# OLIVER WYMAN

# APPLYING MEDIAN POLISH TO US RAIL TRAFFIC: EXAMINING EVENTS THROUGH OUTLIERS

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**SURFACE TRANSPORTATION**

# SIGNAL & NOISE

*Most efforts attempt to unlock the signal from the noise; however, it is also insightful to look at the noise*

# 1,083 WEEKS OF AAR RAILROAD TRAFFIC DATA DIVIDED INTO FIVE CATEGORIES

Large disruptions can be identified (e.g., 2008/2009 recession, COVID-19), but details are buried by trends and seasonality and it is difficult to compare events
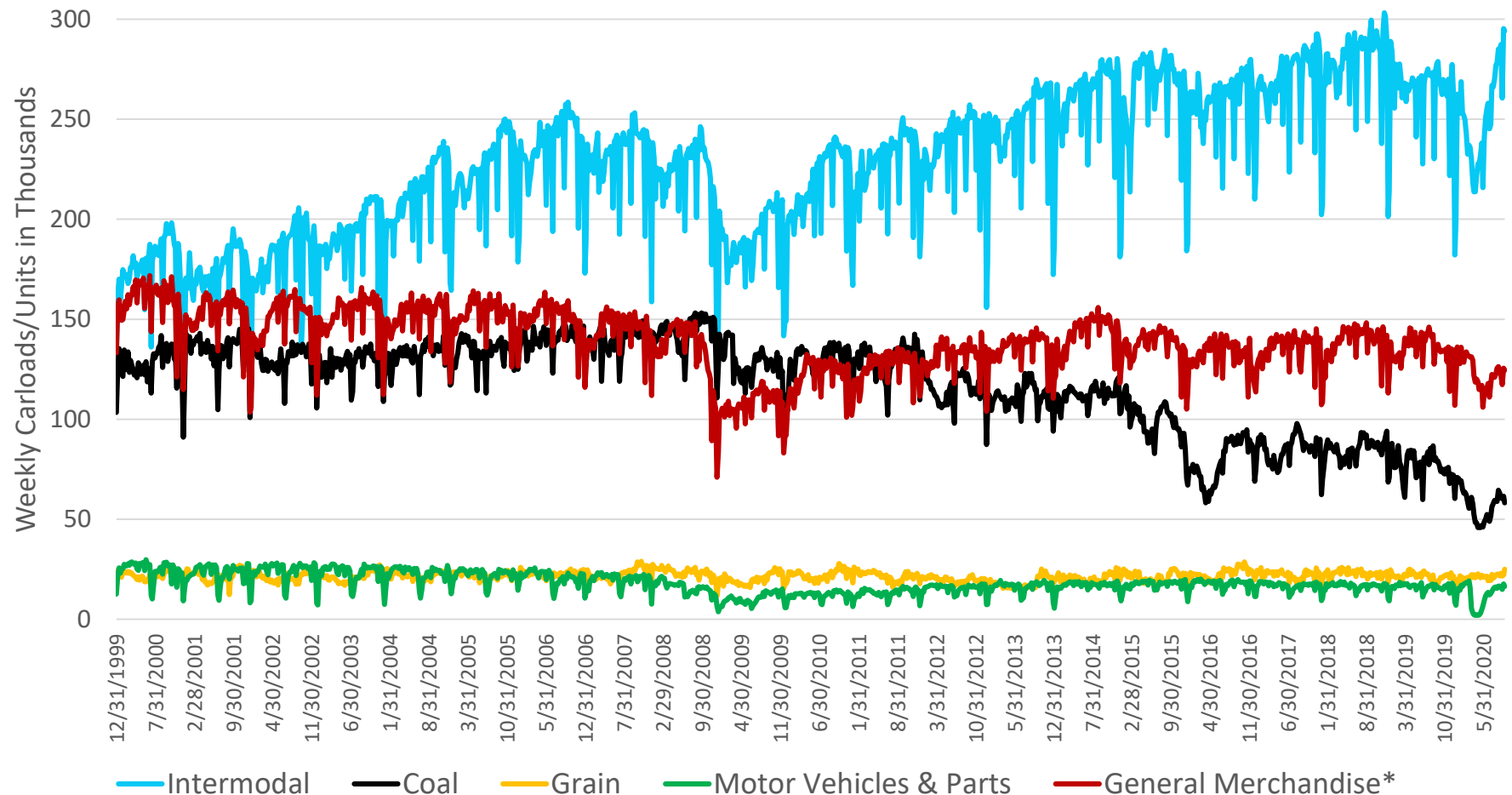


* General Merchandise is all other after grain, coal, motor vehicles and intermodal are removed. Source: Association of American Railroads, "Weekly Railroad Traffic," US Railroads, for the weeks ending 12/31/1999 through 9/25/2020

# MEDIAN POLISH: A METHOD FOR DECOMPOSING A TWO-WAY TABLE

Iteratively remove the median values from the columns and then the rows to decompose a two-way table into 4 components: overall median, row effects, column effects, and residuals

**Input**

| | Jan | Feb | Mar | Apr | ... |
|---|---|---|---|---|---|
| **2000** | | | | | |
| **2001** | | | | | |
| **2002** | | Rail traffic volumes by month and year | | | |
| **2003** | | | | | |
| **2004** | | | | | |
| **2005** | | | | | |
| **2006** | | | | | |
| **2007** | | | | | |
| **...** | | | | | |

**Output**

**Residuals**

**Row Effects (e.g., yearly trend)**

**Column Effects (e.g., monthly seasonality)**

**Overall Median**

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**Rail Traffic Volume = Overall Median + Row Effect + Column Effect + Residuals**

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# INTERMODAL

# RESULTS OF MEDIAN POLISH: AVG WORKDAY INTERMODAL TRAFFIC FOR 249 MONTHS

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Row Effect |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Y2000** | 405 | 735 | 1,160 | 73 | 0 | -55 | -548 | -90 | 0 | 842 | -149 | -214 | -10,980 |
| **Y2001** | 483 | 418 | 1,424 | -611 | -1,060 | -282 | -932 | 77 | -16 | 90 | -22 | -672 | -11,663 |
| **Y2002** | -2,154 | -311 | -699 | 64 | -75 | 1,044 | 8 | 1,046 | 43 | -3,580 | 143 | 46 | -9,883 |
| **Y2003** | 0 | -191 | 577 | 0 | -231 | 0 | 16 | -449 | -75 | 837 | 1,166 | 607 | -8,020 |
| **Y2004** | -1,506 | -1,823 | 120 | -244 | 457 | -215 | 163 | -204 | -147 | 1,286 | 2,095 | 1,181 | -3,986 |
| **Y2005** | -235 | 799 | -1,278 | -443 | -571 | -980 | -467 | 248 | 253 | 1,533 | 1,439 | 1,885 | -1,276 |
| **Y2006** | 32 | -1,039 | -230 | 351 | -17 | 229 | -60 | 757 | 362 | 7 | -734 | -70 | 1,184 |
| **Y2007** | 575 | 1,332 | 800 | -407 | -92 | 872 | 0 | -165 | 257 | -704 | -166 | 55 | 0 |
| **Y2008** | 2,623 | 213 | -275 | 366 | 537 | -1,634 | 1,865 | -1,426 | 1,189 | -1,709 | -3,526 | -7,811 | -1,089 |
| **Y2009** | 3,622 | -516 | 231 | -656 | -809 | -1,794 | 742 | -279 | 650 | 579 | 1,642 | -1,006 | -8,432 |
| **Y2010** | -1,170 | -1,983 | -898 | -1,453 | -131 | -30 | 1,263 | 1,702 | 1,298 | 756 | 634 | 69 | -2,730 |
| **Y2011** | -197 | -71 | 0 | 279 | 531 | -3 | -565 | -393 | -111 | -7 | 22 | 994 | -379 |
| **Y2012** | -473 | -1,028 | 504 | 465 | 269 | 1,567 | 548 | 262 | -248 | -421 | -1,041 | -561 | 1,027 |
| **Y2013** | 13 | 955 | -1,493 | -1,194 | -988 | 89 | -809 | 0 | 55 | 44 | 412 | -46 | 3,507 |
| **Y2014** | -1,215 | -842 | 700 | 874 | 564 | 753 | -235 | -44 | 58 | 283 | -665 | -920 | 5,840 |
| **Y2015** | -1,570 | -5,281 | 2,351 | 2,442 | 1,350 | 1,484 | 563 | 670 | -548 | -1,537 | -2,292 | -3,261 | 7,059 |
| **Y2016** | 2,264 | 2,332 | -383 | 55 | 456 | -71 | -1,052 | -375 | -1,220 | -758 | 384 | 2,085 | 5,459 |
| **Y2017** | -81 | 621 | -968 | -1,134 | 81 | 384 | -628 | 200 | -1,676 | -568 | 195 | 2,170 | 7,857 |
| **Y2018** | -1,126 | 976 | -122 | -472 | 519 | 1,218 | 213 | 73 | -1,136 | -978 | -870 | 1,121 | 9,598 |
| **Y2019** | 3,018 | 3,264 | 2,049 | 427 | 23 | 377 | -40 | -10 | -1,356 | -2,390 | -2,044 | -1,416 | 6,548 |
| **Y2020** | 1,919 | 0 | -3,506 | -7,315 | -5,547 | -1,928 | 1,038 | 3,017 | 3,739 | NA | NA | NA | 5,192 |
| **Column Effect** | -2,360 | -1,240 | -1,133 | -54 | 65 | 942 | -80 | 2,070 | 1,976 | 3,188 | 645 | -2,413 | **45,932** |

Source: Association of American Railroads, "Weekly Railroad Traffic, Intermodal, Week Ending 12/31/1999 – 9/25/2020. Data was converted into average workday (M-F) volume based on the number of workdays per month by year. If a week split a month, then the traffic was apportioned to both months based on the number of workdays. For example, for the week ending 8/4/2000 four-fifths of the traffic that week was assigned to August and one-fifth to July. The total for July was then divided by 21 working days and August by 23 working days. No adjustment was made for holidays since the impact by traffic varies significantly by holiday (e.g., less freight moves on Christmas Day than on Labor Day). The Column Effects should filter out holiday impacts. Median Polish done in R 3.6.3
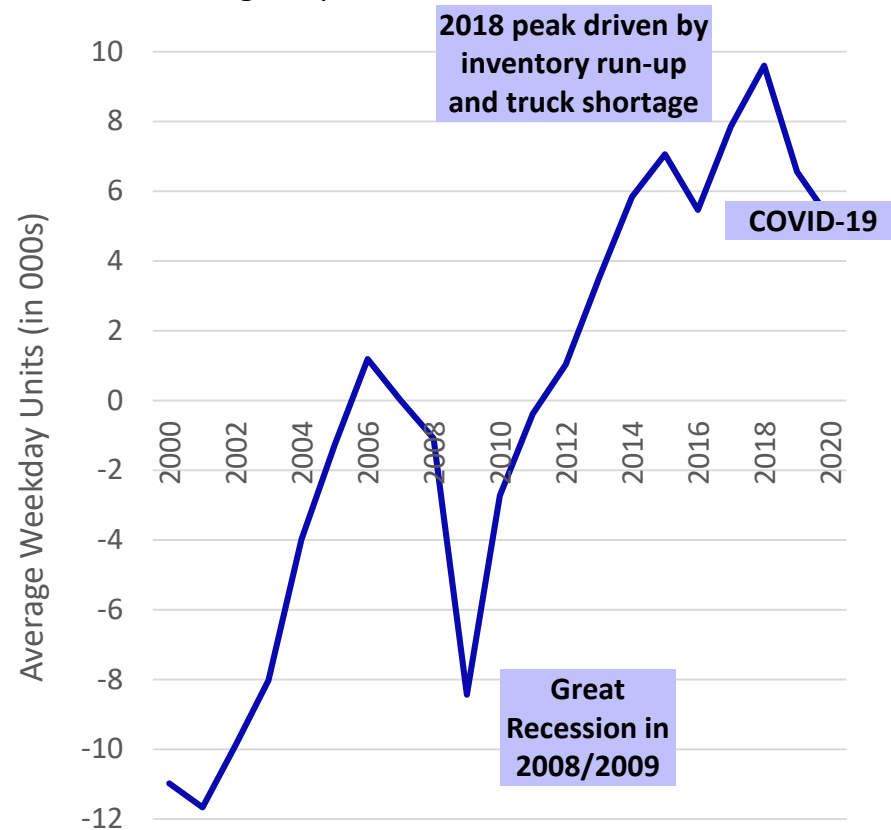
# ROW EFFECTS (TREND) REFLECT STRONG GROWTH IN INTERMODAL VOLUMES

Intermodal has increased from about 24% below the overall median in 2000 to a peak of 21% above the overall median in 2018. Possible reasons for growth include increased demand for products moved by intermodal, shifts from carload to intermodal, and gain of share from trucks
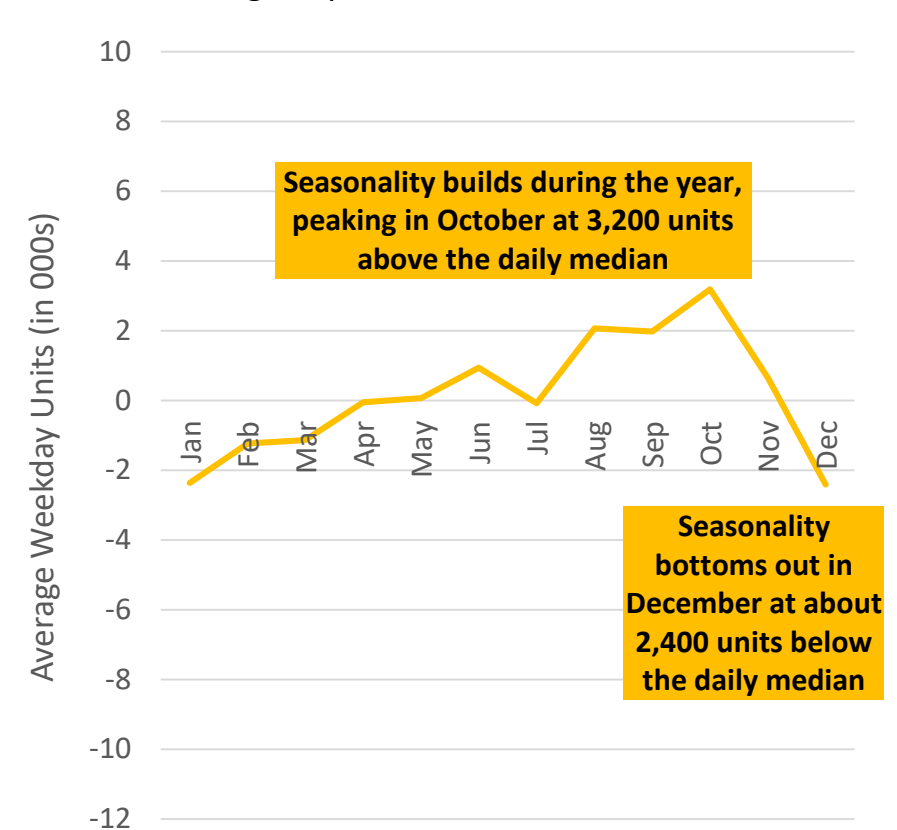
**Row Effects: Trend for Daily Intermodal Units**
Jan 2000 through Sept 2020

**2018 peak driven by inventory run-up and truck shortage**

**COVID-19**

**Great Recession in 2008/2009**

**Column Effects: Seasonality for Daily Intermodal Units**
Jan 2000 through Sept 2020

**Seasonality builds during the year, peaking in October at 3,200 units above the daily median**

**Seasonality bottoms out in December at about 2,400 units below the daily median**
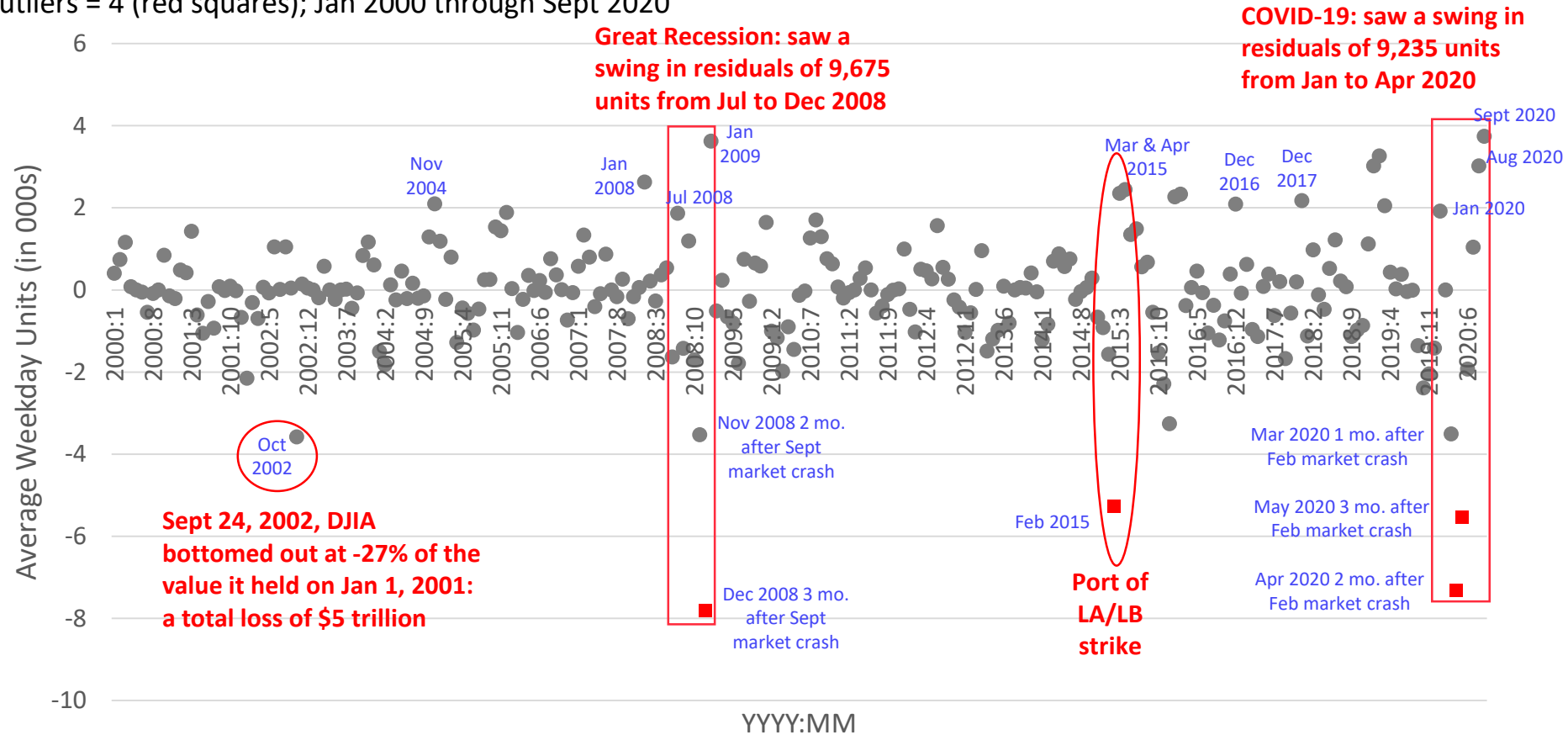


Association of American Railroads, "Weekly Railroad Traffic, Intermodal, Week Ending 12/31/1999 – 9/25/2020. Data was converted into average workday (M-F) volume based on the number of workdays per month by year. If a week split a month, then the traffic was apportioned to both months based on the number of workdays. For example, for the week ending 8/4/2000 four-fifths of the traffic that week was assigned to August and one-fifth to July. The total for July was then divided by 21 working days and August by 23 working days. No adjustment was made for holidays since the impact by traffic varies significantly by holiday (e.g., less freight moves on Christmas Day than on Labor Day). The Column Effects should filter out holiday impacts

# INTERMODAL TRAFFIC DECLINES FOR GREAT RECESSION AND COVID-19 ARE SIMILAR

Four residuals are statistically considered as outliers: one during the Great Recession; one during a Port of LA/LB strike, and two during COVID-19. September 2020, the largest positive residual, was reported by the AAR as the "fourth best intermodal month in history"[1] due to inventory replenishment

**Residuals for Average Workday Intermodal Containers and Trailers**
Outliers = 4 (red squares); Jan 2000 through Sept 2020



Great Recession: saw a swing in residuals of 9,675 units from Jul to Dec 2008

COVID-19: saw a swing in residuals of 9,235 units from Jan to Apr 2020

Sept 2020
Aug 2020
Jan 2020
Nov 2004
Jan 2008
Jan 2009
Jul 2008
Mar & Apr 2015
Dec 2016
Dec 2017

Oct 2002

Sept 24, 2002, DJIA bottomed out at -27% of the value it held on Jan 1, 2001: a total loss of $5 trillion

Nov 2008 2 mo. after Sept market crash

Dec 2008 3 mo. after Sept market crash

Feb 2015

Port of LA/LB strike

Mar 2020 1 mo. after Feb market crash

May 2020 3 mo. after Feb market crash

Apr 2020 2 mo. after Feb market crash

Average Weekday Units (in 000s)

YYYY:MM

Association of American Railroads, "Weekly Railroad Traffic, Week Ending 12/31/1999 – 9/25/2020. Data was converted into average workday (M-F) volume based on the number of workdays per month by year. If a week split a month, then the traffic was apportioned to both months based on the number of workdays. For example, for the week ending 8/4/2000 four-fifths of the traffic that week was assigned to August and one-fifth to July. The total for July was then divided by 21 working days and August by 23 working days. No adjustment was made for holidays since the impact by traffic varies significantly by holiday (e.g., less freight moves on Christmas Day than on Labor Day). The Column Effects should filter out holiday impacts. Outlier based on studentized residual greater than 3. (1) Progressive Railroading, "Intermodal lifted U.S. rail volumes in September," October 8, 2020.
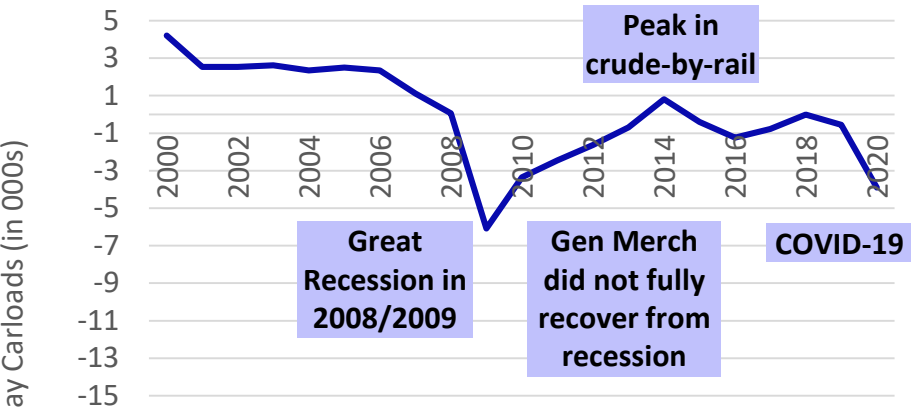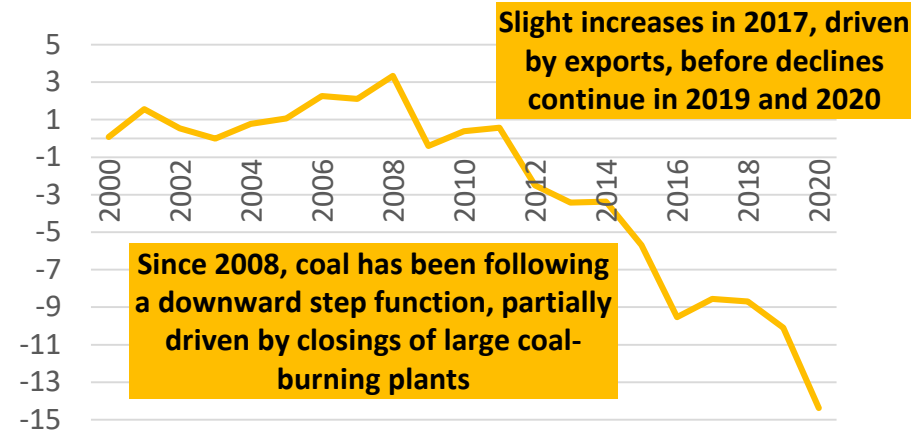
# CARLOAD

# ROW EFFECTS: CARLOAD TRAFFIC CONTINUES TO TREND DOWNWARD

General merchandise and autos saw large declines in the Great Recession, from which they never fully recovered. Coal began a steep drop in 2008. Grain, with flat growth, is the exception
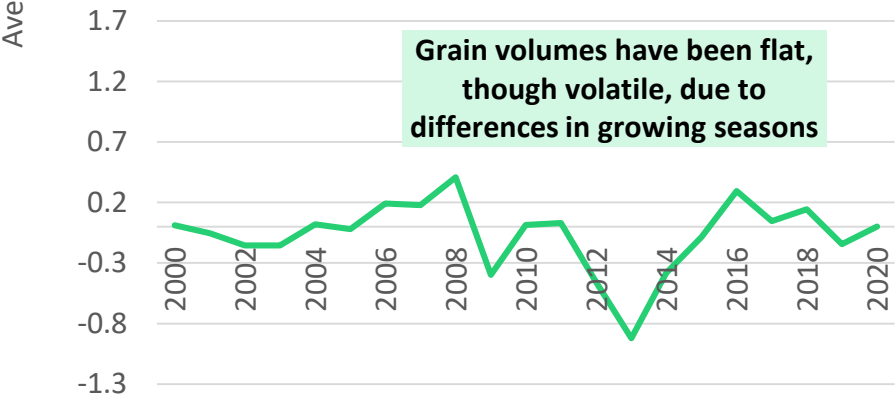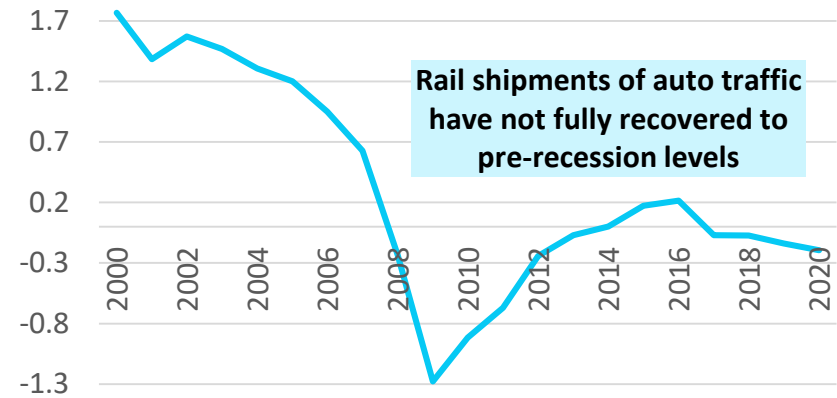
**General Merchandise***
Overall median = 28,284



Peak in crude-by-rail

Great Recession in 2008/2009

Gen Merch did not fully recover from recession

COVID-19

**Coal**
Overall median = 25,586



Slight increases in 2017, driven by exports, before declines continue in 2019 and 2020

Since 2008, coal has been following a downward step function, partially driven by closings of large coal-burning plants

**Grain**
Overall median = 4,319



Grain volumes have been flat, though volatile, due to differences in growing seasons

**Motor Vehicles and Parts**
Overall median = 3,472



Rail shipments of auto traffic have not fully recovered to pre-recession levels
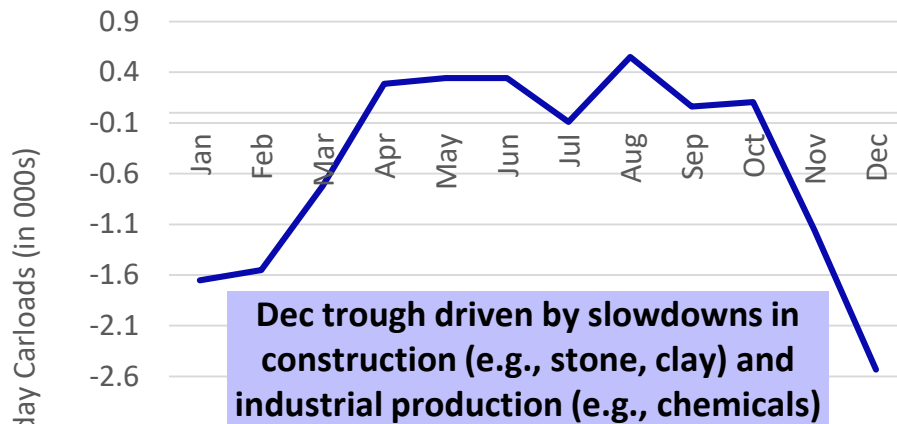
Average Weekday Carloads (in 000s)

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* General Merchandise is all other after grain, coal, automotive and intermodal are removed. Source: AAR "Weekly Railroad Traffic for the weeks ending 12/31/1999 through 9/25/2020. US Energy Information Administration, "U.S. coal production, exports, and prices increased in 2017", February 16, 2018

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# COLUMN EFFECTS: CONSTANT SCALE ALLOWS FOR SEASONALITY COMPARISON

General merchandise slows at the end of the year, while auto shipments slow during summer shutdowns. Coal peaks in August through October while grain peaks in October
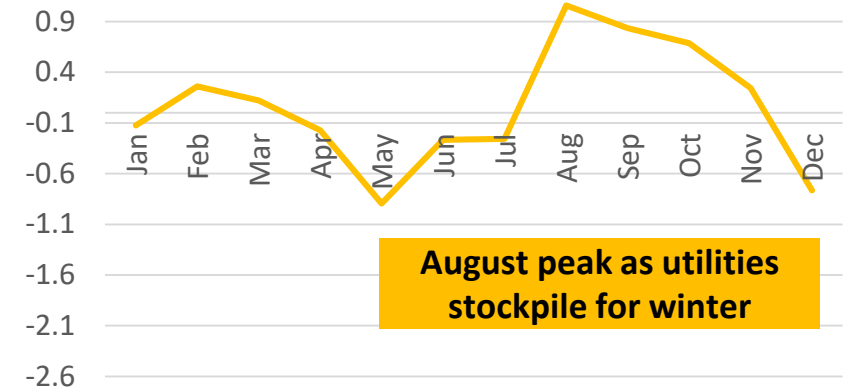
**General Merchandise***
August Peak +615, December Trough -2530

**Coal**
August Peak +1072, May Trough -893

**Grain**
October Peak +490, June Trough -261
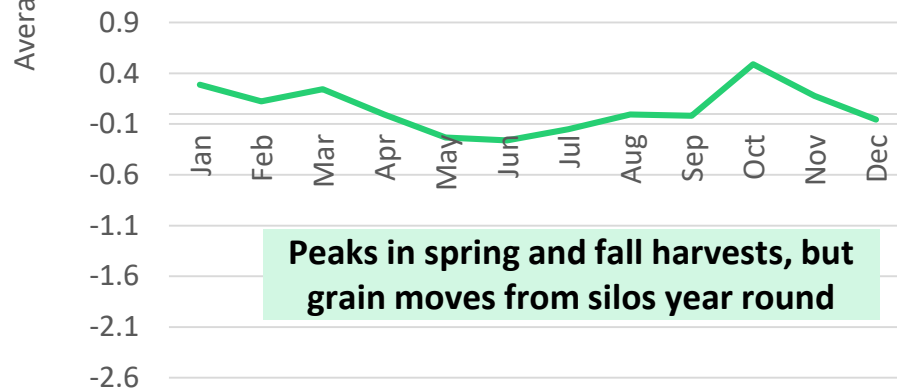
**Motor Vehicles and Parts**
March Peak +158, July Trough -764
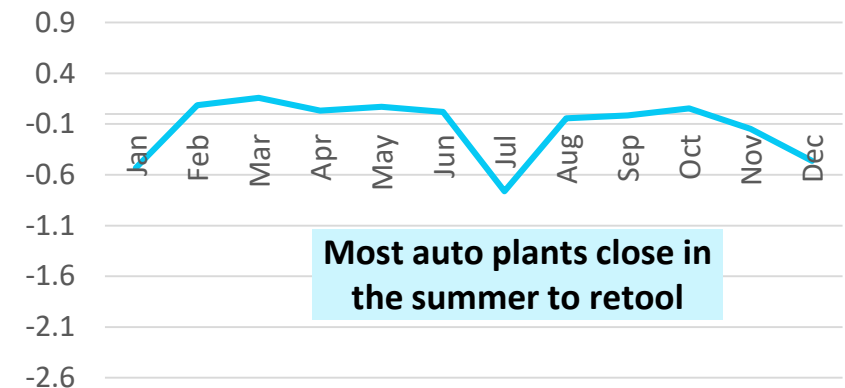


Dec trough driven by slowdowns in construction (e.g., stone, clay) and industrial production (e.g., chemicals)

August peak as utilities stockpile for winter

Peaks in spring and fall harvests, but grain moves from silos year round

Most auto plants close in the summer to retool

Average Weekday Carloads (in 000s)

* General Merchandise is all other after grain, coal, automotive and intermodal are removed. Source: AAR "Weekly Railroad Traffic for the weeks ending 12/31/1999 through 9/25/2020

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# GEN MERCH HAD SWINGS OF 8,150 DAILY CARS IN 2008 AND 5,500 IN 2020

Four residuals are statistically considered as outliers: two during the Great Recession and two during COVID-19. General merchandise does not show the same inventory replenishment-driven bounce back seen in intermodal

**Residuals for Average Workday General Merchandise\* Carloads**
Outliers = 4 (red squares); Jan 2000 through Sept 2020



COVID-19: saw a swing in residuals of 5,537 carloads from Jan to May 2020

Great Recession: saw a swing in residuals of 8,145 carloads from Jul to Dec 2008

Jan & Feb 2020

Mar 2020

Sept 2020

Jul 2008

Oct 2008

May 2020

Nov 2008

Dec 2008

Outliers during the Great Recession are negative while outliers during COVID-19 are positive. This is due to timing. In 2008, there were nine normal months before the late Sept market crash, leading to three months of reduced traffic. During COVID-19, the market crash was in February, so Jan, Feb and part of March were relatively good compared to Apr through Sept
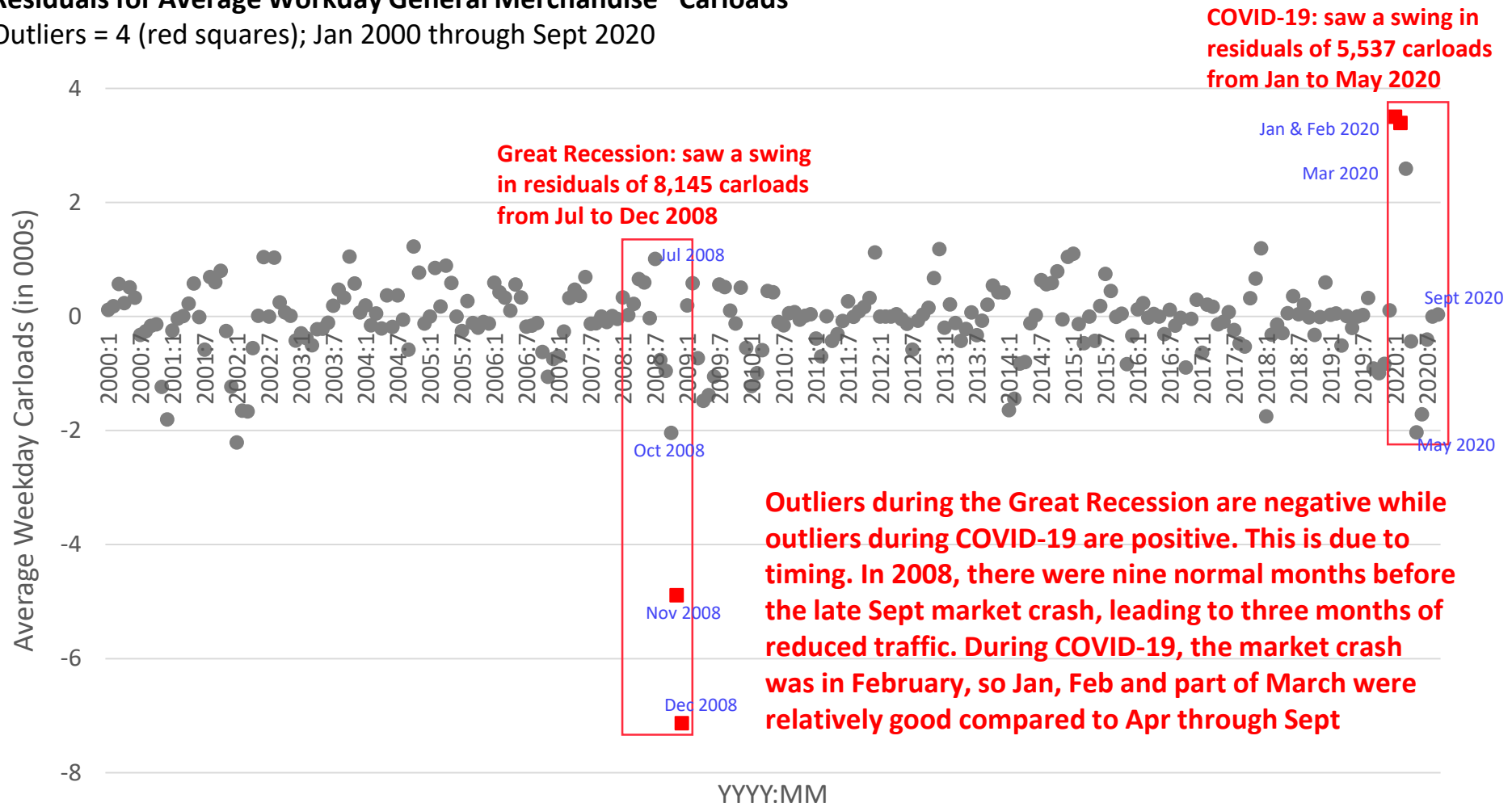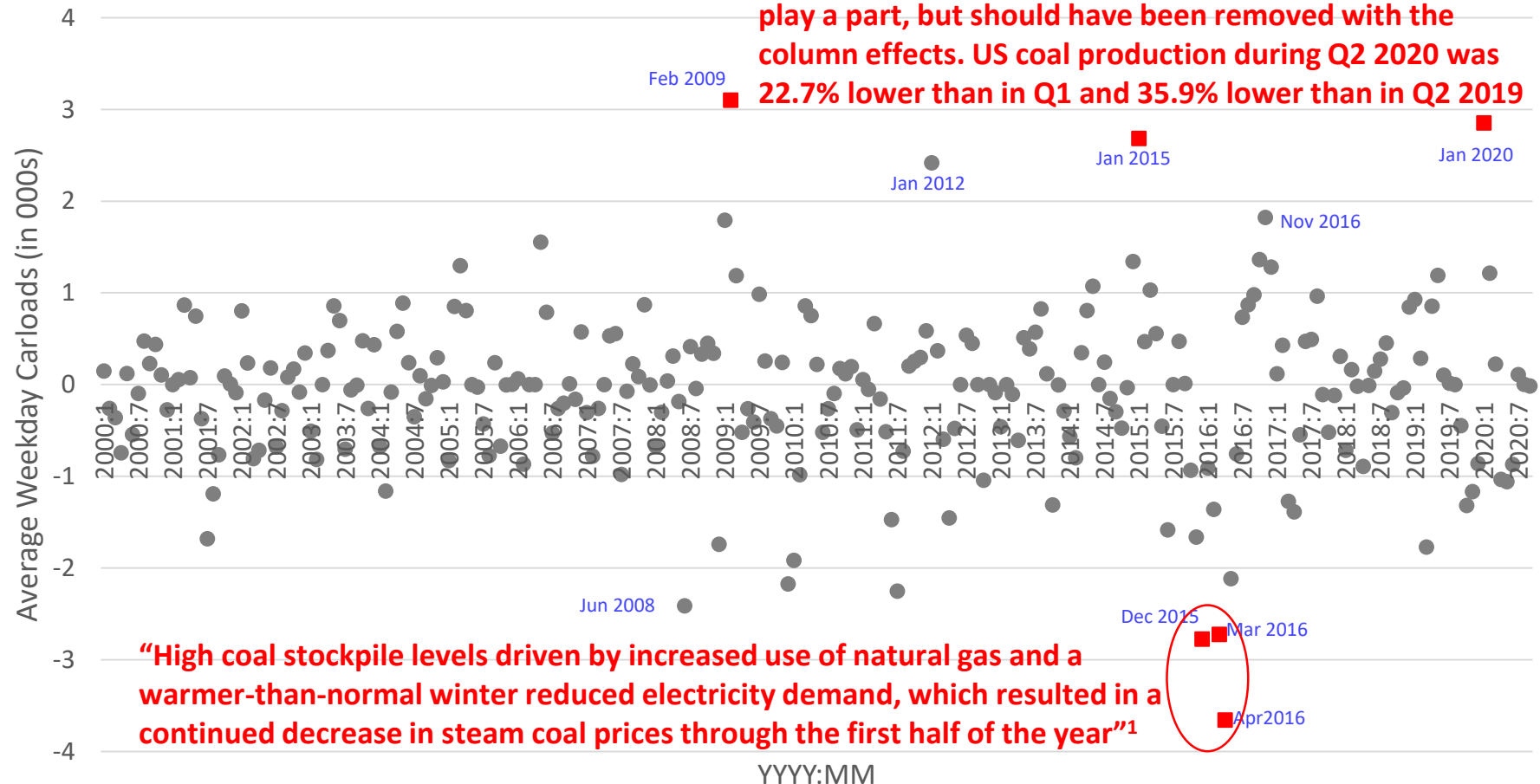
Average Weekday Carloads (in 000s)

YYYY:MM

\* General Merchandise is all other after grain, coal, automotive and intermodal are removed. Source: AAR "Weekly Railroad Traffic for the weeks ending 12/31/1999 through 9/25/2020. Outlier based on studentized residual greater than 3

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# COAL HAD LARGE DECLINES IN 2016, DRIVEN BY LOWER DEMAND

Coal usage is impacted both by domestic plant closures and by reductions in exports. The rapid decline in coal demand caused six residuals to be statistical outliers, the most of any commodity group studied

**Residuals for Average Workday Coal Carloads**
Outliers = 6 (red squares); Jan 2000 through Sept 2020

Coal is steadily declining, so months early in the year are often higher than the annual median. Seasonality could play a part, but should have been removed with the column effects. US coal production during Q2 2020 was 22.7% lower than in Q1 and 35.9% lower than in Q2 2019



"High coal stockpile levels driven by increased use of natural gas and a warmer-than-normal winter reduced electricity demand, which resulted in a continued decrease in steam coal prices through the first half of the year"[1]
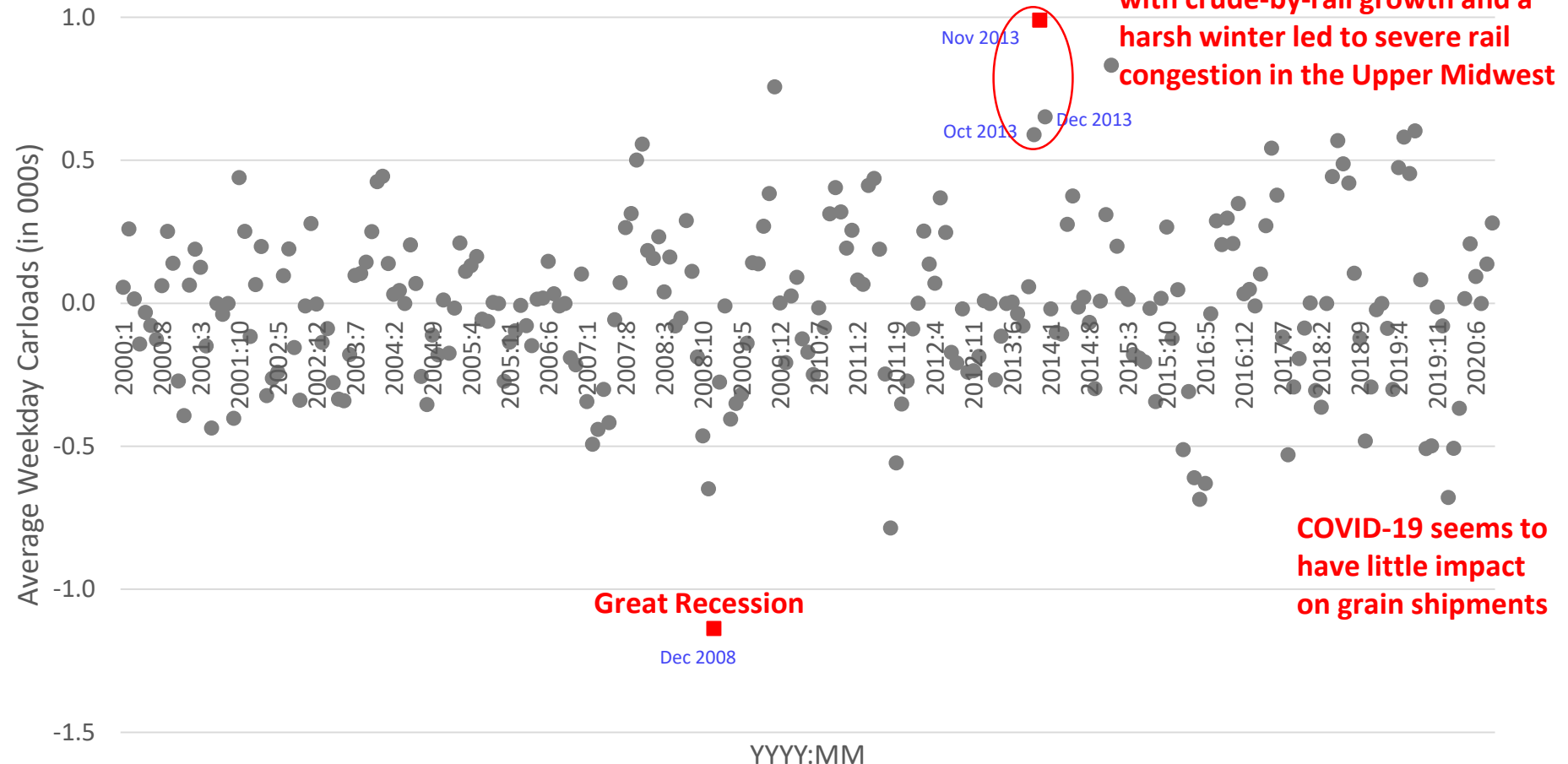
Source: AAR "Weekly Railroad Traffic for the weeks ending 12/31/1999 through 9/25/2020. Outlier based on studentized residual greater than 3. (1) US Energy Information Administration, "Coal production declines in 2016, with average coal prices below their 2015 level," Jan 9, 2017.  US EIA,  "Quarterly Coal Report," October 1, 2020

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# GRAIN HAD THE FEWEST OUTLIERS OF ALL THE GROUPS STUDIED

There are large fluctuations in grain harvests from year to year, but there appears to be fewer outside events impacting grain over the past 20 years than other commodity groups studied

**Residuals for Average Workday Grain Carloads**
Outliers = 2 (red squares); Jan 2000 through Sept 2020



**Winter of 2013/2014 saw a large grain harvest, which combined with crude-by-rail growth and a harsh winter led to severe rail congestion in the Upper Midwest**

Nov 2013
Oct 2013    Dec 2013

**COVID-19 seems to have little impact on grain shipments**

**Great Recession**
Dec 2008

YYYY:MM

Average Weekday Carloads (in 000s)

# MOTOR VEHICLES AND PARTS SEE VOLATILITY DURING ECONOMIC DOWNTURNS

Auto shipments have had two very bad months during the COVID-19 economic fallout, creating two outliers.
The traditional "summer shutdown" has changed, creating many large residuals in July as seasonality changed

**Residuals for Average Workday Motor Vehicles and Parts Carloads**
Outliers = 3 (red squares); Jan 2000 through Sept 2020



Source: AAR "Weekly Railroad Traffic for the weeks ending 12/31/1999 through 9/25/2020. Outlier based on studentized residual greater than 3. Phoebe Wall Howard, "UAW workers may want to wait to make summer vacation plans," Detroit Free Press, May 13, 2020
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