.0000)
 Seasonally Adjusted Series (EV adj)       23.41 (P-Value= 0.0000)
 Irregular Series                         101.72 (P-Value= 0.0000)
 Irregular Series (EV adj)                 29.18 (P-Value= 0.0000)
```

QS output with residual seasonality

- *P*-values < 0.05, say, indicate seasonality (Maravall prefers 0.01)
- In the example on the previous slide, only the model residuals do not show seasonality or residual seasonality
- If QS = 0, the *p*-value is set to 1 (no evidence of seasonality)

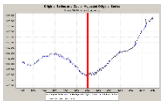
QS Statistics

- The QS statistics appear in the log file if **`savelog = qs`** is in the **`spectrum`** spec
- Most QS statistics are in the Spectrum & QS tab in Win X-13's diagnostics; QS for Residuals in the Model Diagnostics tab

QS for Quarters From a Monthly Series

- With **`spectrum{ qcheck = yes }`**
  X-13A-S will find the QS for quarterly sums* of the monthly (1) original and (2) seasonally adjusted monthly series

- *X-13A-S assumes flow series; use **`series{ … type = stock }`** for end-of-quarter stock series (it will use the 3rd month's value as the quarterly value)
  - No option for other stock series windows



Sliding Spans Diagnostic

- Developed at the U.S. Census Bureau (Findley, Monsell, Shulman, and Pugh; 1990)
- Compares adjustments from overlapping subspans of the series
- We prefer adjustments with more stability

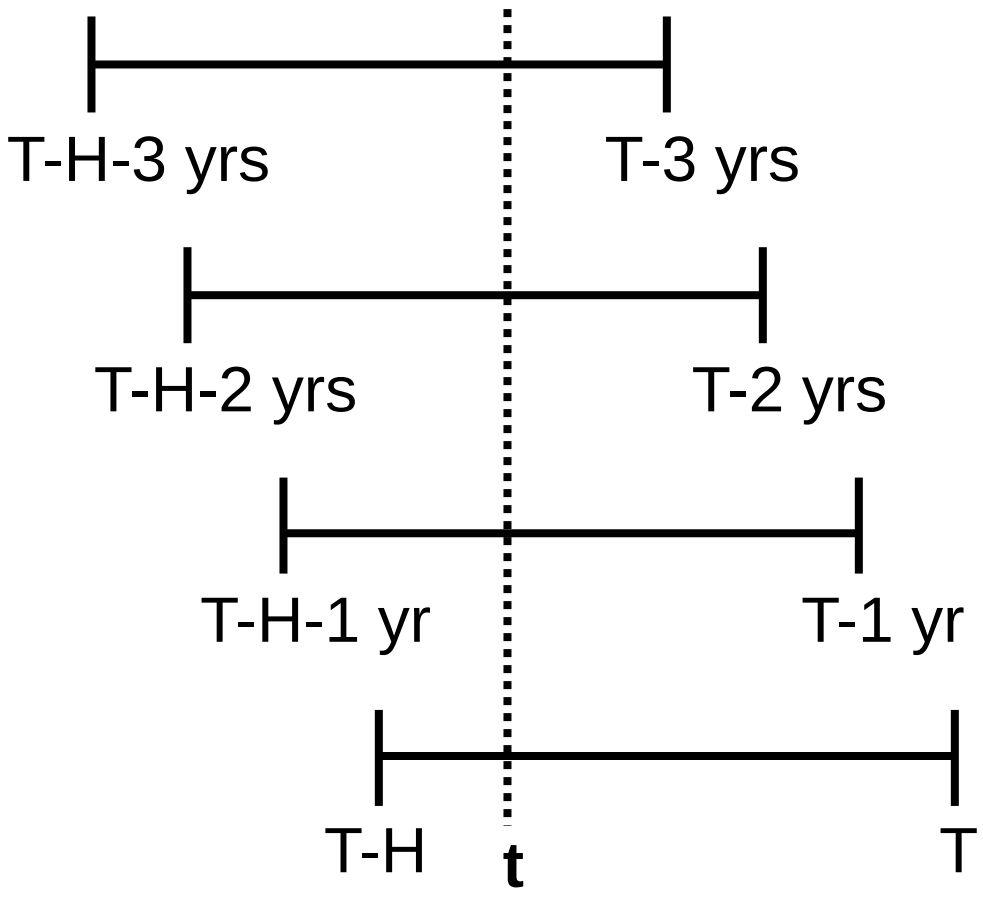
Sliding Spans for Additive Adjustments?

Developed with and primarily for multiplicative adjustments, but with additive adjustments, **`additivesa=percent`** results in the usual output

- Otherwise for additive, no overall percentages, can look at full diagnostic results
- Not available for series with zero or negative values

Sliding Spans, Illustration

- Construct 2 to 4 spans, the last span ending at the last series point T
- Length of the spans (H) depends on the seasonal filter
- Compare wherever spans overlap, such as point *t* in this example



Comparisons

- Seasonal Factors
  - If model parameter estimates are held constant (the default setting), comparing the seasonal factors is equivalent to comparing the seasonally adjusted values
  - Multiplicative adjustments only
- Seasonally Adjusted Series
  - Available for additive adjustments and multiplicative adjustments when **`fixmdl=no`** (regARIMA parameters are re-estimated for each span) and no model span is used
- Month-to-month (Quarter-to-quarter) Change
- Year-to-year Change

- Trading day factors
  - Only when **`fixmdl=no`** and no model span is used

Sliding Spans, Flagging Instability

If the percent change between the maximum and the minimum (maximum percent difference or MPD) is greater than a particular cutoff (in this case 3%), that is, if

$$MPD = \frac{\max(SF_t) - \min(SF_t)}{\min(SF_t)}$$

is > 0.03, then flag the adjustment at time point t as unstable

Seasonal Factor Example

March 2007 Seasonal Factors (x100%)

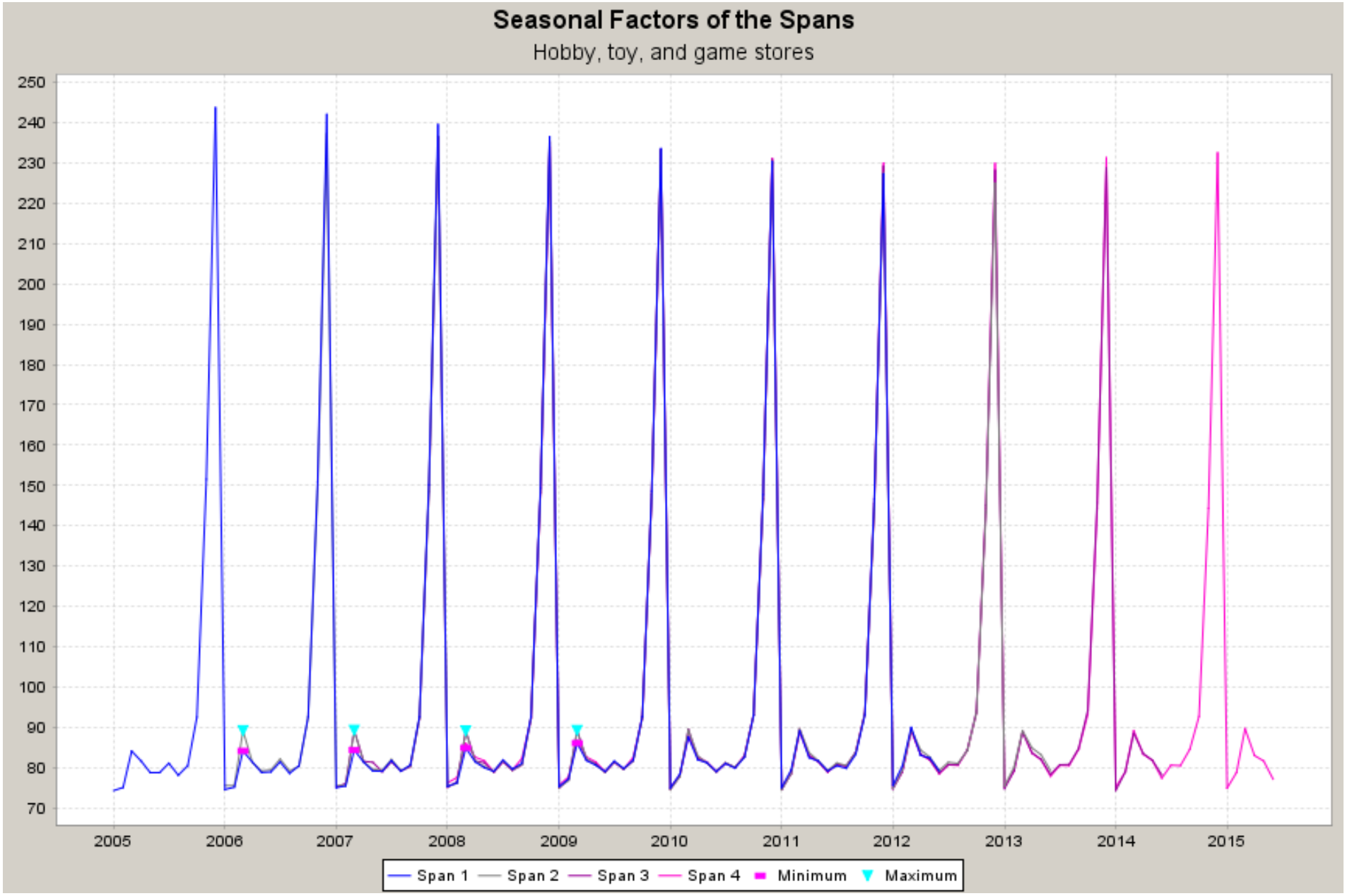
Span 1: 84.36 (Minimum)

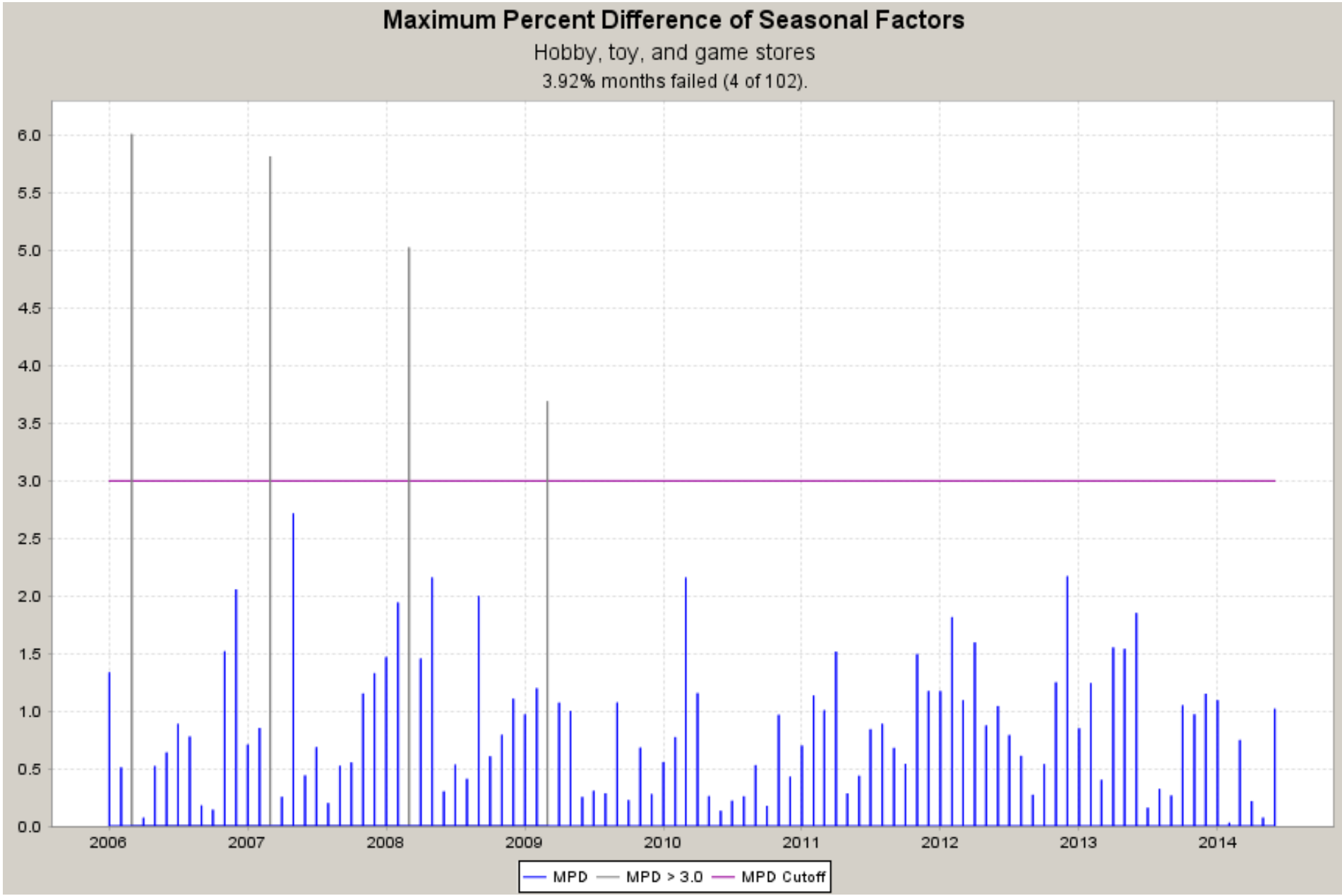
Span 2: 89.06

Span 3: 89.26 (Maximum)

$$\frac{89.26 - 84.36}{84.36} \times 100\% = 5.8\%$$

5.8% is above the 3% cutoff, so March 2007 is flagged as unstable for seasonal factors (we prefer to see fewer flags)


Seasonal Factors of the Spans
Hobby, toy, and game stores
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Span 1
Span 2
Span 3
Span 4
Minimum
Maximum


Maximum Percent Difference of Seasonal Factors
Hobby, toy, and game stores
3.92% months failed (4 of 102).
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2006
2007
2008
2009
2010
2011
2012
2013
2014
MPD
MPD > 3.0
MPD Cutoff

Interpreting Spans Diagnostics

- Generally, an adjustment is considered acceptably stable when
  - Percentage of unstable seasonal adjustment (or seasonal factor) values is less than 15%

    and
  - Percentage of unstable month-to-month percent changes in the seasonal adjustment is less than 40%

Sliding Spans Output

`print = all`

shows for all spans

- Seasonal adjustment values
- Seasonal factors
- Trading day factors, if compared (**`fixmdl = no`**)
- Month-to-month changes
- Year-to-year changes

S 7.a Sliding Spans Analysis of Seasonal Factors for Hobby, Toy, and Game Stores

	1/2005 - 6/2012	1/2006 - 6/2013	1/2007 - 6/2014	1/2008 - 6/2015	MAXIMUM PERCENT DIFFERENCE	Footnote
1-2005	74.26					
…						
2-2007	75.43	75.55	76.06		0.85	
3-2007	84.36	89.06	89.26		5.81	3% Link to definition of 3%
4-2007	81.32	81.38	81.53		0.25	
…						
1-2008	75.30	75.35	75.07	76.16	1.46	TP Link to definition of TP
2-2008	76.18	76.03	76.43	77.50	1.94	
3-2008	84.87	88.92	89.13	86.00	5.02	TP, 3% Link to definition of TP, 3%
4-2008	81.37	81.64	81.59	82.55	1.45	TP Link to definition of TP
…						
3-2009	86.04	89.07	89.21	86.65	3.69	TP, 1% Link to definition of TP, 1%
…						
			81.80	81.74	0.07	
6-2014			78.13	77.34	1.01	
7-2014				80.55		
…						

Output Footnotes

- Turning points (TP)
  - Changes of direction
- Sign changes (SC)
- Maximum percent differences greater than the cutoff
  - Indicates how much greater, in tiers, 1st tier (slightly above the cutoff) up to 4th tier (greatly above the cutoff) with symbols that differ by table: %, $, etc.

Footnotes for Table S7.a

TP	Span values for this observation have a turning point.
1%	The maximum percentage difference is greater than or equal to 3.0% but less than 4.0%.
3%	The maximum percentage difference is greater than or equal to 5.0% but less than 6.0%.
4%	The maximum percentage difference is greater than or equal to 6.0%.

Distribution of the Maximum Percent Differences Above the Cutoff

Breakdown of the maximum percentage differences of the Seasonal Factors for flagged months.		
1%	Greater than or equal to 3.0% but less than 4.0%	1
2%	Greater than or equal to 4.0% but less than 5.0%	0
3%	Greater than or equal to 5.0% but less than 6.0%	2
4%	Greater than or equal to 6.0%	1

Month-to-Month (Percent) Changes

Multiplicative (%)

$$MM_t = \frac{SA_t - SA_{t-1}}{SA_{t-1}}$$

Additive*

$$MM_t = SA_t - SA_{t-1}$$

MPD = max (MM_t) – min (MM_t)
Flag if MPD > 0.03

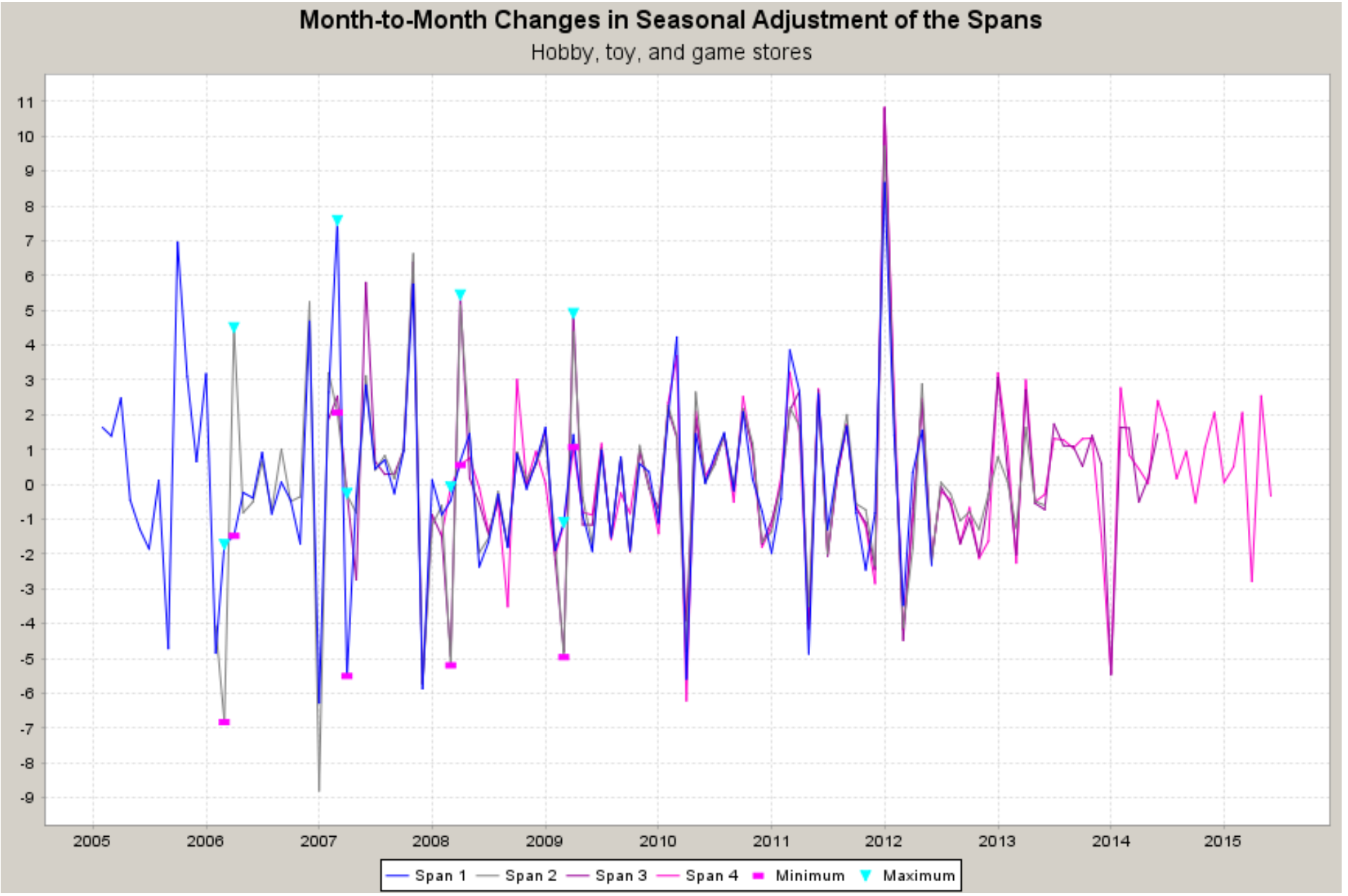
*by default; if **`additivesa=percent`**, the multiplicative calculation is used and the comparison of the MPD to 3% is meaningful (not really an MPD)
(3% or 0.03 is the default and can be changed)

S 7.d Sliding spans analysis of Month-to-Month Changes in SA Series for Hobby, Toy, and Game Stores

	1/2005 - 6/2012	1/2006 - 6/2013	1/2007 - 6/2014	1/2008 - 6/2015	MAXIMUM DIFFERENCE	Footnote
1-2005						
2-2005	1.63					
...						
1-2006	3.17					
2-2006	-4.84	-4.06			0.78	
3-2006	-1.72	-6.83			5.10	2$ Link to definition of 2$
4-2006	-1.48	4.51			5.99	SC, 2$ Link to definition of SC, 2$
5-2006	-0.24	-0.81			0.57	
6-2006	-0.39	-0.51			0.12	
7-2006	0.91	0.66			0.25	
8-2006	-0.84	-0.74			0.11	
9-2006	0.06	1.01			0.95	
10-2006	-0.45	-0.49			0.04	
11-2006	-1.70	-0.35			1.35	
12-2006	4.68	5.24			0.56	
1-2007	-6.27	-8.80			2.52	
2-2007	2.65	3.20	1.88		1.32	TP Link to definition of TP
...						

Footnotes for Table S7.d

SC	A sign change can be found for this observation.
TP	Span values for this observation have a turning point.
1$	The maximum percentage difference is greater than or equal to 3.0% but less than 5.0%.
2$	The maximum percentage difference is greater than or equal to 5.0% but less than 7.0%.


Month-to-Month Changes in Seasonal Adjustment of the Spans
Hobby, toy, and game stores
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Span 1
Span 2
Span 3
Span 4
Minimum
Maximum

Default Cutoffs

- 3% for seasonal factors and seasonally adjusted series
  - **`cutseas = 3.0`**
- 3% for month-to-month (quarter-to-quarter) and year-to-year change
  - **`cutchng = 3.0`**
- 2% for trading day factors (if compared)
  - **`cuttd = 2.0`**

3% Default Cutoff

- For more irregular series whose revisions tend to be larger, we can raise the cutoff to a more reasonable percentage
  - 5% sometimes used for highly variable irregular series
  - (We don’t need to raise the cutoff)

Percentiles

- Without raising the cutoff, we can see what level would provide "passing" stability
  - 85th percentile for seasonally adjusted series
  - 60th percentile for month-to-month (quarter-to-quarter) percent changes

Summary Statistics for the Maximum Percent Differences of the Month-to-Month Changes, Across Spans

	Maximum Percent Differences	
Minimum	0.04	
25th Percentile	0.29	
Median	0.83	
60th Percentile	1.01	<
75th Percentile	0.83	
Maximum	5.99	
Standard Deviation	1.23	

< - hinge value associated with default cutoff value

Slidingspans Spec

```
slidingspans{
   savelog = percents
   additivesa = percent
   length = 96
## May need to set length for
## composite adjustments
#  numspans = 3
## May need to change length or
## number of spans for short series
```

`Slidingspans` Spec (2)

```
. . .
#   cutseas = 5.0 # default is 3
#   cutchng = 5.0 # default is 3
#   cuttd = 3.0 # default is 2
. . .
```

Slidingspans Spec (3)

```
#   fixmdl = no # default is yes

 print = See Manual/Quick Reference
 save = See Manual/Quick Reference
. . .
}
```

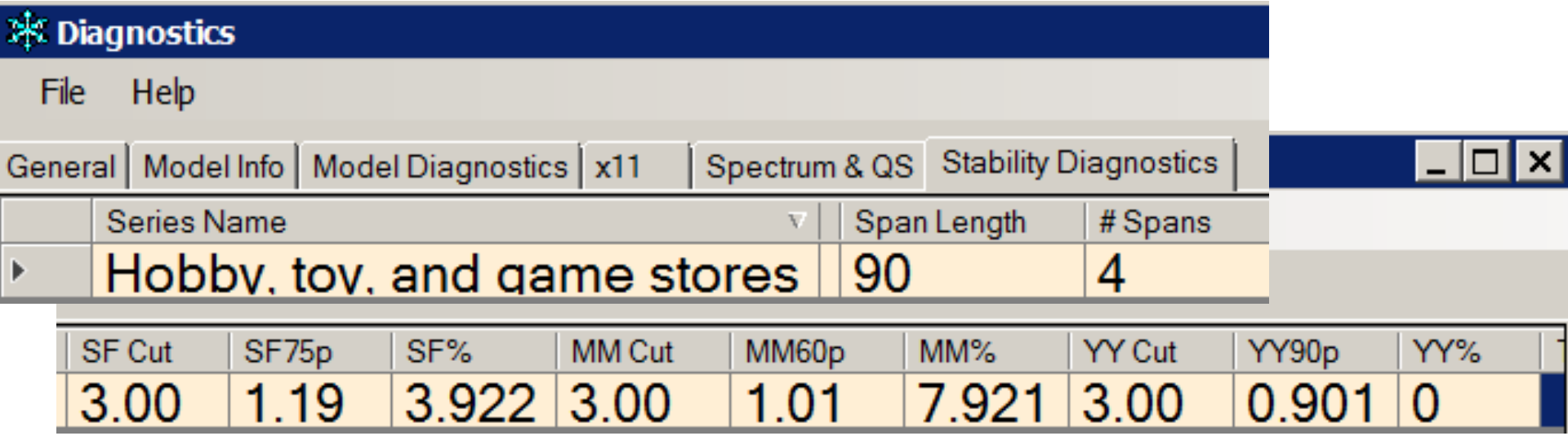
Sliding Spans Summary in Log File

- Not labeled as sliding spans!
- Does not give the number of spans
- Does not give the cutoff levels

Percentage of months flagged as unstable.	
Seasonal Factors	4 out of 102 (3.9 %)
Month-to-Month Changes in SA Series	8 out of 101 (7.9 %)
Year-to-Year Changes in SA Series	0 out of 90 (0.0 %)

Sliding Spans Summary from Win X-13

- Span length and number of spans
- Cutoffs for flagging the unstable months (or quarters)
- Percents of flagged months (or quarters)
- Percentiles for passing cutoffs
  - 75th for seasonal factors, 60th for month-to-month (or quarter-to-quarter) change, 90th for year-to-year change



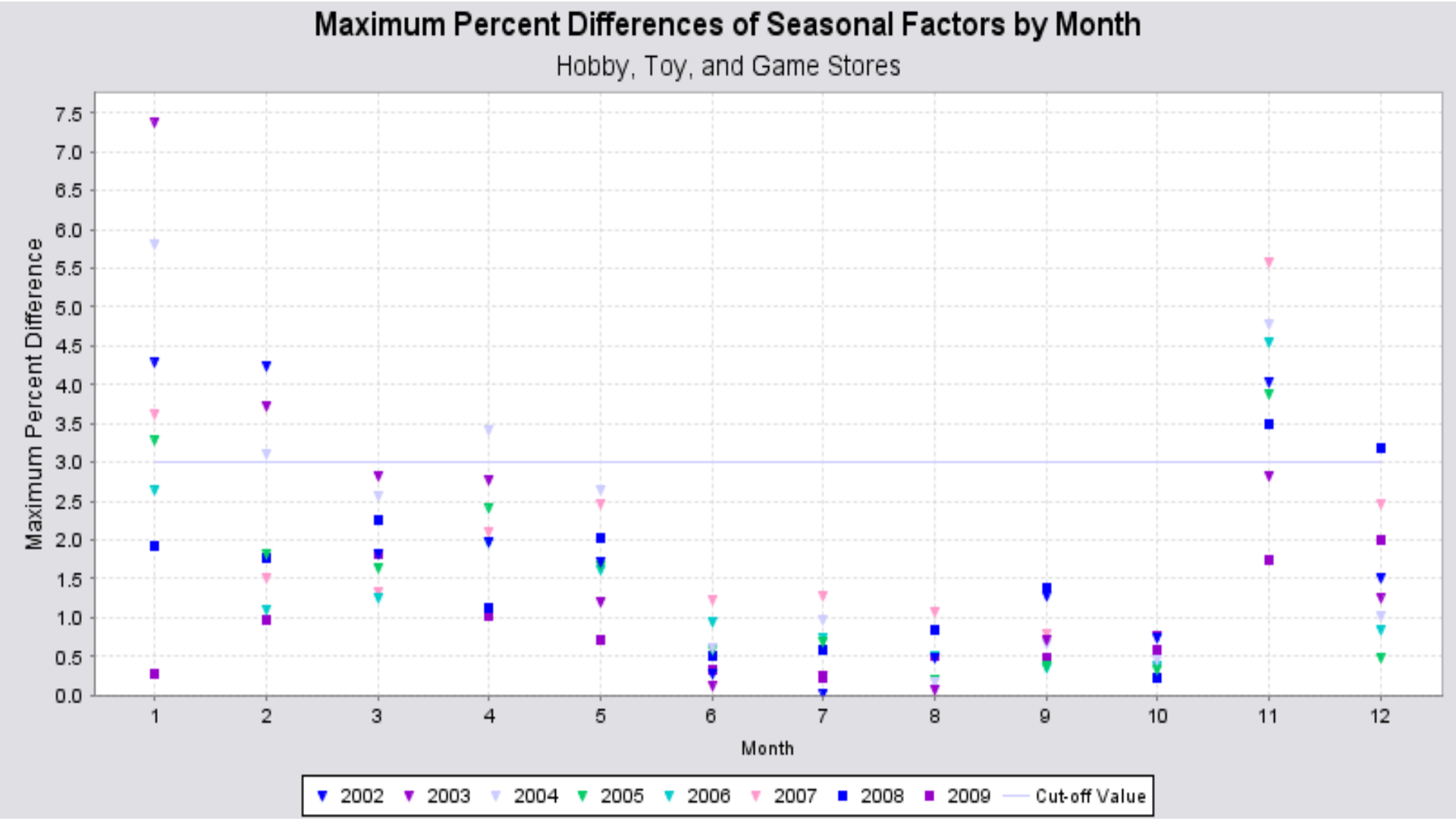
Average Maximum Percent Difference

- Output file shows averages by month (or quarter) and by year

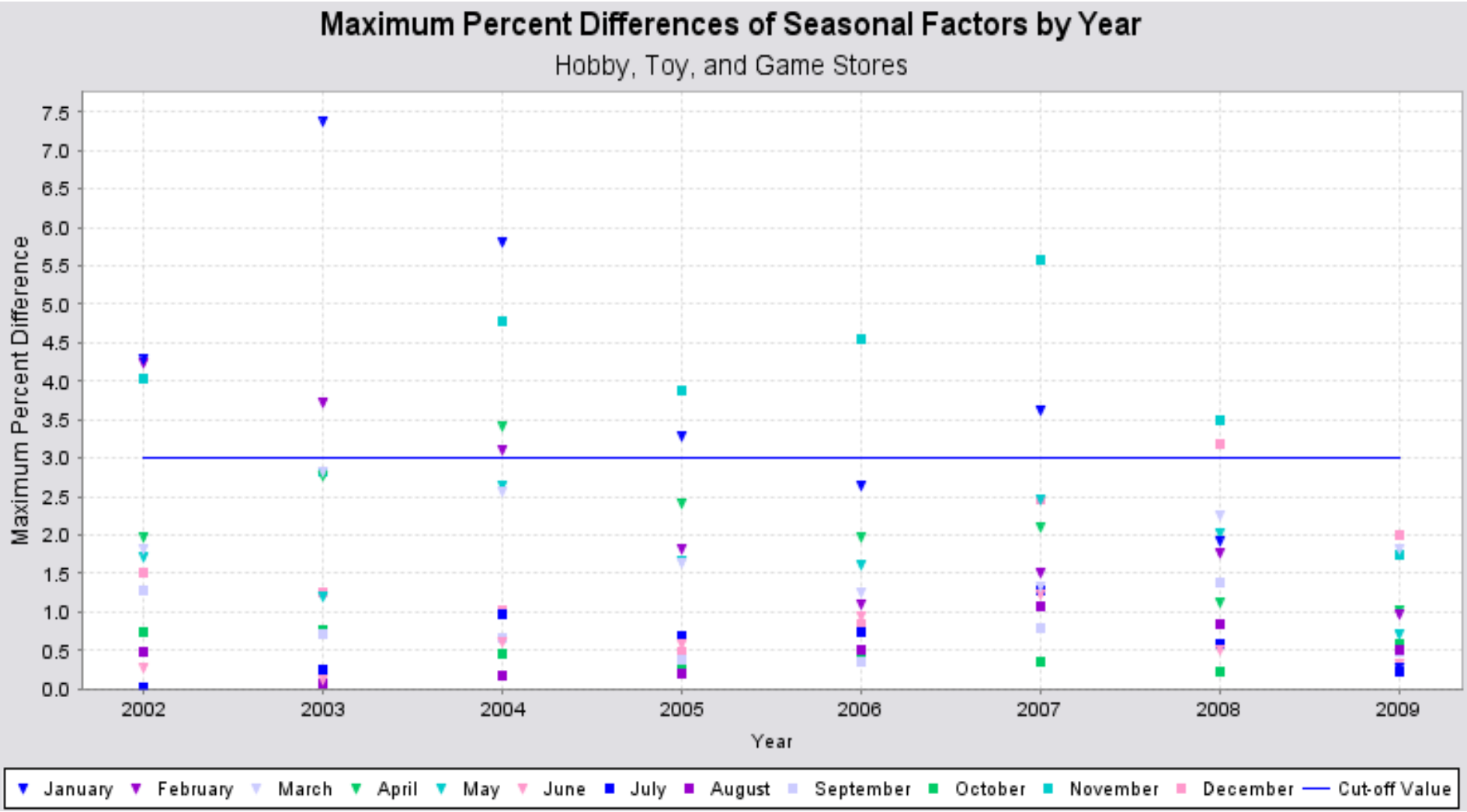
- Look for periods that stand out from others
  - Sometimes cannot solve problems, but can prepare for questions

S 3.a Breakdowns of unstable Seasonal Factors and Average Maximum Percent Differences across spans for Seasonal Factors of HobbyToyAndGameStores.

	Observations Flagged	Average Maximum Percent Differences
January	5	3.66
February	3	2.28
March	0	1.94
April	1	2.11
May	0	1.75
June	0	0.57
July	0	0.60
August	0	0.48
September	0	0.75
October	0	0.48
November	6	3.86
December	1	1.60


Maximum Percent Differences of Seasonal Factors by Month
Hobby, Toy, and Game Stores
Maximum Percent Difference
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1
2
3
4
5
6
7
8
9
10
11
12
Month
2002
2003
2004
2005
2006
2007
2008
2009
Cut-off Value

	Observations Flagged	Average Maximum Percent Differences
2002	3	1.87
2003	2	1.99
2004	**4**	**2.19**
2005	2	1.45
2006	1	1.40
2007	2	1.98
2008	2	1.61
2009	0	0.89


Maximum Percent Differences of Seasonal Factors by Year
Hobby, Toy, and Game Stores
Maximum Percent Difference
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2002
2003
2004
2005
2006
2007
2008
2009
Year
January
February
March
April
May
June
July
August
September
October
November
December
Cut-off Value

Seasonality Tests for Each Span

Summary of tests for stable and moving seasonality from table D8 for each span

	Span 1	Span 2	Span 3	Span 4
Stable seasonality	1171.07	894.02	1066.24	777.39
Moving seasonality	6.16	4.63	6.74	5.93
M7	0.10	0.11	0.11	0.13
Identifiable seasonality?	yes	yes	yes	yes

What If Sliding Spans Diagnostic Fails?

- Try raising X-11 sigma limits if spans fail with default limits
- Double check regARIMA model
  - Problems found with (p d q)(1 1 0) model
- Probably should not use sliding spans results to choose seasonal filters
  - The diagnostic tends to favor longer filters (though it can inaccurately favor short filters in some situations…)

Sliding Spans and Filters

- Imagine a series with a 3x5 filter has sliding spans start in 2007, and with a 3x9 filter spans start in 2004

- If there are many unstable points in 2012-2013, then the long filter may have better sliding span results
  - Longer filters → longer spans, meaning a larger denominator and probably a smaller percentage of flagged points
- If there are many unstable points in 2005-2006, then the short filter may have better sliding span results
  - Shorter filters → later span start date, so instability before the shorter span's start date isn't measured, even though these points would likely be unstable with the shorter filter too

Sliding Spans for Composite Adjustments

- Component spans must have same length and number of spans
- Component series adjustments do NOT have to have the same seasonal filters
  - If any have different filters, then need to set the span length

`History` Spec Diagnostics

- Revisions
  - Adjustments
  - Seasonal factors
  - Trends

- Out-of-sample forecast errors to compare two regARIMA models

History Diagnostics

- Program does many runs, on sequence of increasing spans, imitating advancing time

- We prefer the approach that produces smaller revisions, if the final adjustments from competing options or methods are both acceptable (no residual seasonal or calendar effects)

Revisions History

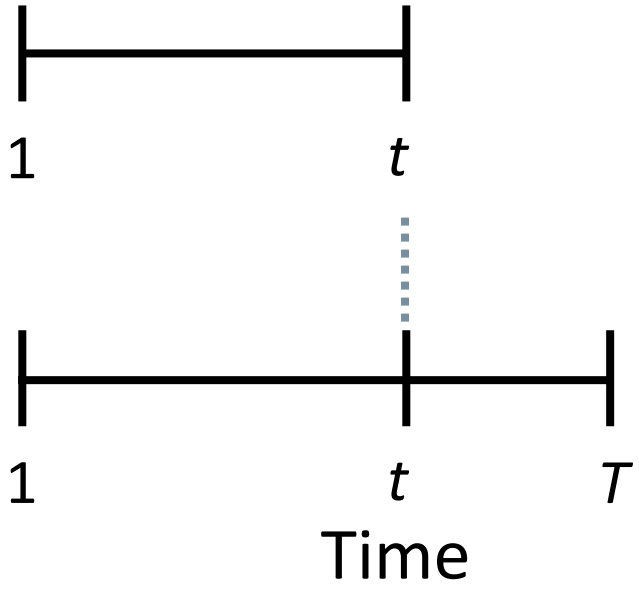
- Refer to history diagnostics as revisions history because they measure sizes of revisions to the adjustment from adding series values

- NO changes/revisions to underlying series values included in these diagnostics

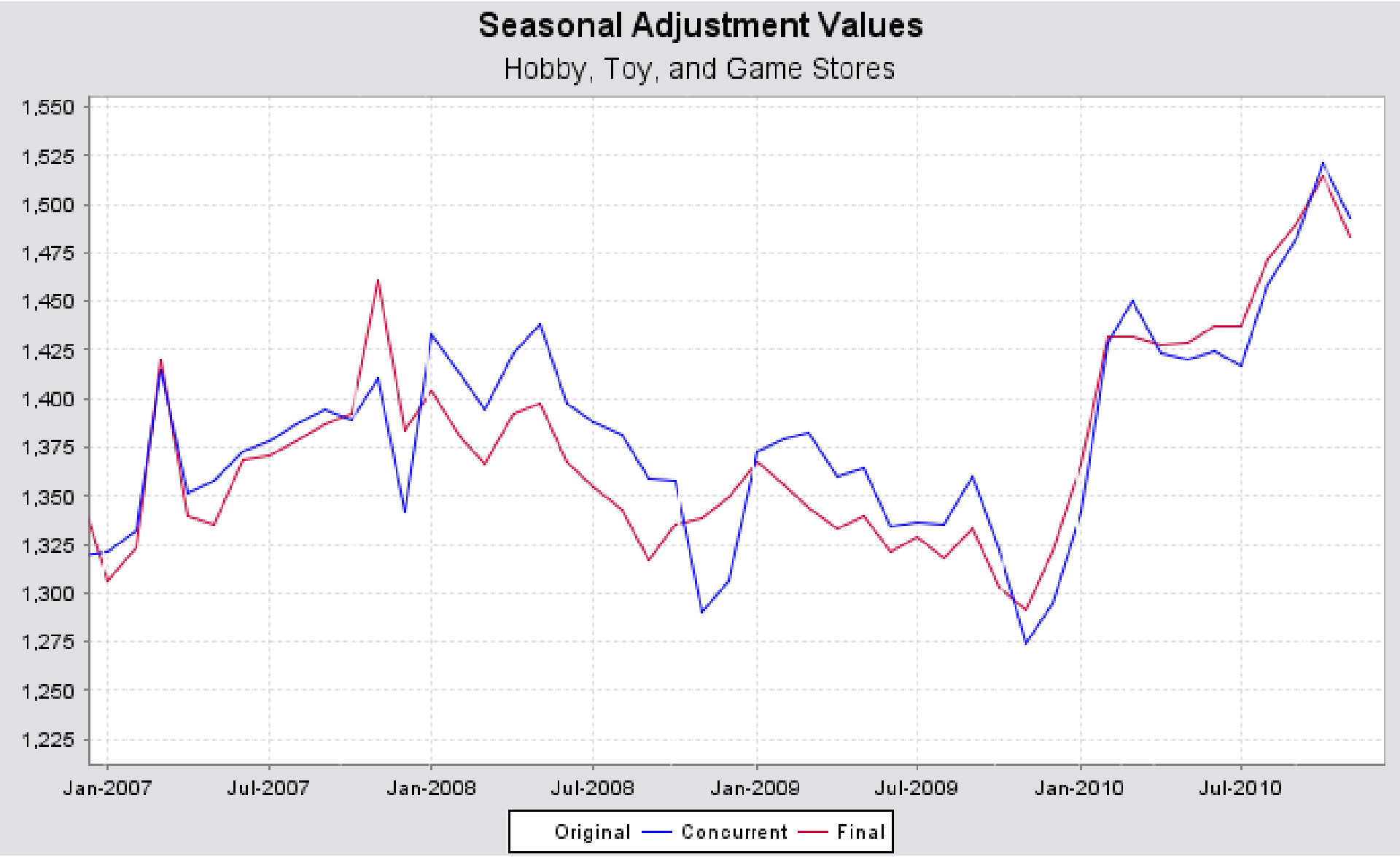
Initial and Final Adjustments

- Define $A_{t|t}$ to be the ***initial*** adjustment or ***concurrent*** seasonal adjustment — the first seasonal adjustment estimate for observation *t*
- Define $A_{t|T}$ to be the ***final*** or ***full-series*** seasonal adjustment — the seasonal adjustment estimate for observation *t* when the series ends at final observation T

Illustration of the History Diagnostic



- $A_{t|t}$ is the "concurrent" or the initial adjustment
- $A_{t|T}$ is the full-series or "final" adjustment


Seasonal Adjustment Values
Hobby, Toy, and Game Stores
1,550
1,525
1,500
1,475
1,450
1,425
1,400
1,375
1,350
1,325
1,300
1,275
1,250
1,225
Jan-2007
Jul-2007
Jan-2008
Jul-2008
Jan-2009
Jul-2009
Jan-2010
Jul-2010
Original
Concurrent
Final

Percent Revisions

- For multiplicative adjustments, the program calculates the percent revision between the initial and final estimates of the seasonal adjustment

$$R_t = \frac{A_{t|T} - A_{t|t}}{A_{t|t}}$$

History Estimates

- Use **`estimates`** to select what to calculate the diagnostic on:
  - **`sadj`**: (default) seasonally adjusted series
  - **`sadjchng`**: period-to-period changes in the seasonally adjusted series
  - **`trend`**
  - **`trendchng`**: period-to-period changes in the trend
  - **`seasonal`**: final and projected seasonal factors
  - **`aic`**: AICCs and maximum log likelihoods for the regARIMA model
  - **`fcst`**: forecasts and evolving mean square forecast errors
  - **`arma`**: estimated AR and MA coefficients
  - **`td`**: trading day regression coefficients

History Spec

```
history{
   start = yyyy.mm
## must set start date
## for composite adjustments
   estimates =
    ( sadj sadjchng trend trendchng
       seasonal aic fcst)
##    aic fcst are other estimates
##    for modeling diagnostics
. . .
```

History Spec (2)

```
. . .
#  additivesa = percent
#  endtable = yyyy.mm
#  fstep = (1, 2, 3, 12)
#  sadjlags = (1, 2)
#  trendlags = (1, 2)
. . .
```

History Spec (3)

```
. . .
  savelog = all
#  savelog = (aveabsrevsa | asa
#    aveabsrevchng | ach
#    aveabsrevtrend | atr
#    aveabsrevtrendchng | atc
#    aveabsrevsf | asf
#    aveabsrevsfproj | asfp
#)

. . .
```

History Spec (4)

```
. . .
#  print = See Manual/Quick Reference
#  save = See Manual/Quick Reference
}
```

History Output

- Revision information for each month/quarter
- Summary information for each month/quarter and year
  - Percentiles or hinge values

Note: Even if a year has only one value, the output still shows an "average" for that year, can be misleading

Manufacturing 36A Automobiles 3x5 Filter

R 1 Percent revisions of the concurrent seasonal adjustments

From 2003.Jan to 2007.Nov

Observations 59

Date	Conc - Final
2003	
Jan	1.12
Feb	-0.54
Mar	-1.92
Apr	1.27
May	2.41
Jun	-0.30
Jul	-0.26

. . .

R 1.S Summary statistics : average absolute percent revisions of the seasonal adjustments

Date	Conc - Final
Months:	
Jan	0.93
Feb	1.09
Mar	1.27
Apr	0.95
May	0.87
Jun	0.67
Jul	1.82
Aug	1.77
Sep	0.50
Oct	1.02
Nov	0.97
Dec	1.37
Years:	
2003	1.39
2004	1.13
2005	1.10
2006	1.17
2007	0.66

Toward the end of the history run, there is less and less difference between the concurrent series and the final series, so expect the average revision across years to get smaller

R 1.S Summary statistics : average absolute percent revisions of the seasonal adjustments

. . .

Total:

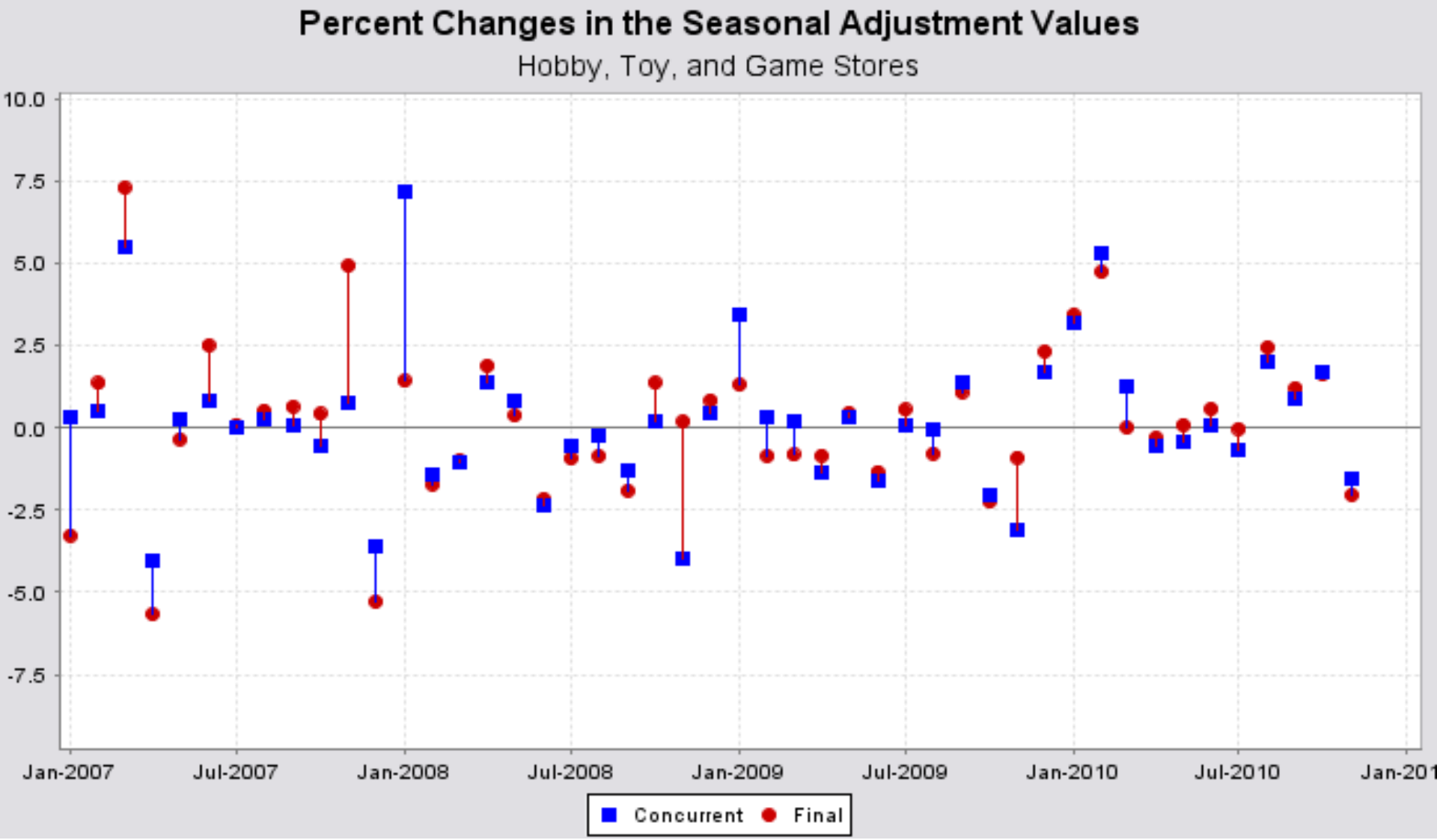
1.10

Hinge Values:

Min	0.02
25%	0.52
Med	0.85
75%	1.72
Max	4.32

Graphs

- Graph the initial and final estimates for the last years of the series to look at individual months to see how various models and options affect the revisions to the
  - Final seasonally adjusted series
  - Month-to-month change in the series



Month-to-month percent change

- Blue squares are the initial estimates of the seasonally adjusted values
- Red circles are the final estimates of the seasonally adjusted values

Interpreting **`History`** Diagnostics

- No recommended pass/fail levels
  - Comparison – if BIG differences in results
- Probably should not use results to choose seasonal filter
  - The diagnostic tends to favor longer filters

`History` Diagnostic for **`Composite`** Adjustments

- Component spans must have same **`start`** date

Not `History` but Other Revisions

- Service Sector devised a way to look at revisions – actual revisions to the underlying series values
  - When revised data available, rerun X-13A-S with the revised values (but not the newest value)
  - Compare those results to running through the very newest value with all revised values
- Creates separation between the seasonal adjustment with the revised series alone and with the added newest value
- BEA research into Census Bureau revisions – SSSD method is sensible approach

Monitoring and Quality Diagnostics

Developed at Statistics Canada

J. Lothian, M. Morry (1978) “A Set of Quality Control Statistics for the X-11-ARIMA Seasonal Adjustment Method,” working paper: Statistics Canada 78-10-005

For X-11 adjustments only

M Diagnostics

- Each M is designed to "fail" if it is greater than 1.0
- Ms range from 0.0 to 3.0
- Eleven Ms: M1, M2, … M11
- Each M measures a characteristic of the series or adjustment

Historically important, some of the first diagnostics available for seasonal adjustments!

Q Diagnostic

- Weighted average of M1-M11, denoted Q, is a simplified quality indicator
  - Range: 0 to 3
- Q "fails" when greater than 1

M Weights for Calculating Q

Weights imply relative importance

M1	10	M7	18
M2	11	M8	7
M3	10	M9	7
M4	8	M10	4
M5	11	M11	4
M6	10		

Q2 Statistic

- The Census Bureau created Q2, a second Q obtained by eliminating M2 from the weighted average
  - M2 values can be misleading if the trend shows several changes of direction
  - At the time, the Census Bureau considered Q2 more appropriate for its series

Use of Ms & Q

- Studies at Census Bureau show little correlation between the M diagnostics and accurate adjustments (measured from simulated series with known seasonal pattern)
- Ms and Q not very helpful in deciding on seasonal adjustment options
  - Can use M7 when deciding whether to adjust but other diagnostics seem more accurate in detecting seasonality

Diagnostics Summary

- Diagnostics are valuable to help us make decisions
  - Should a series be adjusted?
  - What options are best?

Diagnostics Summary (continued)

- Check for residual seasonality
  - Seasonal regression fit to the seasonally adjusted series
  - QS
  - Spectrum (for monthly series)
- Check sliding spans and revisions history for stability information