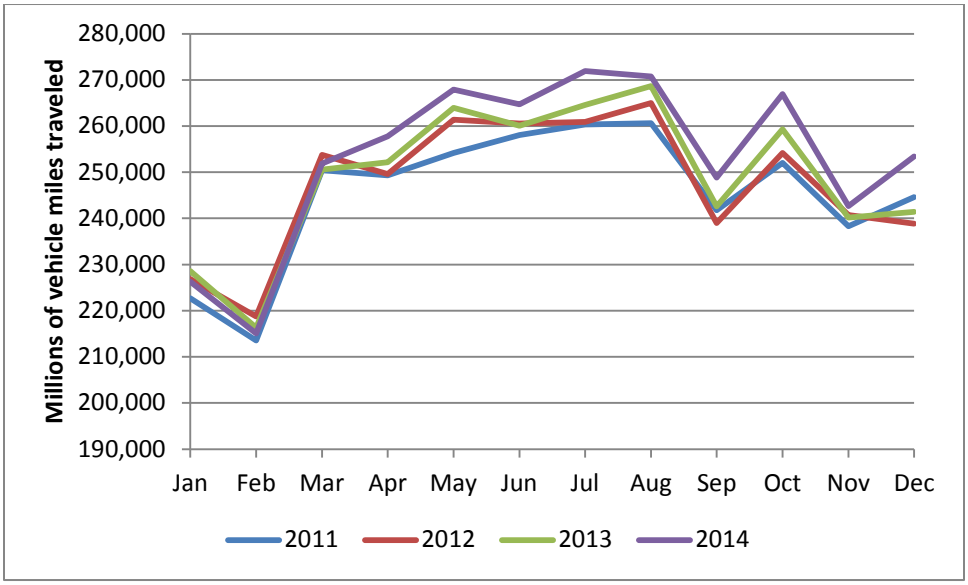
Seasonally Adjusting Vehicle Miles Traveled

Vehicle-miles traveled (VMT) are key data for highway planning and management, and a common measure of roadway use. Along with other data, VMT are often used in estimating congestion, air quality, and potential gas-tax revenues, and can provide a general measure of the level of the nation's economic activity. Many of these applications require an understanding of how much change in VMT is due to recurring fluctuations rather than other causes. Some fluctuations are due simply to the number of days in a month, while other fluctuations are due to seasonal changes in driving patterns. To distinguish recurring fluctuations from underlying changes, the Bureau of Transportation Statistics (BTS) developed a method for seasonally adjusting monthly VMT estimates.

Seasonal adjustment is the process of estimating and removing movement in a time-series caused by regular seasonal variation in activity[1]. VMT tend to be highly seasonal with month-to-month movement in VMT being similar across years. VMT reach an all-time low over the calendar year in February; rise sharply in March; continue to rise, albeit at a slower rate, through the summer months until peaking in August. VMT decline through the Fall and Winter but not continuously, because they rise in October and to a lesser extent in December before reaching the all-time calendar year low in February. (See Figure 1)

Figure 1. Vehicle Miles Traveled, 2010-2014



Source: Data provided by U.S. Department of Transportation (U.S. DOT) Federal Highways Administration (FHWA) to the U.S. DOT, Bureau of Transportation Statistics. Data collected by FHWA for their monthly *Traffic Volume and Trends* report: http://www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm.

[1] For more information on seasonal adjustment, see *Seasonally-Adjusted Data: What it Really Means*, U.S. Department of Transportation, Bureau of Transportation Statistics, as of 3/13/2015 http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/subject-areas/economics_and_finance/deseasonalized_data_meaning

The seasonal movement in VMT makes it difficult to see underlying changes in the data. "Real" differences, which are differences brought about by non-seasonal changes in the data, can be measured only from a seasonally adjusted data series. With a seasonally adjusted data series, data in one month can be compared to data in any other month, and the entire series can be ranked to find highs and lows.

BTS developed a model to seasonally adjust total VMT[2] from January 2000 to present (November 2014). In creating the model, BTS looked into potential calendar effects (trading days and holidays) and data outliers. Both calendar effects and data outliers make it difficult to uncover regular seasonal movement. Calendar effects often introduce additional movement in the time series, and data outliers may disrupt regular movement altogether. Statisticians therefore control for the effects of both, when necessary.

Trading day effects result from the differences in the number of days in the month across months and the number of times each day of the week occurs in the month between years. For instance, January 2012 contains five Sundays while January 2013 contains only four. The varying number of specific weekdays in a month makes it difficult to analyze a time series properly when underlying weekly periodicity exists in the data itself. Underlying weekly periodicity exists when activity, such as travel, is higher on specific days of the week than others. VMT are known to be collectively different by day of week. The 2009 National Household Travel Survey shows that vehicle miles traveled are longer, than average, on Wednesday, Thursday, and Friday (and marginally longer than average on Monday) (see Table 1). Therefore one could expect VMT will be larger in a month with more Wednesdays, Thursdays, or Fridays relative to the same month in a different year with fewer Wednesdays, Thursdays, or Fridays. Using the monthly VMT time series, BTS statistically tested and found that the number of specific days of the week significantly impacts the time series[3]. To control for this effect, BTS included a day-of-the-week effect to seasonally adjust VMT.

[2] Total VMT were obtained from the U.S. Department of Transportation, Federal Highways Administration (FHWA). FHWA releases total VMT in their monthly Traffic Volume Trends report: https://www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm

[3] BTS tested whether the number of times each day of the week occurs in a month has a significant impact on observed monthly VMT by creating a model with a day-of-the-week regressor (known as a full trading day regressor) and one without. The two models were compared using Akaike's Information Criterion for finite sample sizes (AICC). The AICC is a common statistic for comparing two models. The model with the smaller AICC is said to fit the data better. The model with the full trading day regressor had a smaller AICC and hence, fits the data better.

Table 1. Daily vehicle miles traveled per household, 2009

Day of week	Daily vehicle miles traveled per household
Sunday	6.13
Monday	8.16
Tuesday	7.69
Wednesday	8.24
Thursday	8.43
Friday	8.51
Saturday	7.23
Average	7.77

Source: Federal Highway Administration, 2009 National Household Travel Survey (NHTS), tabulated by author

Holidays are the second type of calendar effects and have the potential to introduce year-to-year variation in seasonal movements. Holidays introduce year-to-year variation when they affect more than one month. This happens when activity related to the holiday, such as holiday travel, takes place during the days immediately before and/or after the holiday and these days belong to the month prior to or just after the month of the holiday itself. For example, vehicle trips rise above the average number the Friday before Labor Day and remain above the average through Labor Day itself. The days before Labor Day often fall in August while Labor Day occurs in September. Labor Day therefore has the potential to impact both August and September. Holidays such as Easter, Memorial Day, Thanksgiving, and Christmas also have this potential. Easter additionally has the potential to impact more than one month, because it may occur in March in one year but April in another. Other holidays such as Martin Luther King, Jr. Day, President's Day, etc. typically are not considered to have an impact on other months, because they always occur in the same month (unlike Easter) and any holiday related activity tends to occur in the month of the holiday itself. Holidays that affect more than one month are included in the model to seasonally adjust VMT so as to control for the year-to-year variation they induce in seasonal movements.

Holidays associated with a change in VMT only need to be included when the change in VMT spills into the month before or the month after the actual month containing the holiday and the amount of spillage changes year to year. The holidays and the days over which holiday-related travel is thought to occur are listed in Table 2.

Table 2. Holidays with Activity Affecting Months Other than Holiday Month

Holiday	Holiday Travel Period	Months Impacted
Easter	Thursday before to Tuesday after (6 days)	March, April
Memorial Day	Friday before to the Tuesday after (5 days)	May, June
Labor Day	Friday before to Tuesday after (5 days)	August, September
Thanksgiving	Tuesday before to Sunday after (7 days)	November, December
Christmas		
If Christmas falls on a Monday	23rd through the 1st (10 days)	December, January
If Christmas falls on a Tuesday	22nd through the 1st (11 days)	
If Christmas falls on a Wednesday	21st through the 1st (12 days)	
If Christmas falls on a Thursday	23rd through the 4th (13 days)	
If Christmas falls on a Friday	23rd through the 3rd (12 days)	
If Christmas falls on a Saturday	23rd through the 2nd (11 days)	
If Christmas falls on a Sunday	23rd through the 1st (10 days)	

Source: U.S. Department of Transportation, Bureau of Transportation Statistics

Only Labor Day and Thanksgiving were found to affect a month other than the month of the holiday[4]. Christmas is statistically significant when included in the model with Thanksgiving but not when Thanksgiving is excluded from the model. Thanksgiving is significant whether or not Christmas is included[5]. This suggests that Christmas is significant only because it is correlated with Thanksgiving and not because it impacts multiple months.

When Christmas is included with Thanksgiving, Christmas appears to have a negative effect. The model suggests that VMT falls in December and rises in January in years when more of travel days associated with Christmas occur in December than in January. This empirically does not make sense. The American Travel Survey shows that Christmas induces travel and is the second most traveled day over the entire year. The American Travel Survey suggests that Christmas travel occurs within the month of December itself and does not carry over into January. This can be seen in the data, which shows that travel returns to a level below the daily average for the entire year before the end of December. New Year's Day appears to depress travel, beginning on New Year's Day and lasting a few days after[6]. These patterns also can be seen in the 2001 National Household Travel Survey and are present when looking at all travel as well as when looking exclusively at travel by automobile[7]. Because Christmas empirically

[4] The number of days before and after a holiday over which holiday-related travel is thought to occur was expanded and/or contracted to test for all possible increases in VMT associated with the holiday. For instance, the Labor Day travel period was expanded to include the Thursday before. A maximum of seven days before and seven days after was set in expanding the holiday travel period. Holidays that were insignificant remained insignificant when a day was added or subtracted from the holiday travel period.

[5] Labor Day, like Thanksgiving, was found to impact a month other than the month of the holiday when included in the model alone and when included in the model in combination with other holidays.

[6] See "Sunday After Thanksgiving is Heaviest Travel Day of the Year," *Home for the Holidays*, American Travel Survey 1995, U.S. Department of Transportation, Bureau of Transportation Statistics http://apps.bts.gov/publications/1995_american_travel_survey/home_for_the_holidays/index.html

[7] See "U.S. Holiday Travel", *America on the Go*, U.S. Department of Transportation, Bureau of Transportation Statistics, November 2003 http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/america_on_the_go/us_holiday_travel/index.html. Data can be found at:

appears to affect only travel in December, Christmas does not need to be included in the model. Holidays only need to be included when the holiday-related activity spills into the month before or the month after the actual month containing the holiday and the amount of spillage changes year to year.

The specification for the model used to seasonally adjust VMT is shown in Table 3[8].

Table 3. Model for Seasonally Adjusting Vehicle Miles Traveled (VMT)

Model Type (1)	Trans-formation	Trading days / Significance (3)		Holidays (2) / Significance (3)		Outliers	ARIMA(4)
A	None	Day-of-week	***	Labor Day	**	None	(0 1 1)(0 1 1)
				Thanksgiving	*		

(1) A = Additive
(2) Holidays
Labor Day = Friday before to Tuesday after (5 days).
Thanksgiving = Tuesday before to Sunday after (7 days)
(3) Significance
*** = significant at 0.01 level
** = significant at 0.05 level
* = significant at 0.10 level
N/S = not significant at 0.10 level
N/A = not applicable
(4) ARIMA = Autoregressive integrated moving average. ARIMA is a statistical model for describing the relationship between points in a time series. The autoregressive part describes a value in the series in terms of past values (lagged values). The integrated part takes differences between lagged values so as to remove patterns (i.e. trend and seasonality) in the data. The moving average part describes a value in the series in terms of lagged errors. The ARIMA model used for seasonally adjusting VMT was used in X-12 to seasonally adjust the series. More information on X-12 and seasonal adjustment is available from the U.S. Census Bureau X-12-ARIMA Reference Manual http://www.census.gov/ts/x12a/v03/x12adocV03.pdf.

Source: U.S. Department of Transportation, Bureau of Transportation Statistics

Model Results and Implications

The seasonally adjusted data make it possible to see real changes and trends in the data. The seasonally adjusted data can be ranked to find the top month. The top month (between January 2000 and December 2014), for instance, is December 2014. December 2014 ranks lower in the unadjusted series because of seasonal movement. The top unadjusted months are all summer months. VMT tend to be higher in the summer months (except for October 2014) because of a greater number of vacation and recreational trips, and for this reason, the summer months rank the highest prior to seasonal adjustment. (See Table 4)

http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/america_on_the_go/us_holiday_travel/html/figure_01_04_table.html

[8] The U.S. Census Bureau, Time Research Staff provided guidance in developing the model to seasonally adjust VMT.

Table 4. Vehicle Miles Traveled (VMT), January 2000 - December 2014

Unadjusted VMT Rank (millions)

Rank (Unadjusted)	Date	Unadjusted	Adjusted	Rank (Adjusted)
1	Jul-14	271,921	254,990	6
2	Aug-07	271,401	253,606	14
3	Aug-14	270,721	254,120	9
5	May-14	267,895	254,014	10
6	May-07	267,646	253,574	15
7	Jul-07	267,179	252,660	20
8	Jul-05	267,025	251,019	26
9	Oct-14	266,955	256,347	2
10	Jul-04	265,969	247,298	89

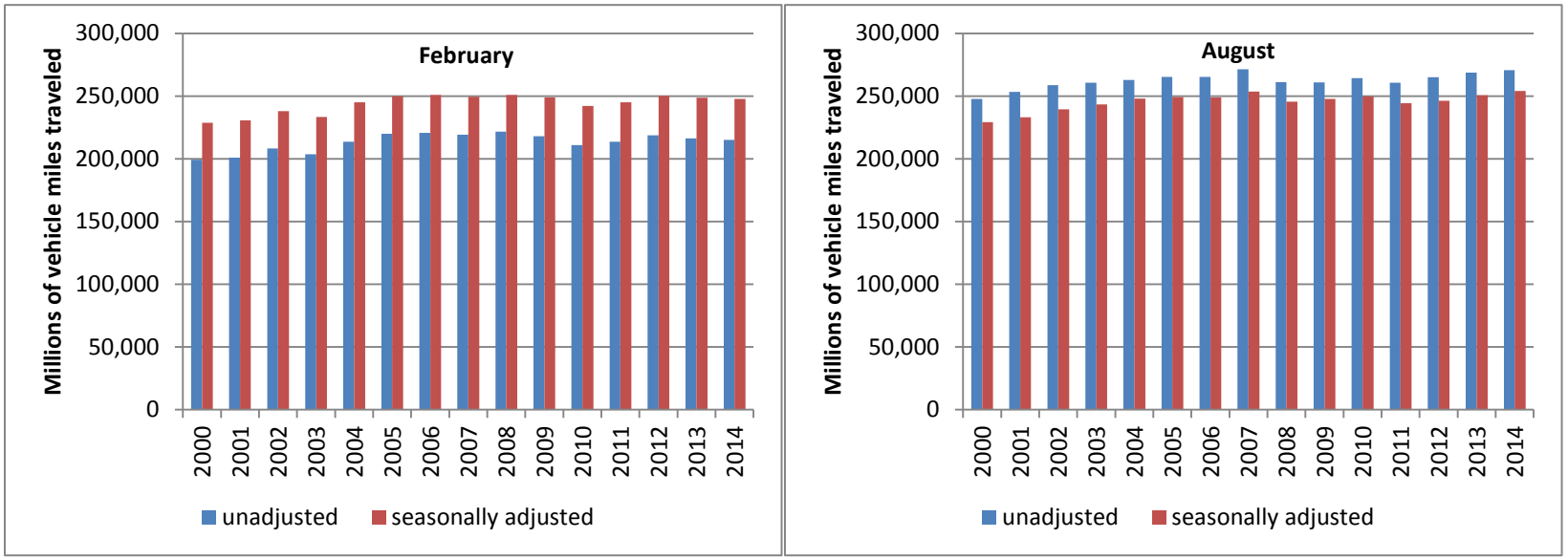
Seasonally Adjusted VMT Rank (millions)

Rank (Adjusted)	Date	Adjusted	Unadjusted	Rank (Unadjusted)
1	Dec-14	258,219	253,392	63
2	Oct-14	256,347	266,955	9
3	Jan-06	255,642	233,302	142
5	Sep-14	255,006	248,860	88
6	Jul-14	254,990	271,921	1
7	Mar-07	254,536	259,740	41
8	Sep-07	254,127	246,050	93
9	Aug-14	254,120	270,721	3
10	May-14	254,014	267,895	5

Source: Bureau of Transportation Statistics, U.S. Department of Transportation

Seasonal movement in VMT results in August ranking the highest and February the lowest within a calendar year (see figure 1). The seasonally adjusted data provide a different picture of travel in these two months. After removing seasonality, VMT in February are close to VMT in August and in a few years (2005, 2006, 2008, 2009, 2011, and 2012), VMT is greater than VMT in August (see figure 2).

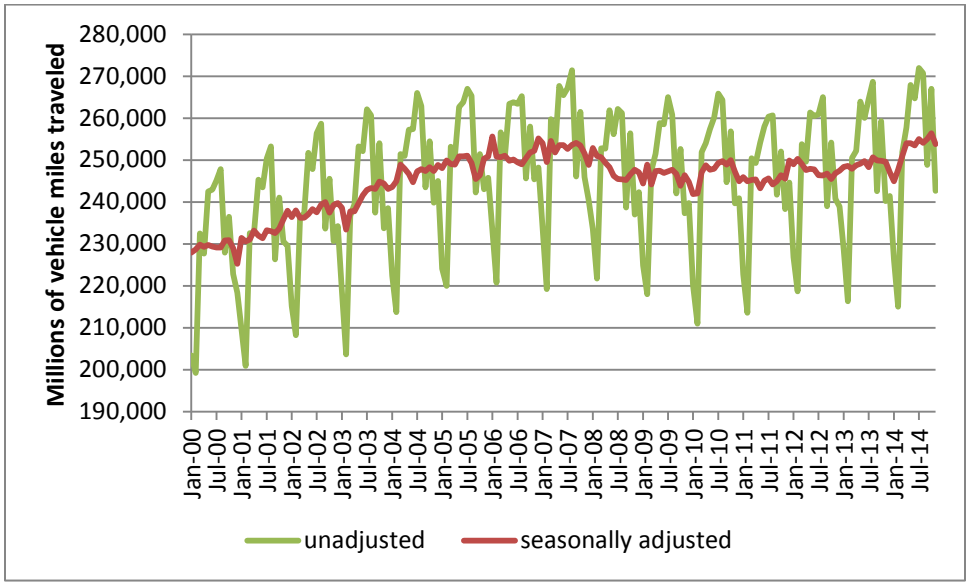
Figure 2. Unadjusted and Seasonally Adjusted Vehicle Miles Traveled in Peak Month (August) and in Lowest Month (February)[1]



Note: August is the peak month prior to adjustment; February is the lowest month prior to adjustment
Source: Unadjusted vehicle miles traveled (VMT) from U.S. Department of Transportation, Federal Highways Administration; VMT seasonally adjusted by the U.S. Department of Transportation, Bureau of Transportation Statistics

The seasonal increase in VMT during the summer months makes it difficult to see the overall trend in the data. The seasonally adjusted series show VMT began to decline after 2006 and leveled off in roughly 2008. VMT began to rise in early 2014 and reached an all-time high in December 2014. (See Figure 3)

Figure 3. Unadjusted and Seasonally Adjusted Vehicle Miles Traveled, January 2000 - December 2014



Source: Unadjusted vehicle miles traveled (VMT) from U.S. Department of Transportation, Federal Highways Administration; VMT seasonally adjusted by the U.S. Department of Transportation, Bureau of Transportation Statistics

The seasonally adjusted VMT shows that VMT only recently recovered from a downward decline that began just prior to the December 2007 –June 2009 recession. The unadjusted data make it difficult to see this recovery because of seasonal fluctuations. This highlights the importance of using seasonally adjusted VMT to understand year-to-year and month-to-month trends and changes in VMT. BTS produces the seasonally adjusted VMT on a two month lag and in sync with the Federal Highways Administration issuance of the Travel Volume Trend report[9]. For example seasonally adjusted VMT for February 2015 will be available in April 2015. Seasonally adjusted VMT is available on the BTS website[10].

[9] http://www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm
[10] http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/subject-areas/economics_and_finance/deseasonalized_data