
Basics of Seasonal Adjustment

Seasonal Adjustment With X-13ARIMA-SEATS

2019

Economic Statistical Methods Division

U.S. Census Bureau

Objectives

- **At the end of this unit, you should understand –**
 - Basic seasonal adjustment concepts
 - Components of seasonal decomposition

What Are Data Users Looking for in an Economic Time Series?

- Direction
- Turning points
- Changes in rate of increase/decrease
- Comparisons of indicators

Comparisons of Indicators

- Data users might compare manufacturing data to retail data to construction data, etc.
 - Components of Gross Domestic Product (GDP)
- Some users compare monthly data to quarterly data to annual data, etc.
 - GDP is quarterly
- Users like consistency

What Is a Seasonal Effect?

- Effect that is “stable” in terms of annual timing, direction, and magnitude
 - Can change over time, but change should be smooth and gradual

Census Bureau Principle: Production of Estimates and Projections

"The Census Bureau performs seasonal adjustment of a time series of estimates only given clear evidence of seasonal behavior and only when the adjustment passes a suitable set of diagnostic tests. Diagnostics will be reviewed on a regular basis."

What Causes Seasonality?

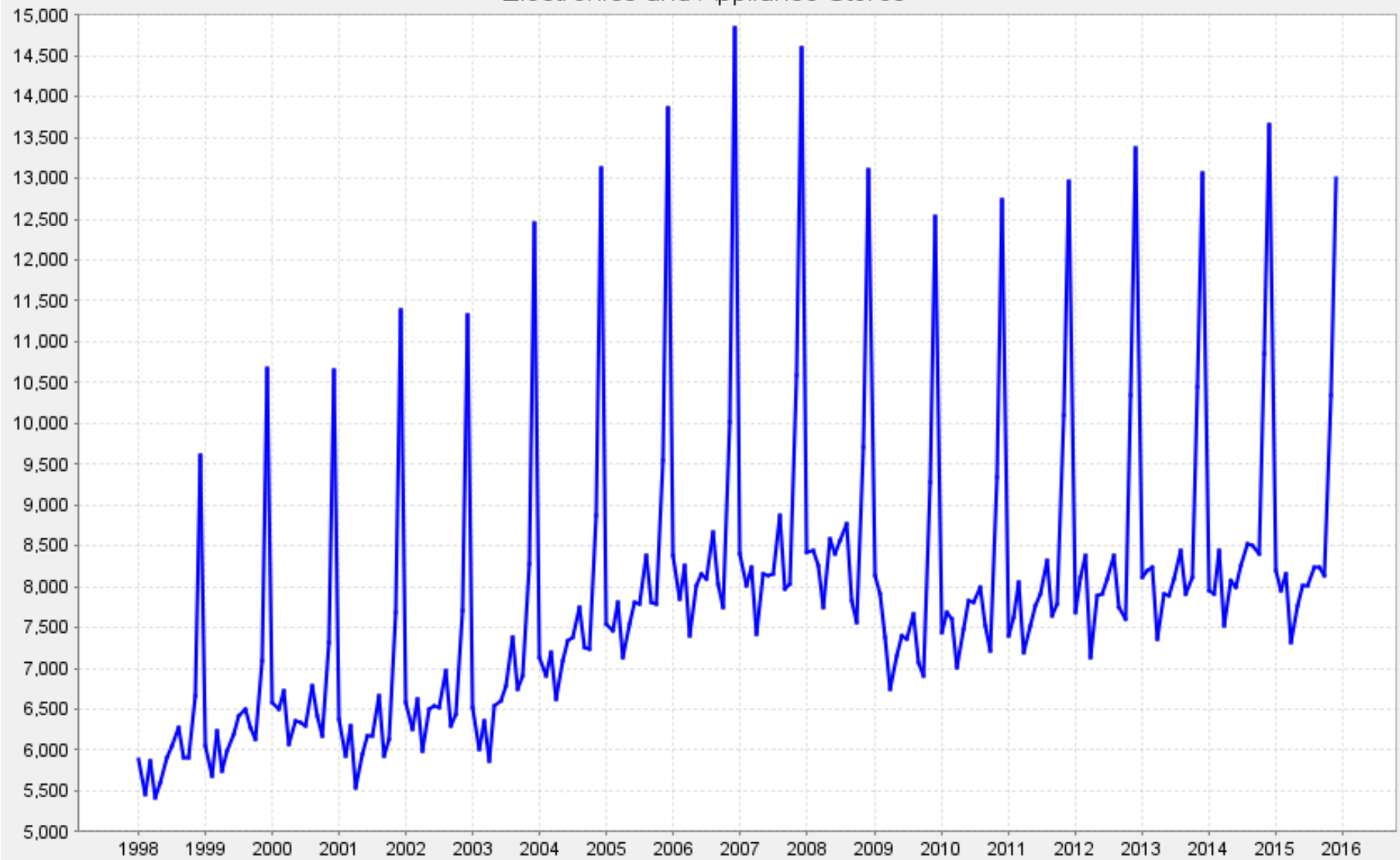
- Natural factors
 - Weather, amount of rainfall, temperature
- Administrative measures
 - Starting and ending dates of the school year, corporate policies
- Social/cultural/religious traditions
 - Fixed holidays such as Christmas
 - New car models

Seasonality in Time Series

- Economists look at the most recent months of time series to see direction and turning points
- Original series have seasonal oscillations that
 - Obscure economic movements
 - Make it difficult to compare indicators

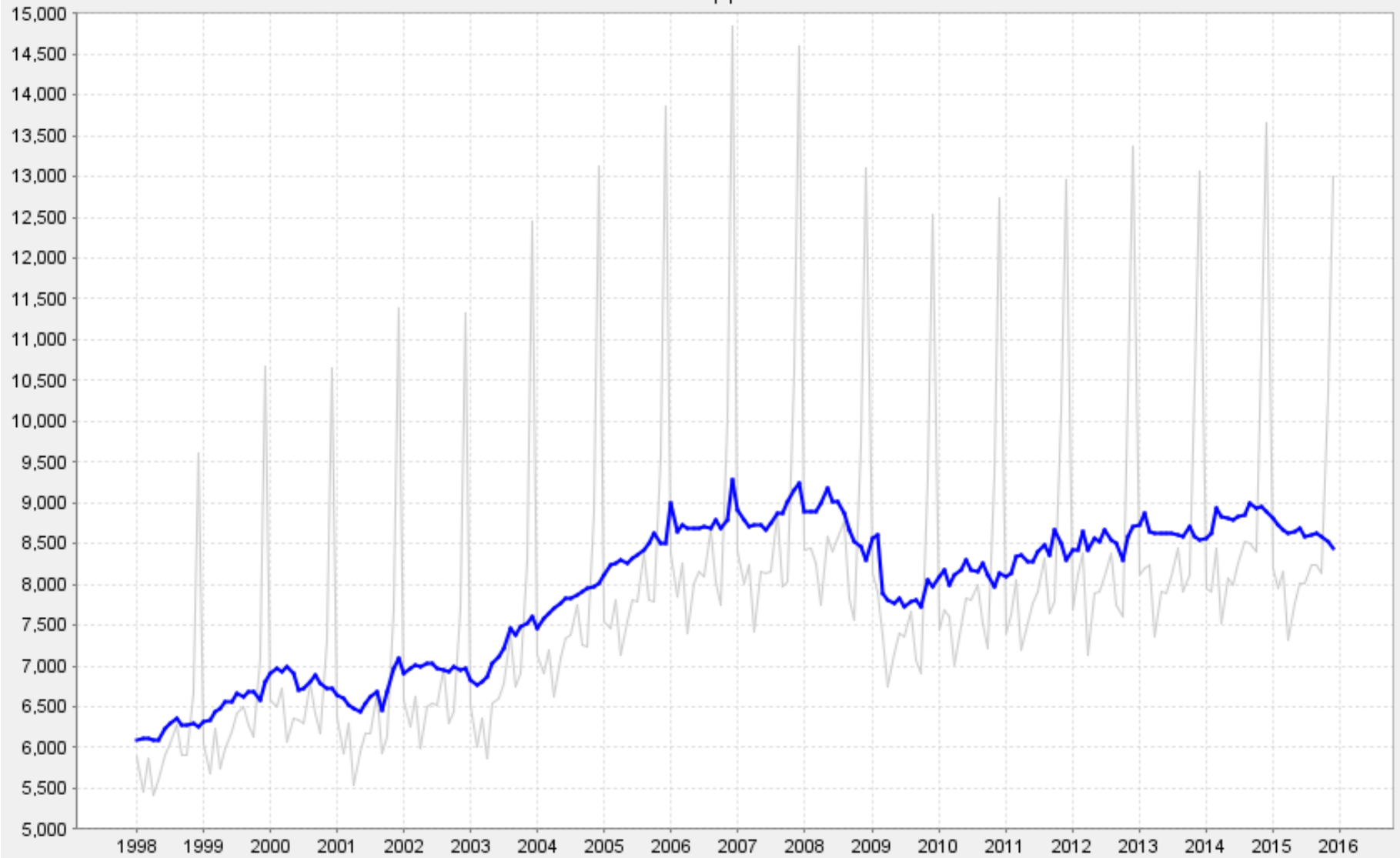
Original Series

Electronics and Appliance Stores



Seasonally Adjusted Series and Original Series

Electronics and Appliance Stores



Why Remove Seasonal Effects?

- Bell and Hillmer (1984)
 - Seasonal patterns can obscure relationships between different time series or between the time series and external events
- In other words, remove the seasonal patterns to reveal the relationships

Example

November to December (1998)

Month-to-Month Percent Change

- Midwest Total Housing Starts
24,700 to 17,100 → -31%
- General Merchandise Store Sales
34,377 to 48,231 → +40%

How Was the Economy Doing?

- Midwest Housing Starts down 31%
- General Merchandise Sales up 40%

Solution?

- Look at year-to-year changes instead of month-to-month changes

Example, Year-to-Year

- December Year-to-Year Percent Change (1997 to 1998)
 - Midwest Total Housing Starts
16,800 to 17,100 → +2%
 - General Merchandise Store Sales
45,412 to 48,231 → +6%

What do year-to-year changes tell us about how the economy was doing?

- Midwest Housing Starts up 2%
- General Merchandise Sales up 6%

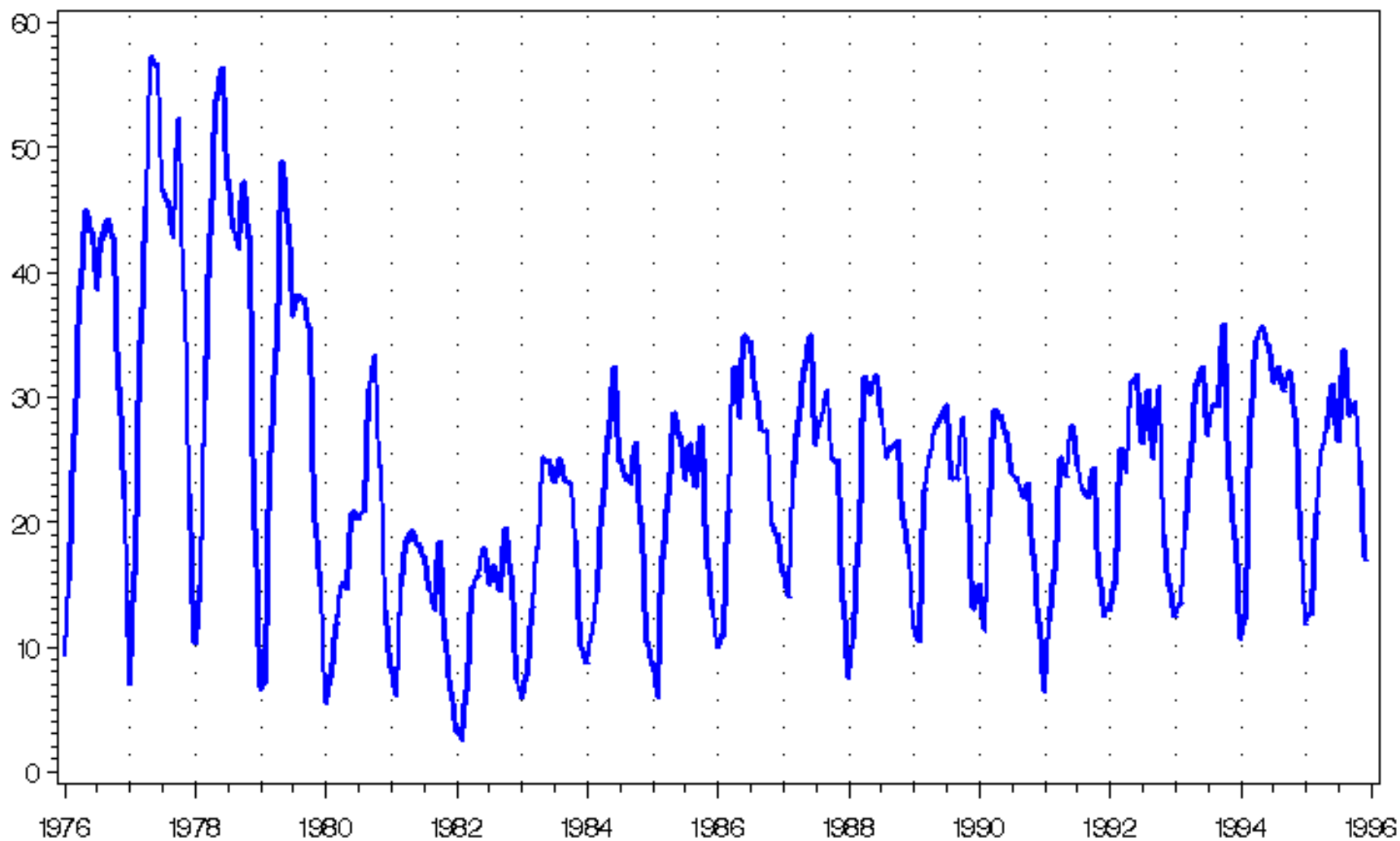
At least the two indicators agree in direction!

Example (continued)

- Year-to-Year Changes in a Monthly Series
 - Midwest Total Housing Starts
 - May 1981: 19,200
 - May 1982: 15,700
 - \Rightarrow 18 % decrease
- Was the economy that grim in 1982?

Original Series

Housing Starts — Midwest Total



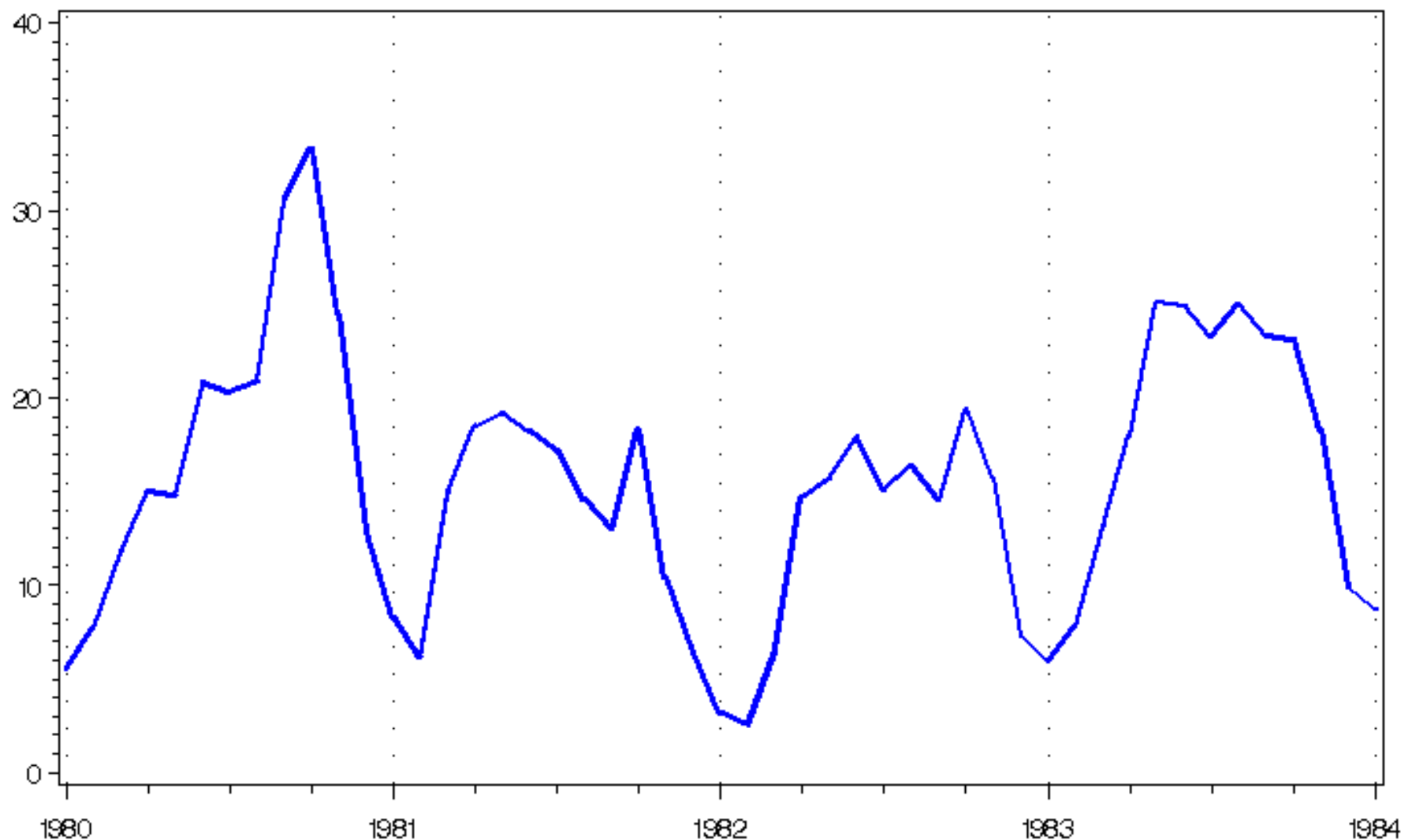
— Original Series

Turning Point in Early 1982

- Change from moving downward to moving upward (in this example)
- Looking only at year-to-year changes takes months before seeing the turning point
- Where exactly is the turning point?

Original Series

Housing Starts — Midwest Total



— Original Series

Finding the Turning Point

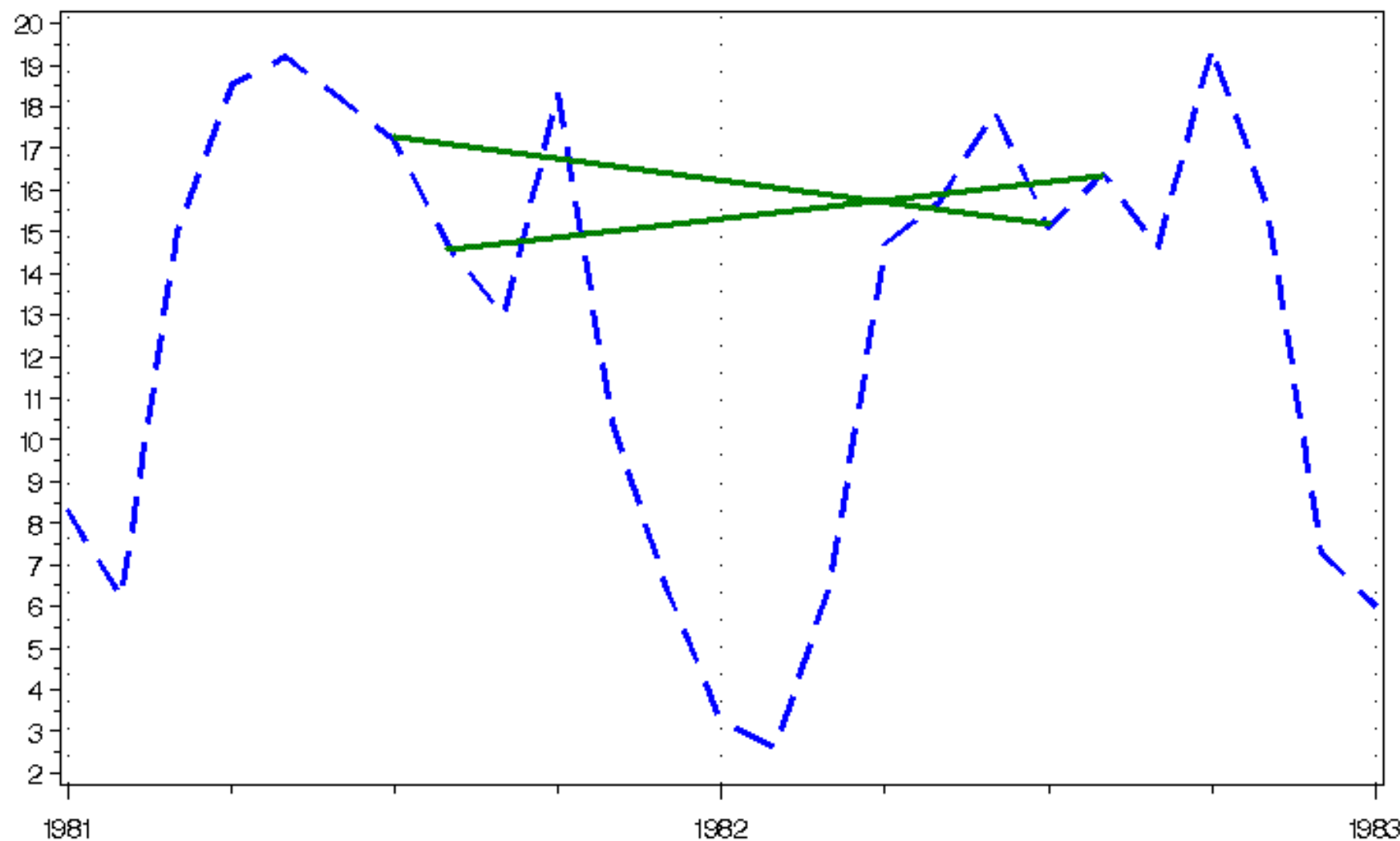
- Looking at year-to-year changes, how many months does it take to find the turning point?
- Would the turning point be easier to find if the series were smoother?

Where Is the Turning Point?

1981-07	-15.3%	1982-02	-58.1%
1981-08	-30.1%	1982-03	-56.0%
1981-09	-57.5%	1982-04	-20.5%
1981-10	-45.0%	1982-05	-18.2%
1981-11	-57.4%	1982-06	-1.6%
1981-12	-50.0%	1982-07	-12.2%
1982-01	-61.4%	1982-08	12.3%

Original Series

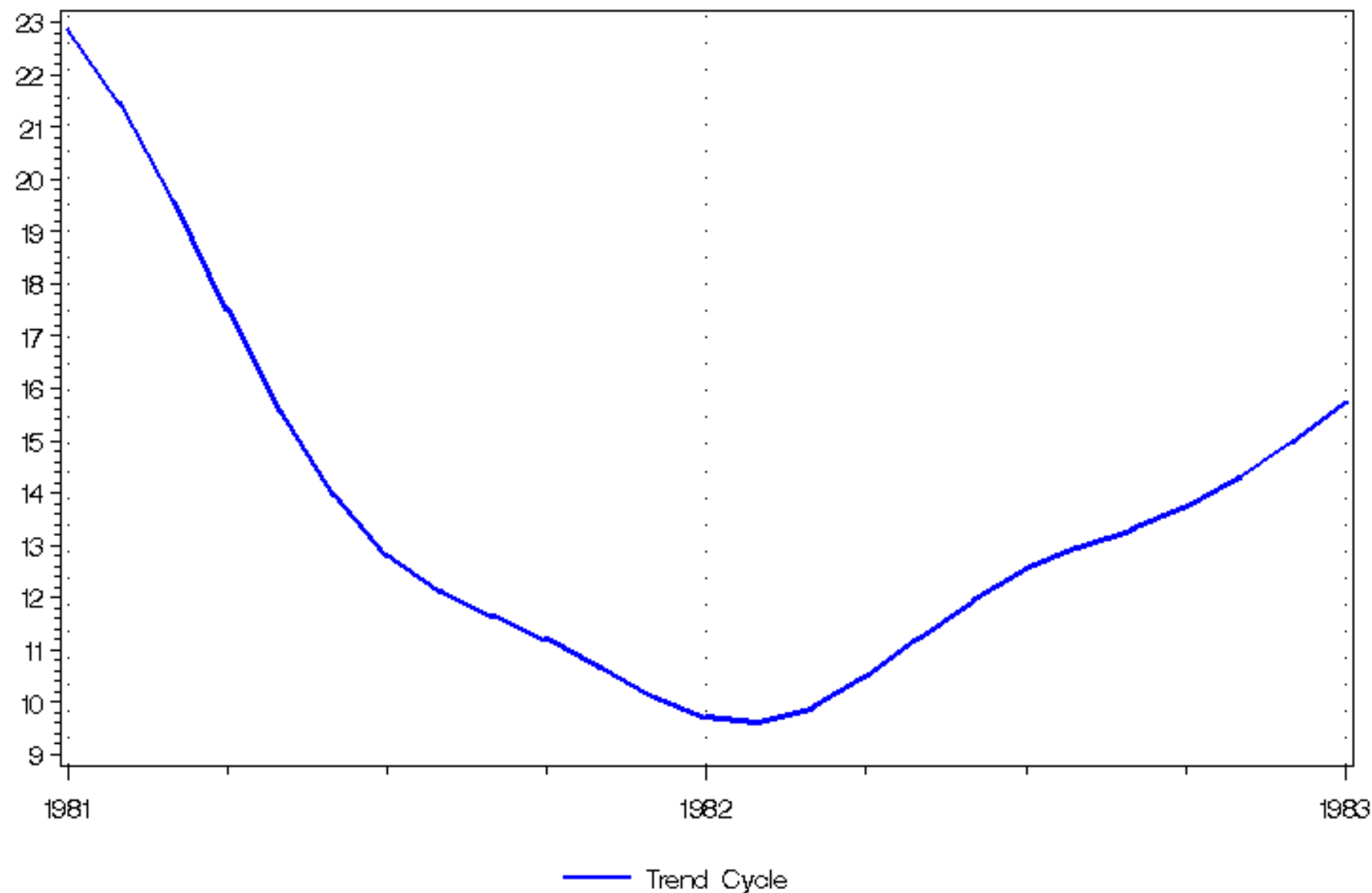
Housing Starts — Midwest Total



Original Series

Trend Cycle

Housing Starts — Midwest Total



Where Was the Turning Point?

- August: Year-to-year changes finally turn up instead of down
- March: Actual turning point

Note: In real time, in March 1982, the turning point probably was not apparent, but looking back, we can tell the turnaround definitely occurred before August

General Problem

- Series with seasonal movements are “signal plus noise”
- How to find the signal?

Seasonal Adjustment = Finding the Signal

Removing those consistent, repeated seasonal patterns from a time series to be able to see underlying movements and make meaningful comparisons

"Decompose" the time series into components

Components of a Time Series

C = Trend-cycle

S = Seasonal effects

- Trading-day effects
- Moving holiday effects
 - Easter, Thanksgiving, Chinese New Year, etc.

I = Irregular

Serie Original

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No transformation
(0 1 3)(0 1 1)

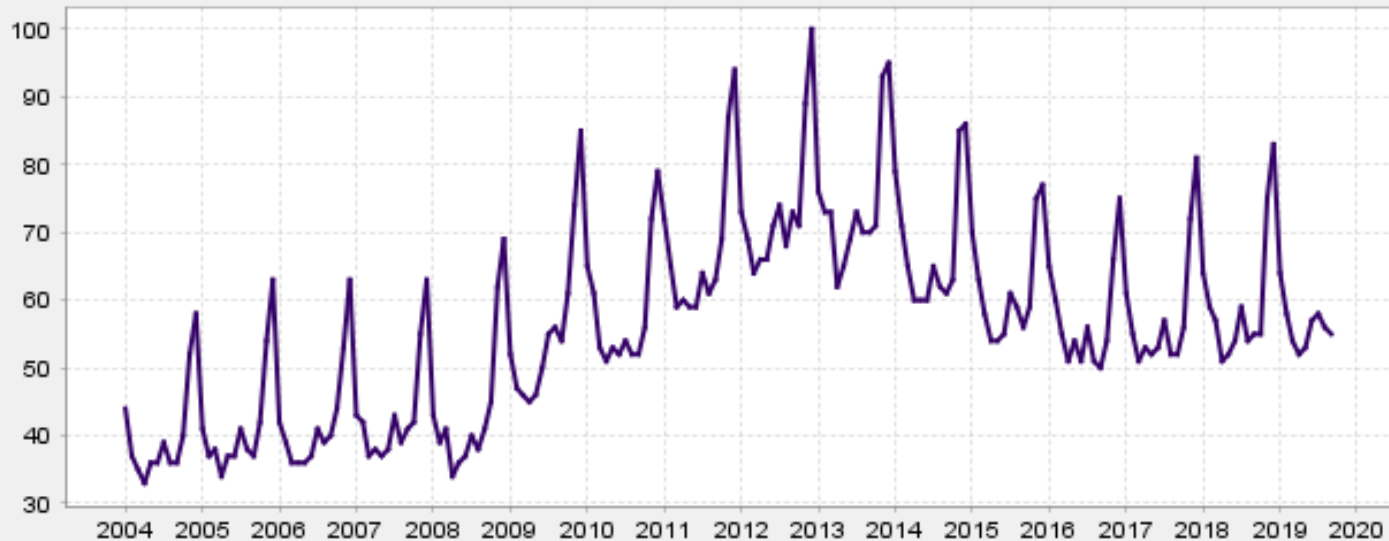
No TD

Easter[8] $t=8.97$

TC2004.12 $t=-4.91$

Original Series

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Log transformation
(0 1 1)(0 1 1)

TD1coef $t=-7.50$

Easter[1] $t=7.28$

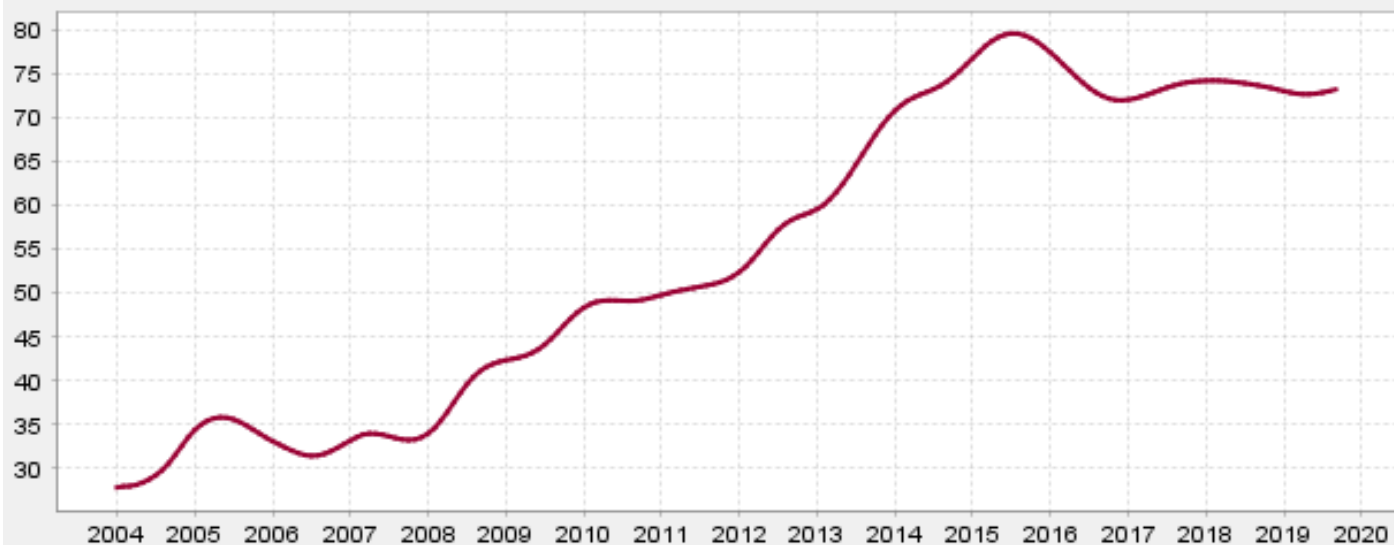
LS2011.01 $t=4.97$

Trend-Cycle

- Basic level of the series
 - "Local" level
- Reasonably smooth, includes movements and cycles that last longer than a year
 - Find turning points in the historical series
- For convenience, we usually say “trend”

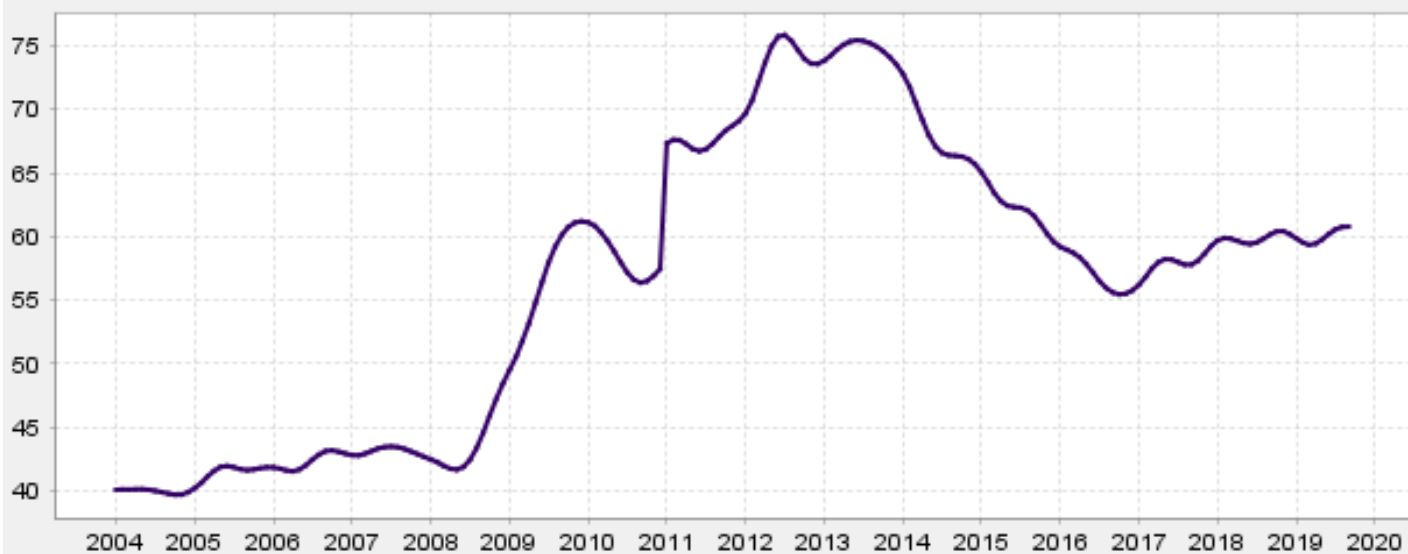
Tendencia-Ciclo

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Trend

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Outliers in the Trend-Cycle

In general, outliers that indicate changes of series level are part of the trend

- Level Shifts
- Ramps

As part of the trend, these outliers are included in the seasonally adjusted series

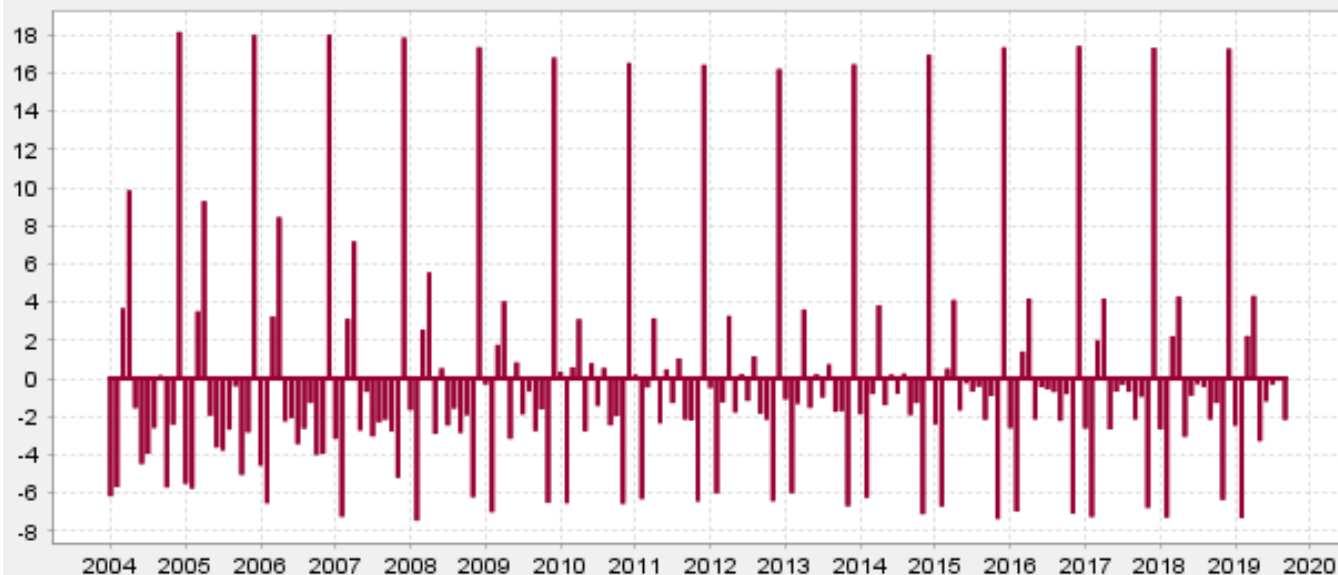
Seasonal Effects

Reasonably stable in terms of

- Annual timing
 - Within same month or quarter
- Direction
- Magnitude

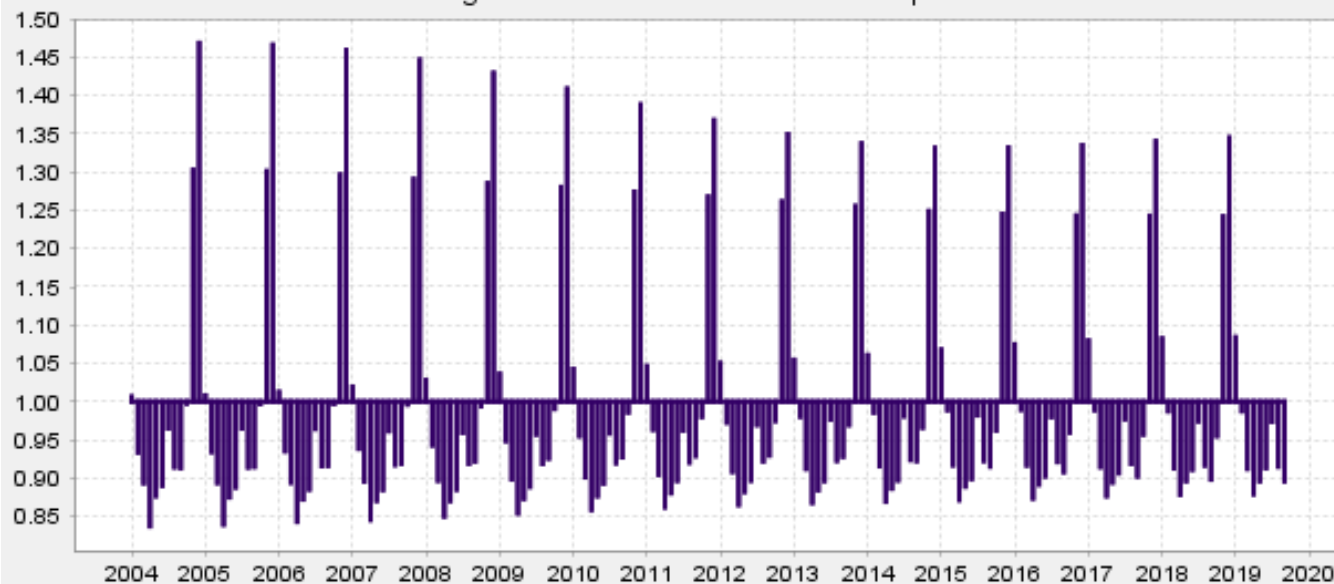
Factores Estacionales

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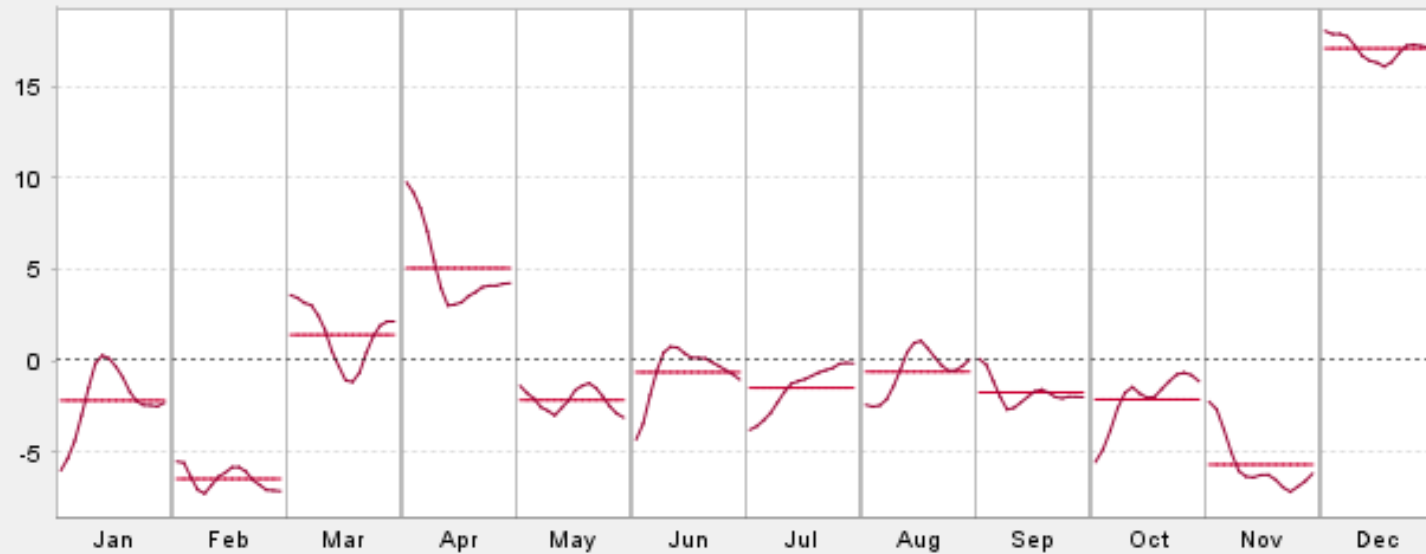
Seasonal Factors

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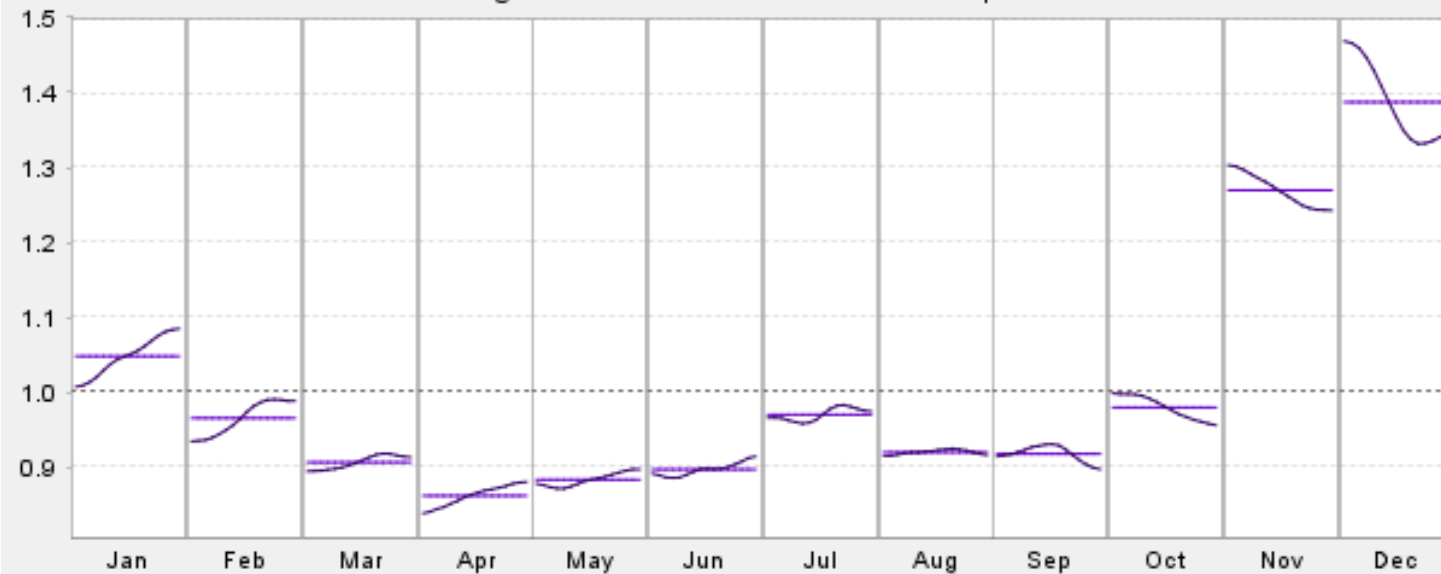
Factores Estacionales por Mes

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Seasonal Factors by Month

Google Searches in the U.S. for 'recipe'



Irregular Effects

- Unpredictable in terms of
 - Timing
 - Impact
 - Duration
- Left over after removing seasonal and trend

Causes of Irregular Effects

Possible causes

- Sampling error
- Nonsampling error
- Unseasonable weather/natural disasters
- Strikes
- Unusual events

Outliers in the Irregular

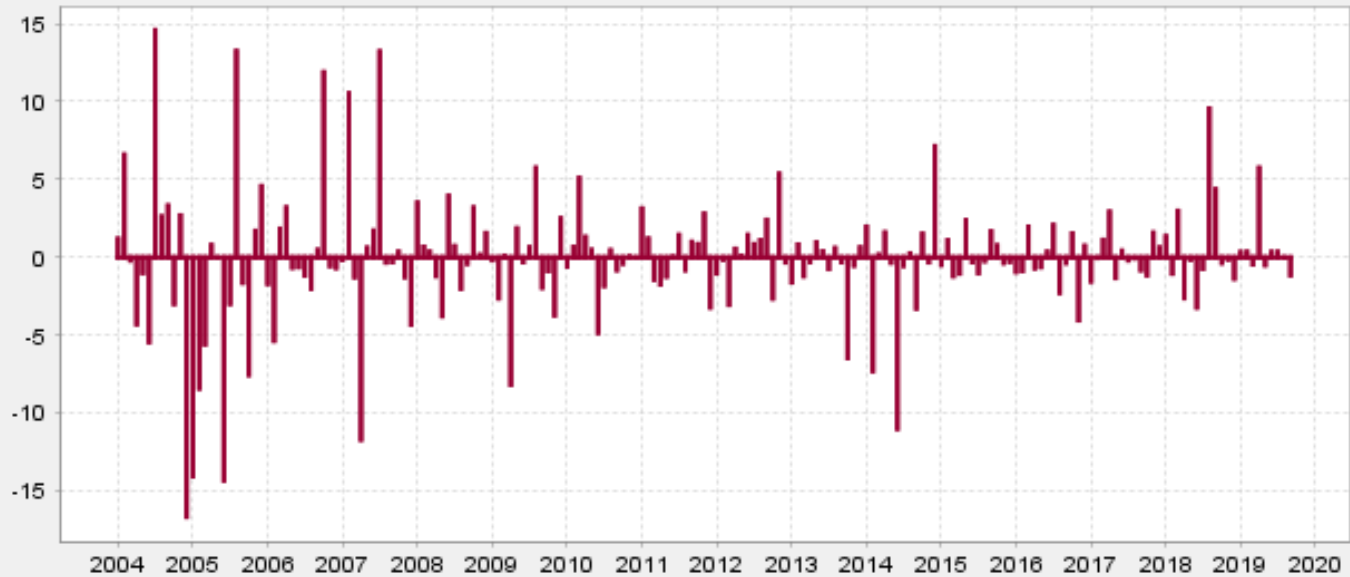
In general, outliers that do not measure a “long-term” change in the series level are assigned to the irregular

- Additive Outliers
- Temporary Changes

As part of the Irregular Component, these outliers are included in the seasonally adjusted series

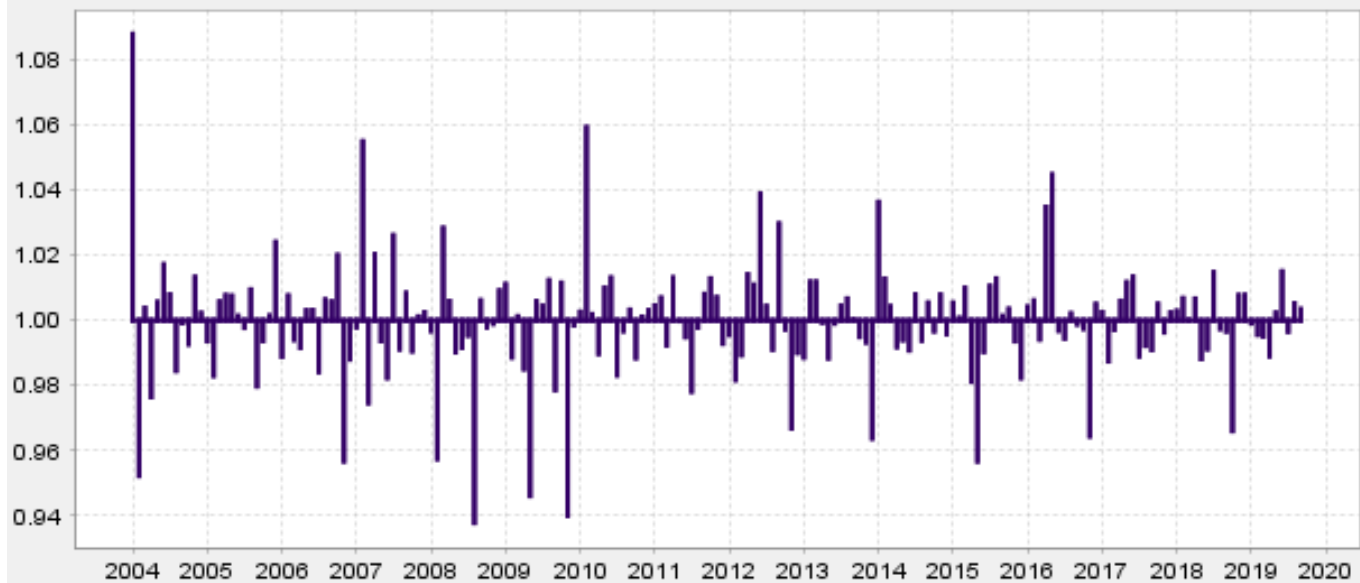
Irregular

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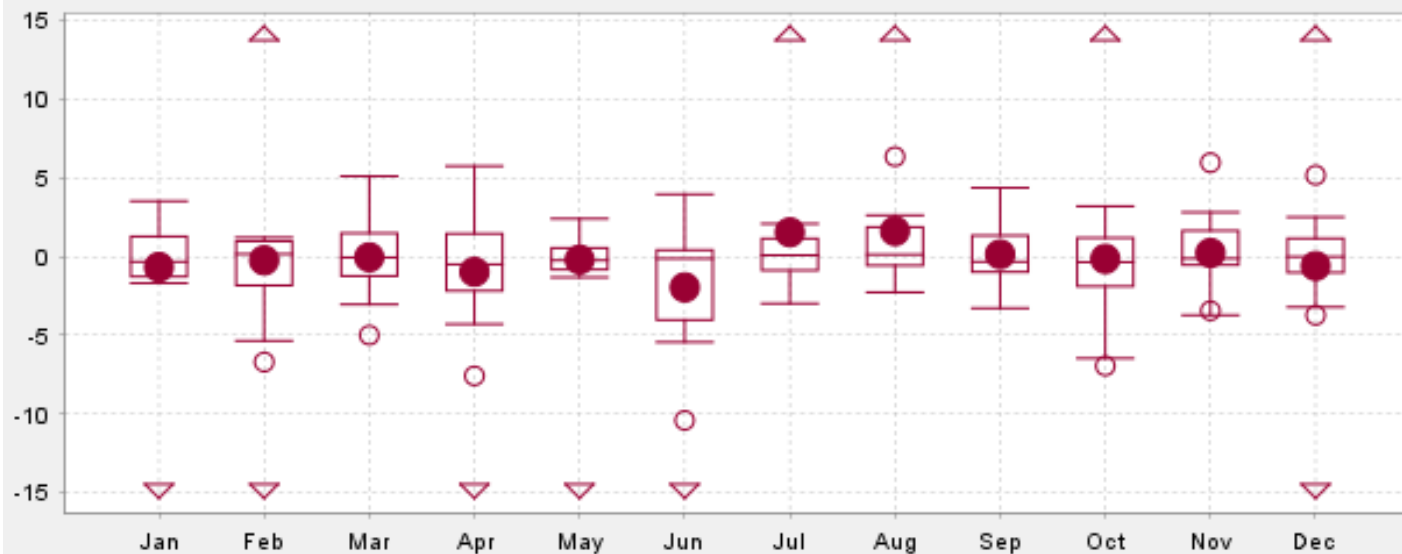
Irregular

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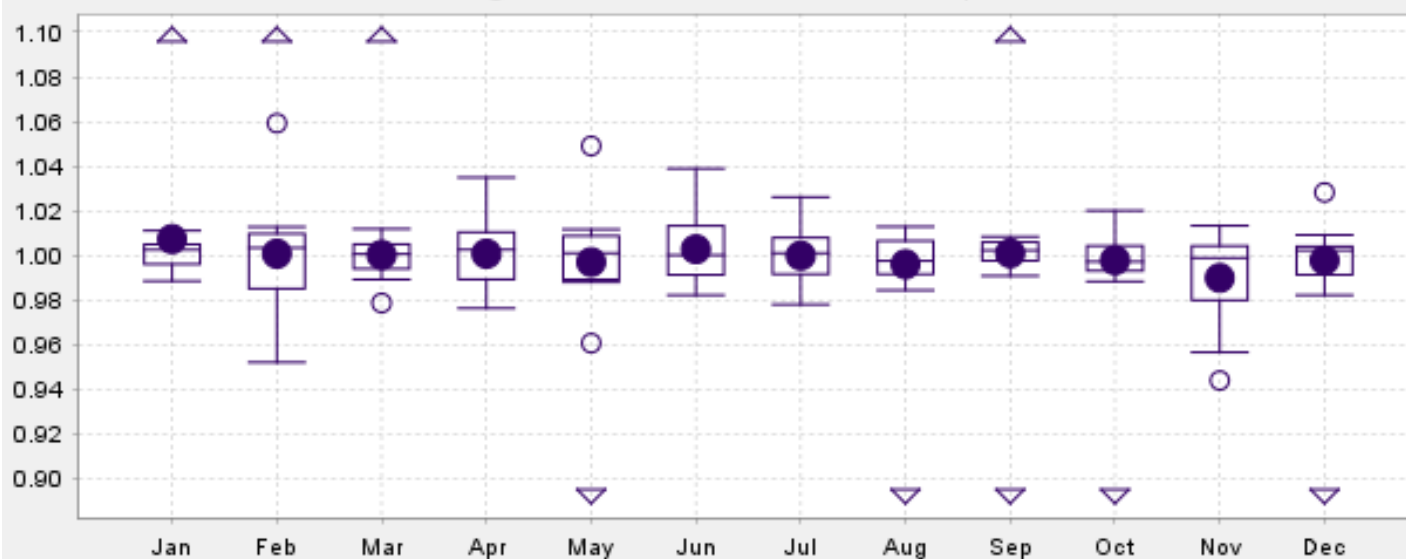
Irregular por Mes

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Irregular by Month

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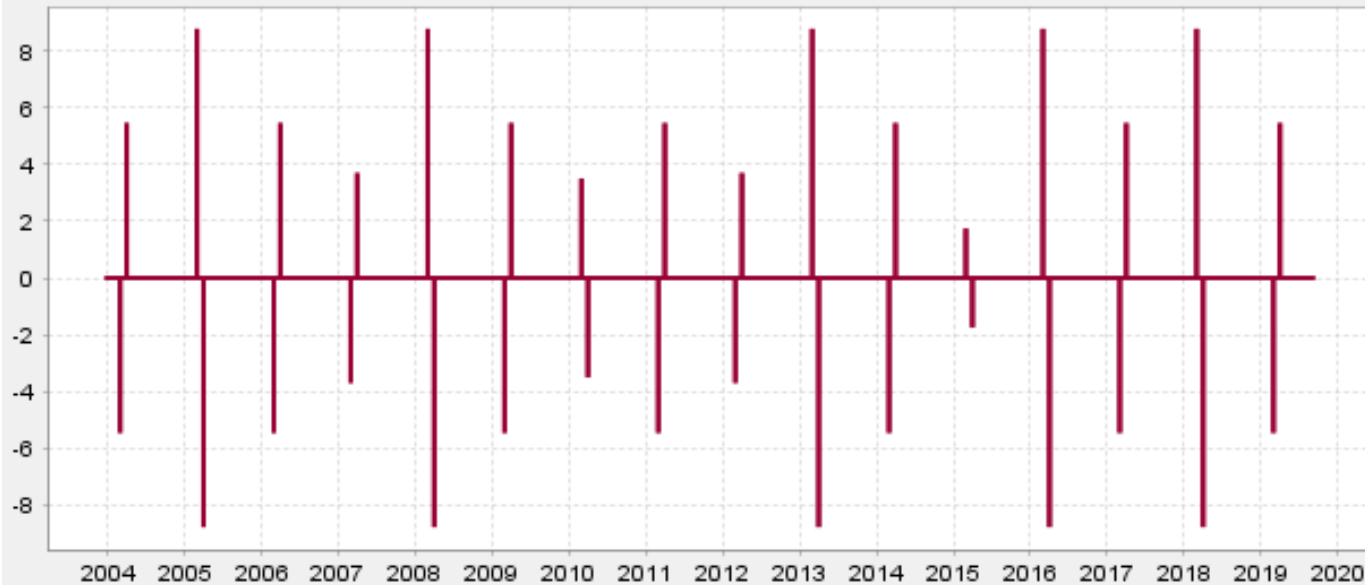


“Combined” Effects

- Persistent, predictable, calendar-related effects, like trading day and moving holiday effects often are included with the seasonal effects
 - Adjusted out of the original series
 - “Combined” factors vs. purely seasonal factors

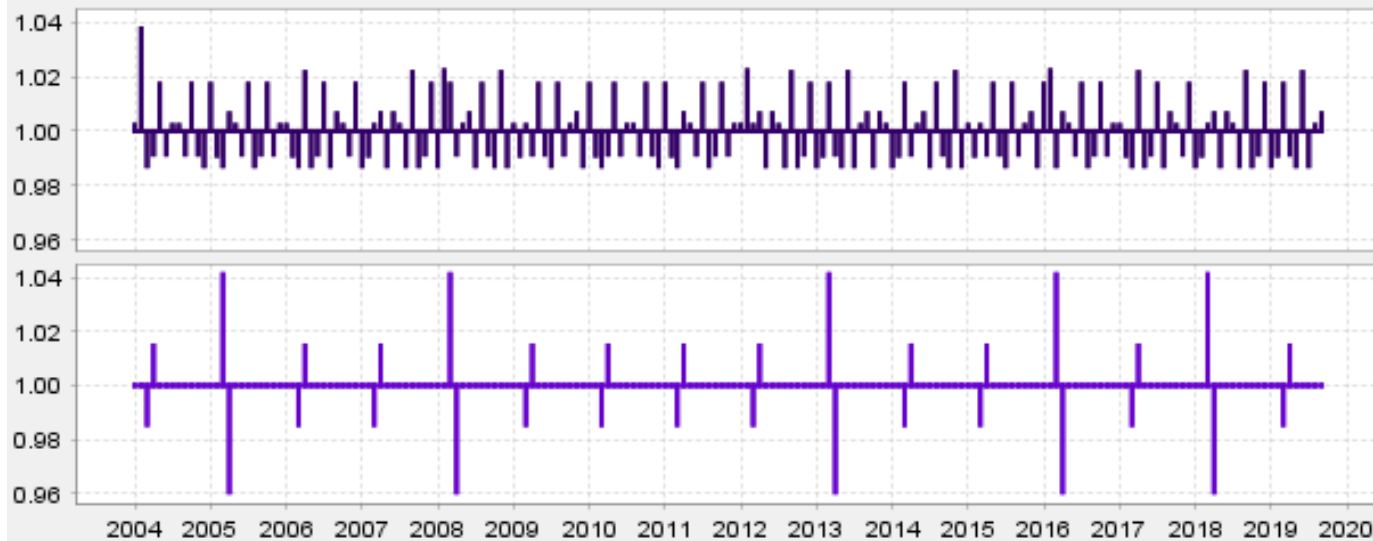
Factores de Pascua

Busqueda de google en Costa Rica para 'receta'



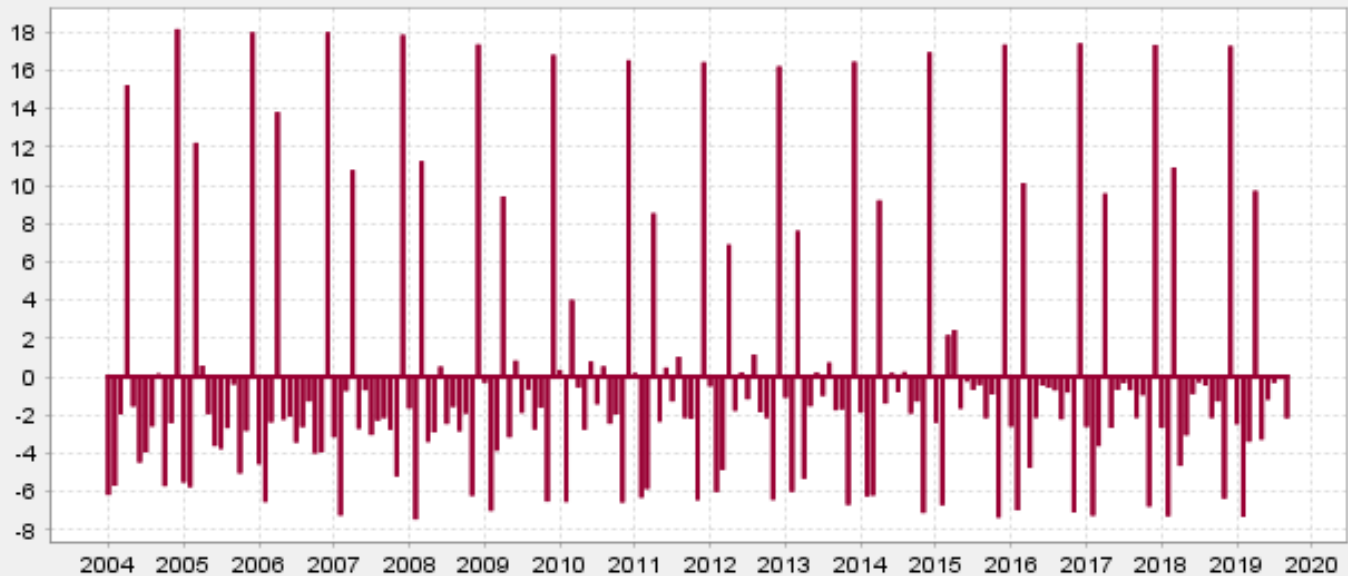
Trading Day Factors and Holiday Factors

Google Searches in the U.S. for 'recipe'



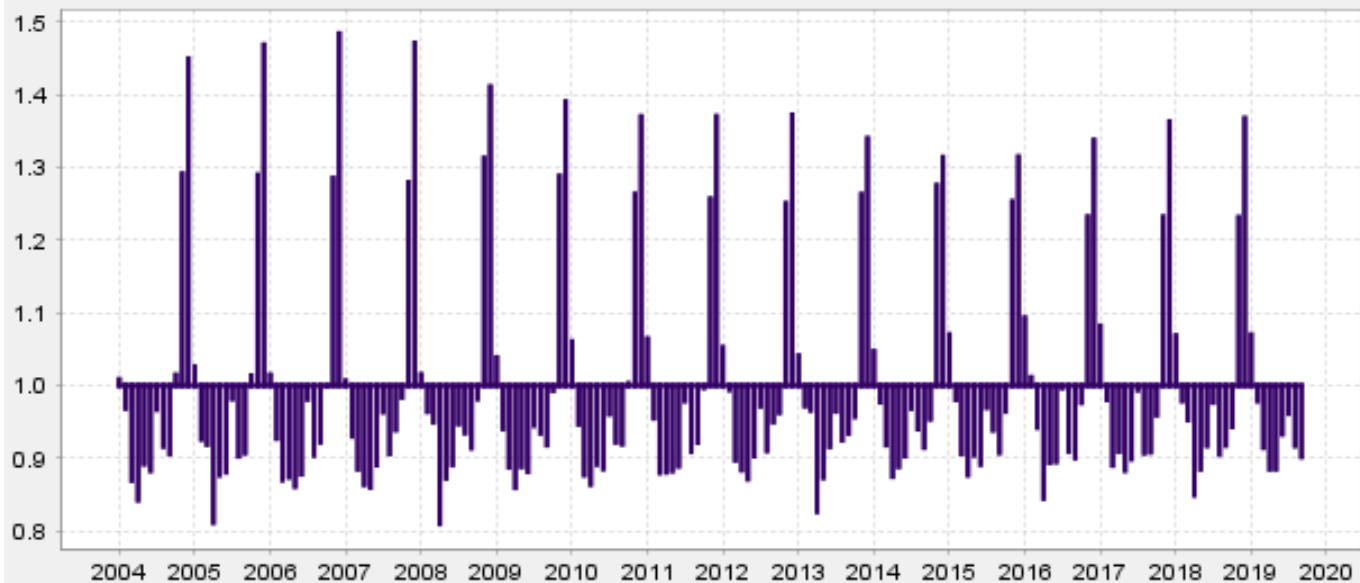
Factores Combinados de Pascua y Estacionales

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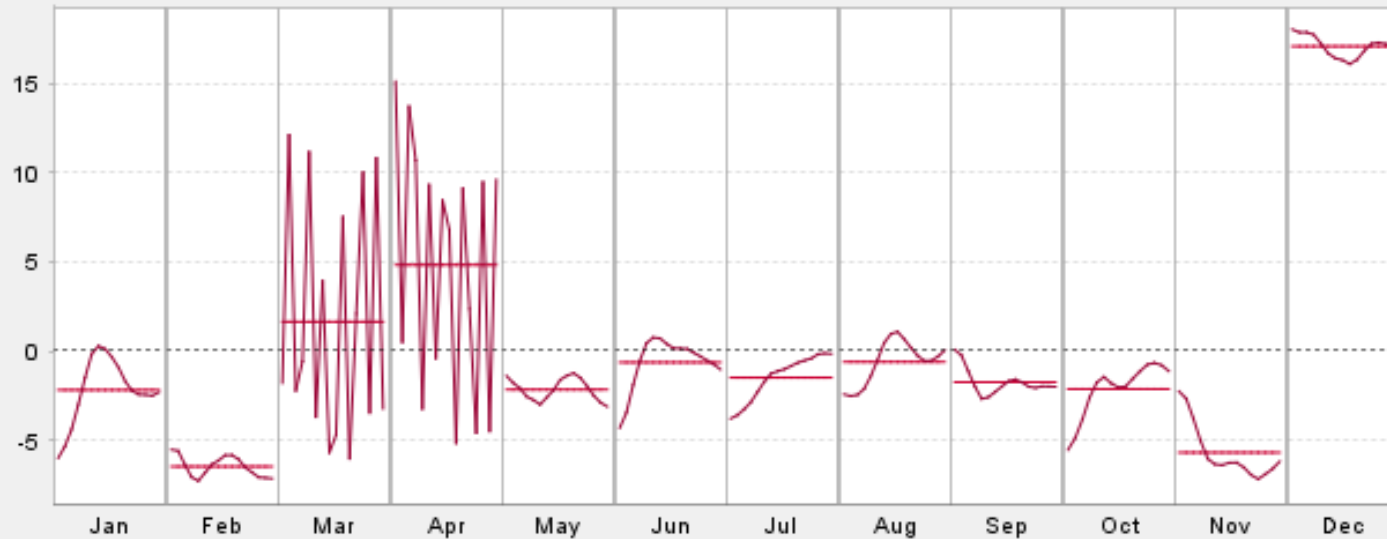
Combined Holiday, Trading Day, and Seasonal Factors

Google Searches in the U.S. for 'recipe'



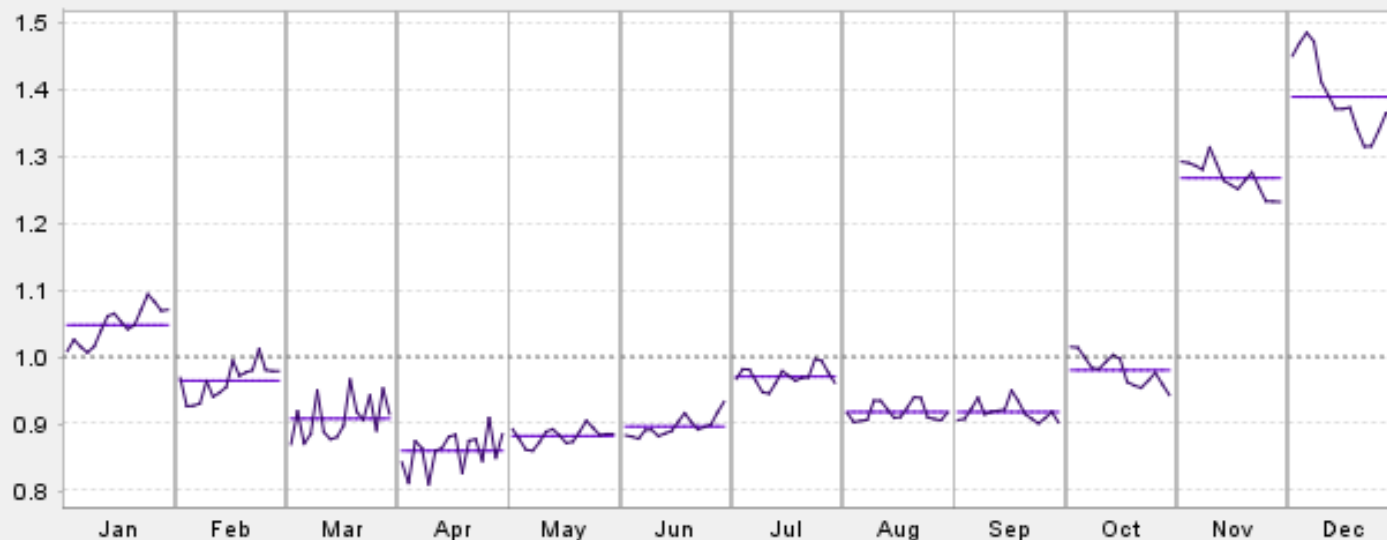
Factores Combinados de Pascua y Estacionales

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Combined Holiday, Trading Day, and Seasonal Factors

Google Searches in the U.S. for 'recipe'



Multiplicative Decomposition

- Most economic series, especially when measured in currency, have multiplicative adjustments

Y = original series

A = adjusted series

$$Y = S \times C \times I$$

$$A = C \times I = Y / S$$

- Log transform for regARIMA model → multiplicative adjustment
- No regARIMA transform → additive adjustment

Additive Decomposition

- For some series, additive adjustments are preferred
 - Negative or zero values in a series mean we cannot use log transformations
 - Variation is not always increasing – additive approach may be appropriate

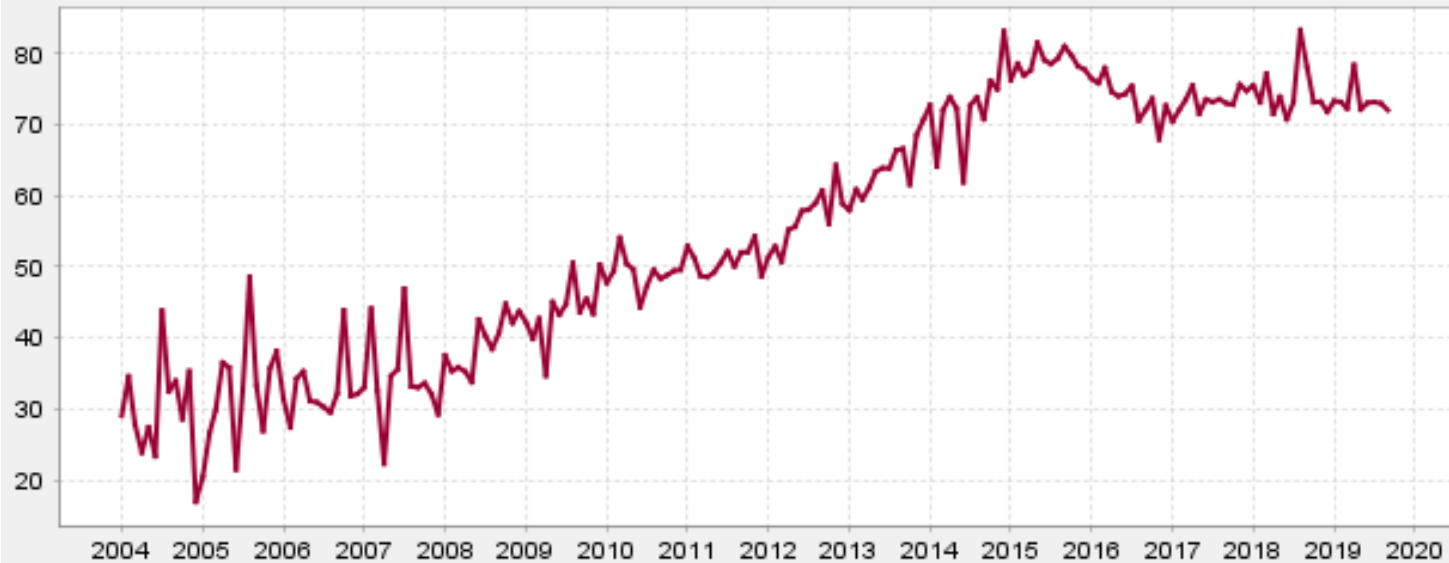
$$Y = S + C + I$$

$$A = C + I = Y - S$$

- Often do not publish seasonal factors for additive adjustments

Serie Desestacionalizada

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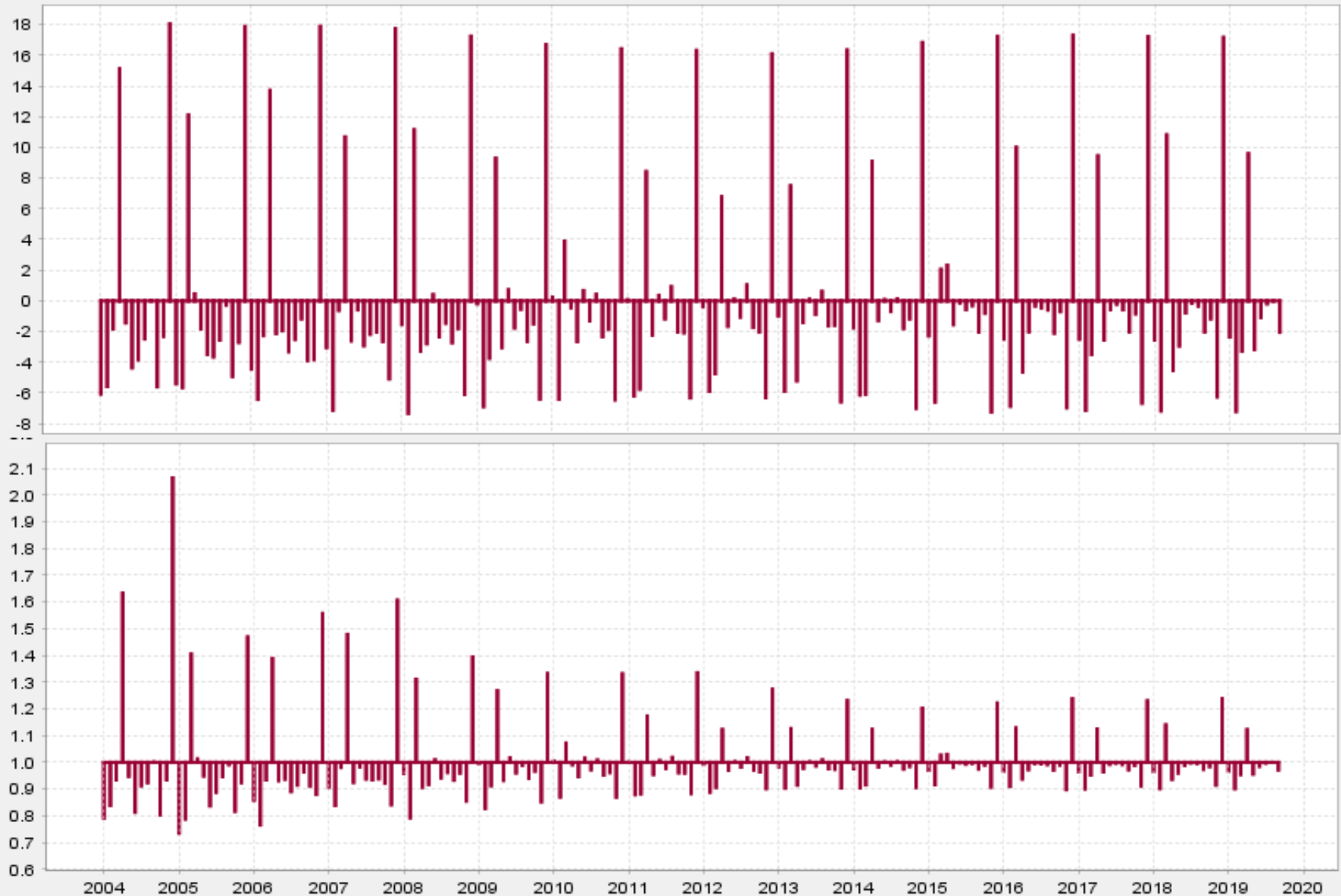
Seasonally Adjusted Series

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Factores Combinados (D16) y Ratios de Ajuste Final (E18)

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Final adjustment ratio = Y/A

(For a multiplicative adjustment, final adj ratio = combined factors)

Seasonal Adjustment Modes

Mode	Decomposition	Adjusted Series
Multiplicative	$Y_t = S_t C_t I_t$	$A_t = C_t I_t$
Additive	$Y_t = S_t + C_t + I_t$	$A_t = C_t + I_t$
Pseudo-Additive (somewhat rate)	$Y_t = C_t(S_t + I_t - 1)$	$A_t = C_t I_t$

Identifying Seasonality

- Lytras, Feldpausch, and Bell (2007)
- F test measuring significance of seasonal regressors
 - New in X-13ARIMA-SEATS

Identifying Seasonality (2)

- Spectrum (monthly series only)
 - Peaks at seasonal frequencies indicate seasonality
- QS of the original series (with or without adjustment for extremes)
 - Measures positive autocorrelation at seasonal lags
- Graphs
 - Original series
 - Year over year

Identifying Seasonality (3)

- X-11 D8 F statistic assuming stability
 - “D8 F” because it follows Table D8 in the output
 - Values over 7 indicate seasonality
 - (7 is empirical result, not statistical)
- M7
 - Less than 1 indicates reliable seasonality
 - Ranges from 0 to 3
 - Function of the D8 F statistic
 - Very often agrees with the D8 F statistic

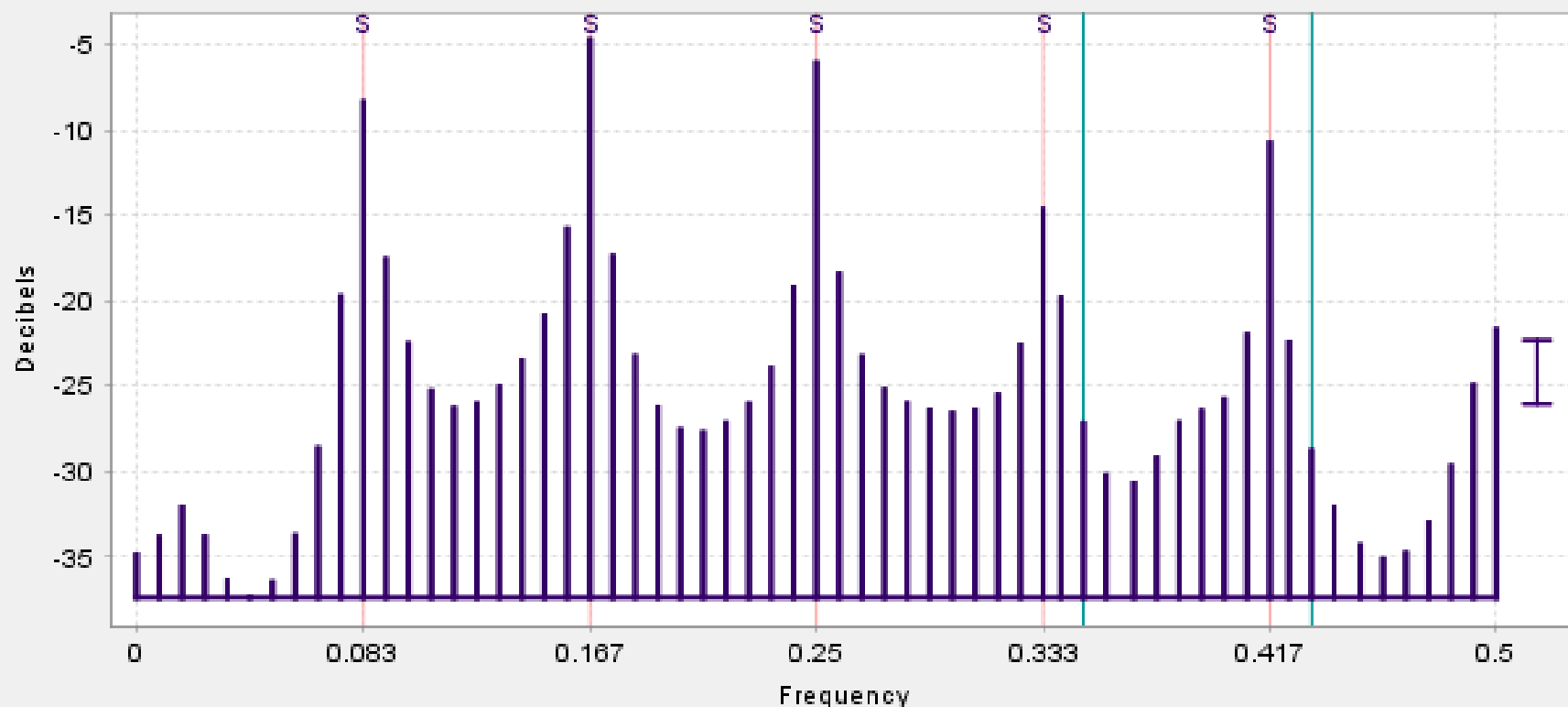
Significance of Seasonal Regressors

F Tests for Seasonal Regressors

	df	F-statistic	P-Value
Seasonal	11, 174	222.24	0.00

Spectrum of the Transformed Differenced Prior Adjusted Original Series

Google Searches in the U.S. for 'recipe'



— Spectrum of the Transformed Differenced Prior Adjusted Original Series — Seasonal Frequencies

— Trading Day Frequencies

S: Significant Seasonal Peaks

QS Statistic

QS statistic for seasonality (Full series)

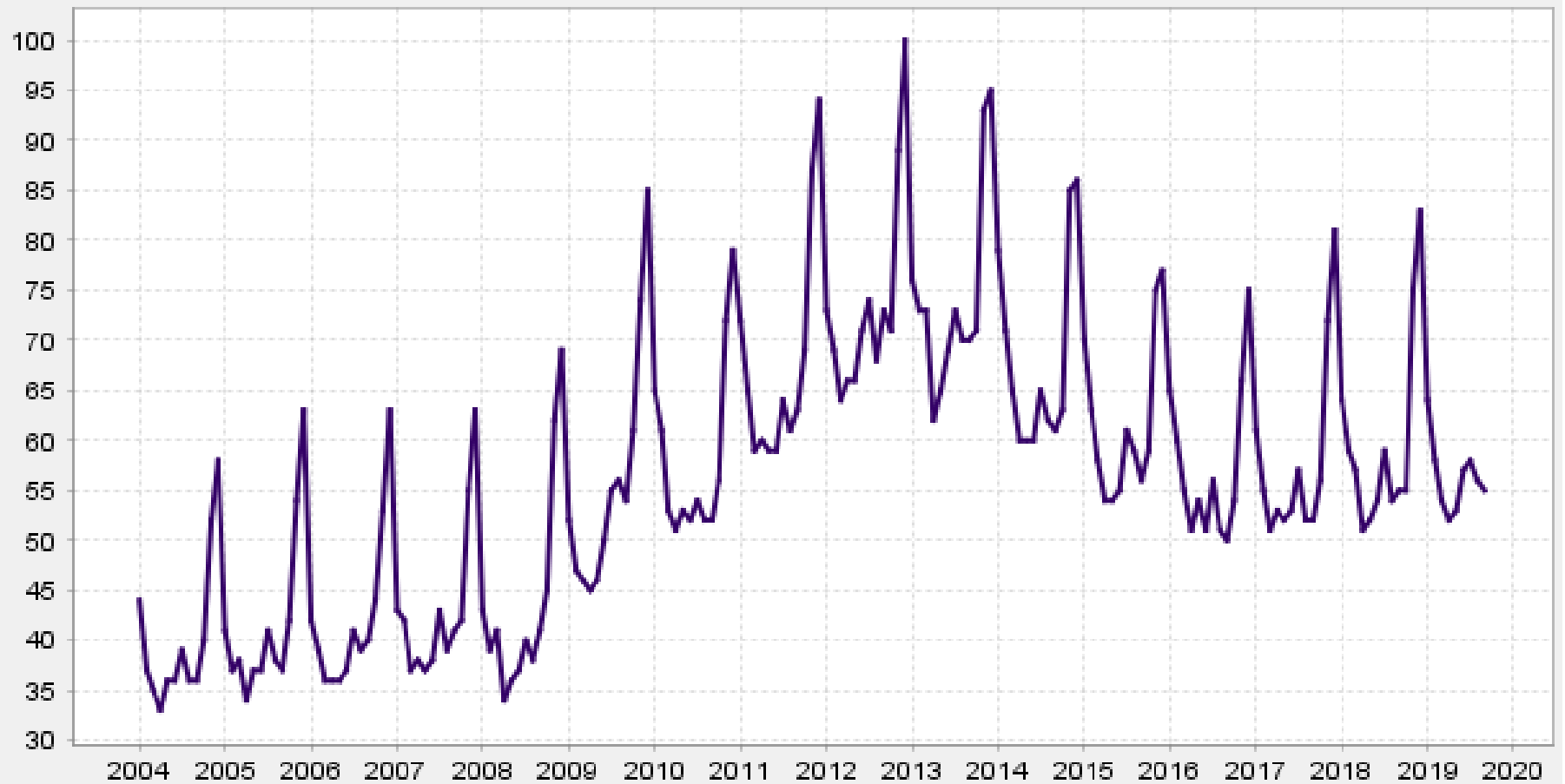
	QS	p-value
Original Series	224.12	0.0000
Original Series (extreme value adjusted)	290.52	0.0000

QS statistic for seasonality (Series start in 2011.Oct)

	QS	p-value
Original Series	93.72	0.0000
Original Series (extreme value adjusted)	123.92	0.0000

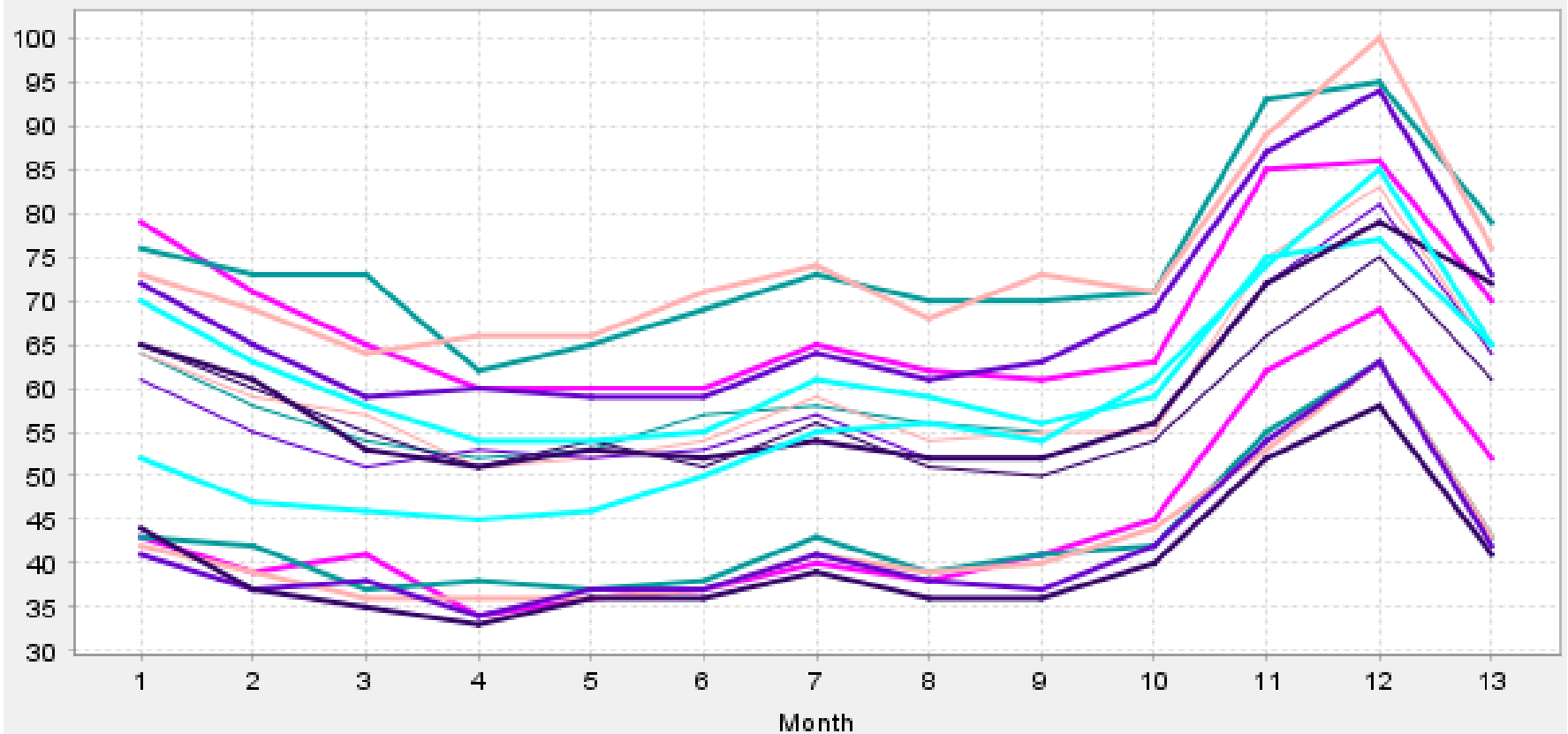
Original Series

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Original Series

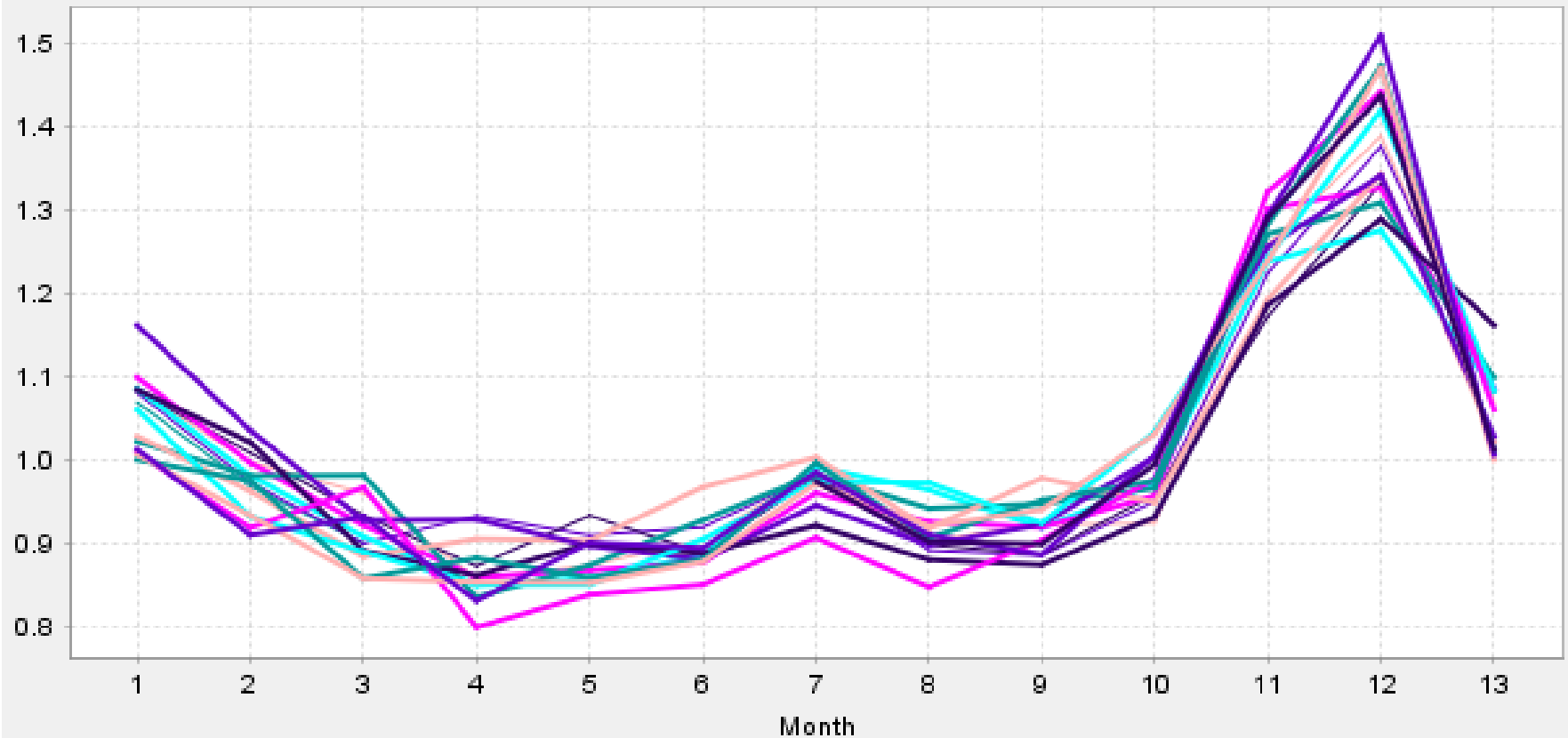
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2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
2016 2017 2018 2019

Detrended Original Series (2x12 Filter)

Google Searches in the U.S. for 'recipe'



2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
2016 2017 2018 2019