Is Traffic Pattern in Pennsylvania Changing? Why?

1. Introduction

Pennsylvania Department of Transportation (PennDOT), under its Bureau of Planning and Research (Transportation Planning Division), every year publishes traffic reports about roads. The publication includes numerous types of data and information about traffic conditions. One of the major data included in the publication is the hourly distribution factors of a 24 hours traffic volume of any road that is included in the road system. The road system in the state is categorized into 10 Traffic Pattern Groups, TPG (Table 1). A 24-hour traffic volume factor by total and directional (Dir1 & Dir2) for each hour is also given as shown on Table 2. The hourly factors are useful to estimate the hourly amount of traffic on a given road. The sum of all the factors in the 24 hours adds up to 100% (Table 2). The counting of hours starts from midnight, hence, 12:00 am to 1: 00 am becomes the first hour. In its report, PennDOT provides the hourly factor tables for 10 pattern groups (TPGs).

Analysis of historical hourly factors for each traffic pattern group (TPG) shows significant changes in proportion of the traffic distribution in the 24 hours. In order to see these changes in traffic distribution pattern through time, 10 years (2009 to 2019) of the factor data were acquired from PennDOT publications, and analyzed using python (pandas). Putting these years' factors together, it was possible to see the trend of changes in traffic apportionment factors for each hour of the 24 hours. While a brief observation shows changes in all pattern groups, the focus of this analysis is on TPG1 and TPG2 which include Urban Interstate and Rural Interstate respectively.

The analysis and understanding of such data help traffic engineers, transportation planners, policy makers and so forth to look into the traffic pattern changes through time and make the necessary design or policy changes so that traffic flow is improved and optimized on any road system.

In this short article, a brief description about the data, data analysis method mostly through data visualization, and suggestion about the probable causes of changes are discussed.

2. Data Acquisition

As indicated in the introductory section, data for hourly traffic apportionment factors are published by PennDOT on its annual traffic information report. The traffic pattern group hourly distribution factors are included in the report published since 2009 as a pdf. For this analysis, tables of hourly percentage for each pattern group for the years 2009 through 2019 were collected from the pdf on PennDOT's website. And data were converted to excel files using a pdf to excel converter. Once converted to excel, each table was imported into Pandas' (python) data frame and processed. Processes include but not limited to, data reorganization, cleaning, parsing, additional features derivation and adding other supporting data.

Table 1. Pennsylvania Road System by Traffic Pattern Group

TRAFFIC PATTERN GROUP	*DESCRIPTION*
TPG 1	*URBAN - INTERSTATE*
TPG 2	*RURAL - INTERSTATE*
TPG 3	*URBAN - OTHER PRINCIPAL ARTERIALS*
TPG 4	*RURAL - OTHER PRINCIPAL ARTERIALS*
TPG 5	*URBAN - MINOR ARTERIALS, COLLECTORS, LOCAL ROADS*
TPG 6	*NORTH RURAL - MINOR ARTERIALS*
TPG 7	*CENTRAL RURAL- MINOR ARTERIALS*
TPG 8	*NORTH RURAL - COLLECTORS AND LOCAL ROADS*
TPG 9	*CENTRAL RURAL- COLLECTORS AND LOCAL ROADS*
TPG 10	*SPECIAL RECREATIONAL*

Table 2. Hourly Percentage factors/ values for TPG1 in 2018 in Pennsylvania

TPG 1			
HOUR	**DIR 1**	**DIR 2**	**TOTAL**
1	0.93%	1.09%	1.02%
2	0.72%	0.78%	0.75%
3	0.67%	0.69%	0.69%
4	0.80%	0.78%	0.79%
5	1.26%	1.14%	1.20%
6	2.88%	2.21%	2.58%
7	6.04%	4.17%	5.12%
8	8.35%	5.61%	6.82%
9	7.14%	5.35%	6.14%
10	5.62%	4.90%	5.26%
11	5.18%	4.86%	5.06%
12	5.21%	5.10%	5.22%
13	5.35%	5.34%	5.41%
14	5.44%	5.57%	5.56%
15	5.94%	6.33%	6.14%
16	6.57%	7.77%	7.07%
17	6.91%	8.78%	7.66%
18	6.73%	8.46%	7.44%
19	5.21%	5.97%	5.62%
20	3.82%	4.35%	4.19%
21	3.12%	3.60%	3.46%
22	2.62%	3.05%	2.91%
23	2.04%	2.35%	2.25%
24	1.45%	1.75%	1.64%
TOTAL	**100.00%**	**100.00%**	**100.00%**

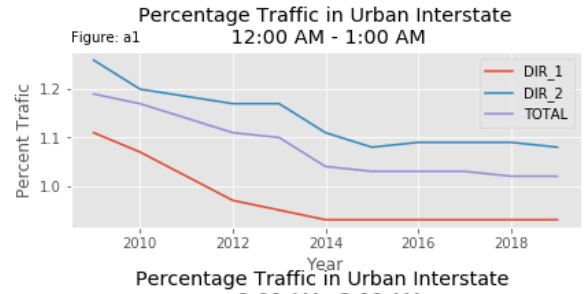
3. Analysis and Observation

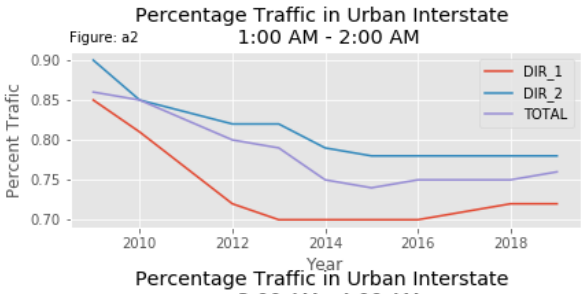
The analysis for this data was mainly done in python, pandas' package. After data was acquired, it was organized and preprocessed. Although all TPG groups are gathered, for this analysis, two of the TPG groups were selected; Urban Interstate and Rural Interstates. Hourly factors in each TPG group were graphed in factor versus year axis for Total factors, Direction-1 and Direction-2 factors for every one hour of the 24 hours. In the graphs, while change was observed in all the hours, the direction and magnitude of change were not the same. Changes in factors of some hours are higher than in others.

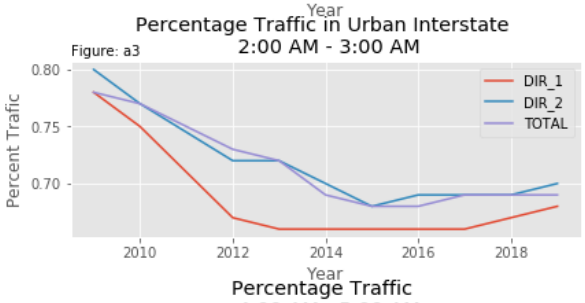
As depicted in both Urban and Rural Interstate factors graphs, in general, a decreasing trend on the off-peak hours (early morning, late night and mid-day) factors were observed for the year that are considered for this analysis. On the other hand, slight increases in the peak hours period were observed (see Figures a1 to a24, Figure b1 to b24) for the Urban Intestate and Rural Interstate roads.

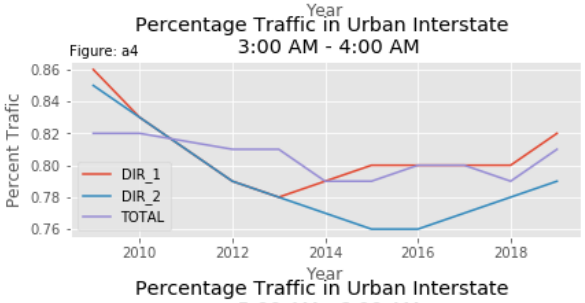
Furthermore, to understand and determine the direction of changes and estimate the magnitude of change, a linear regression model was developed for every hour in both TPG groups, and coefficients of regression lines of change of the factors were calculated. Table of coefficients (slopes) value of change pattern for every hour's factor is shown in Tables 4 and 5. Regression line coefficients for each hour was also graphed (see Figure c1 and d1). Both the tables and graphs show that there is change in the hourly factors in the years 2009 through 2019.

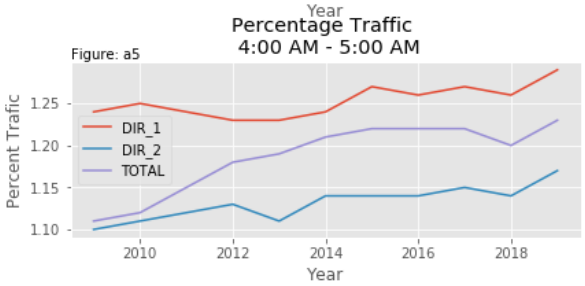
TPG1, Hourly Percentage of Traffic (Urban Interstate)

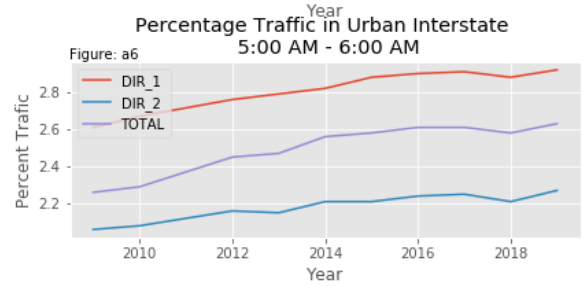


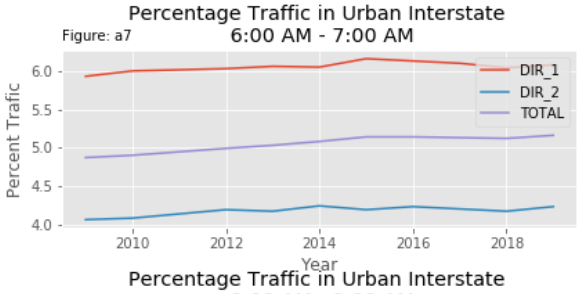


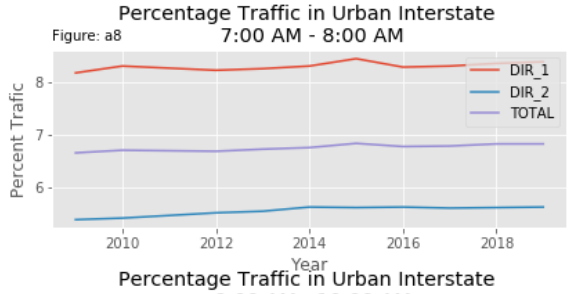


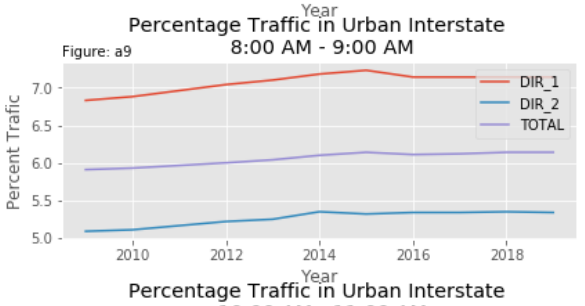


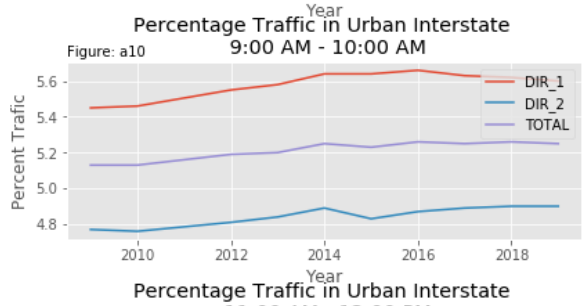


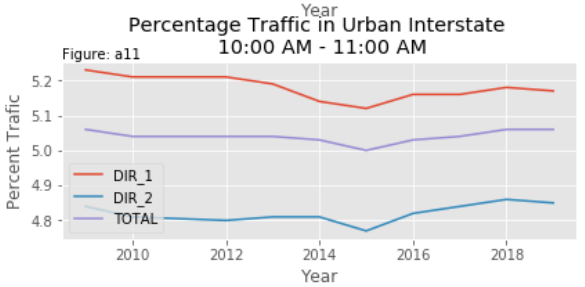


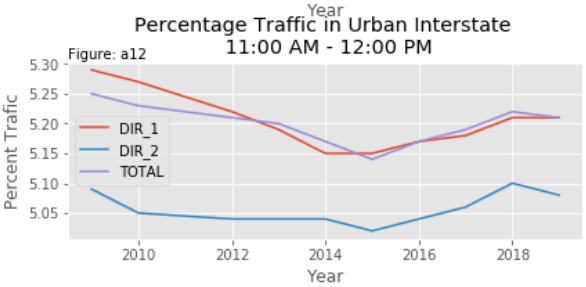












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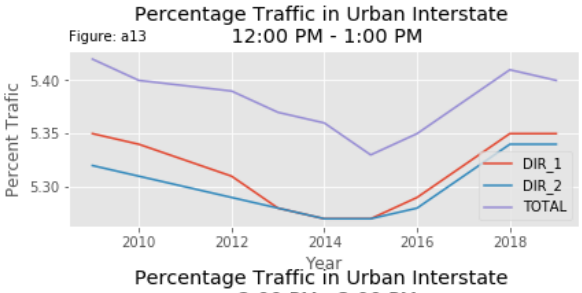

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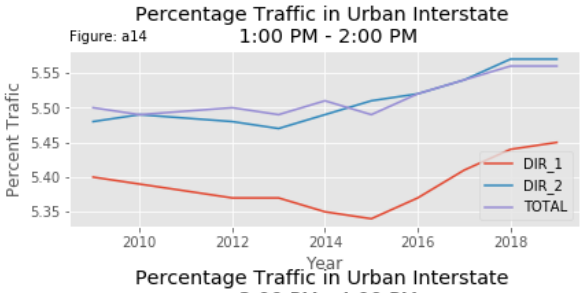

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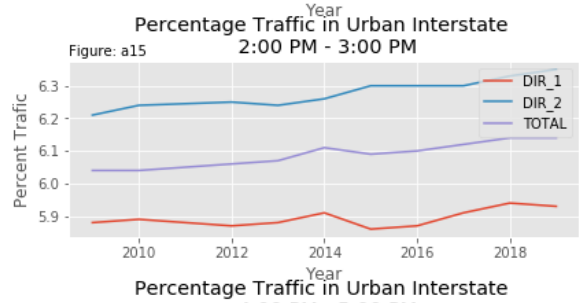

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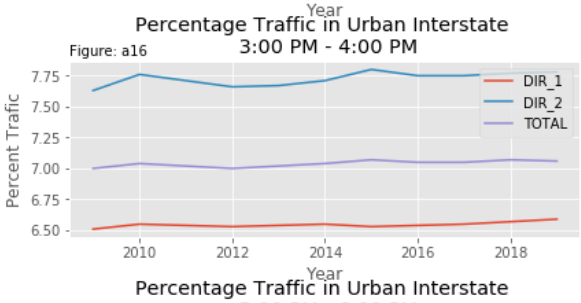

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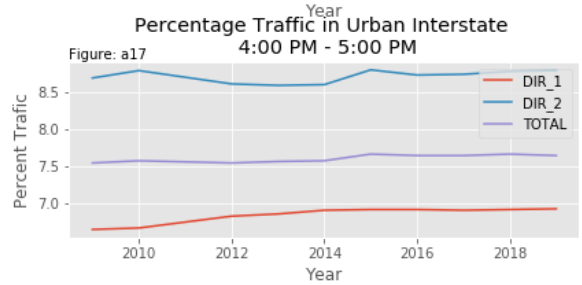

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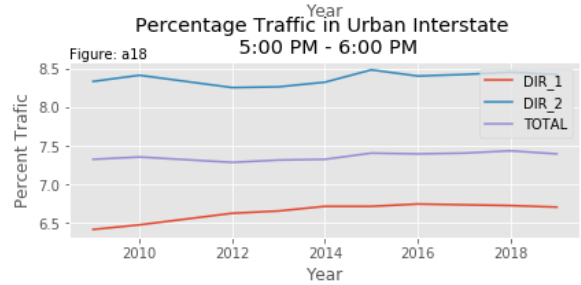

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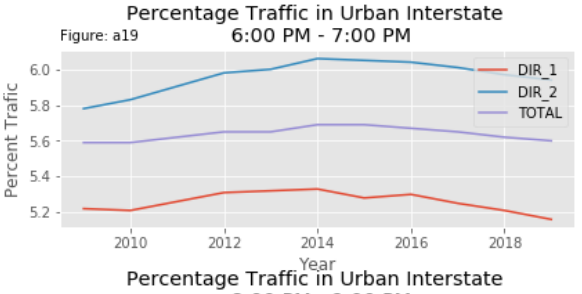

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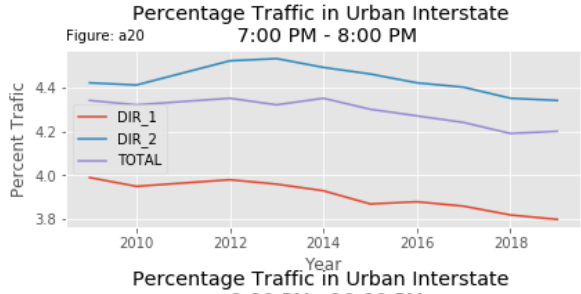

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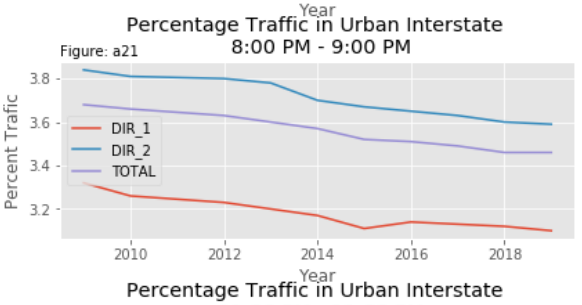

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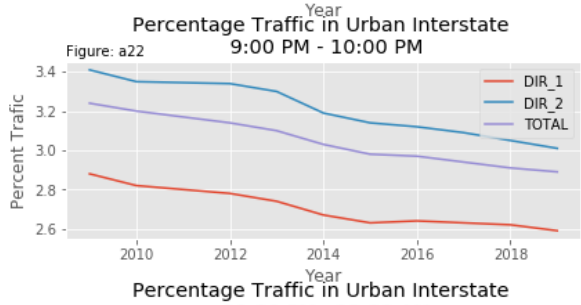

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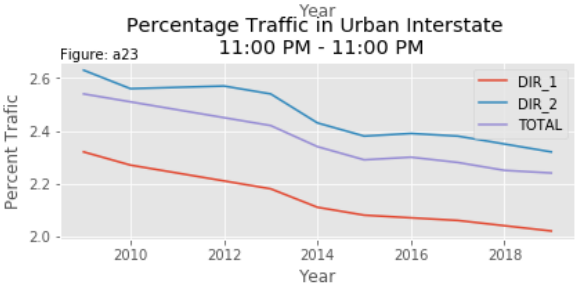

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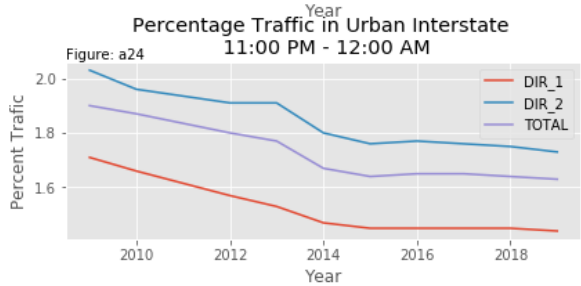
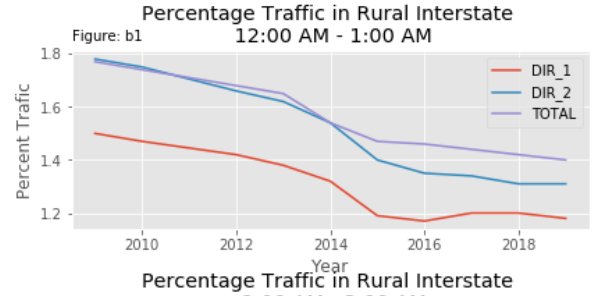
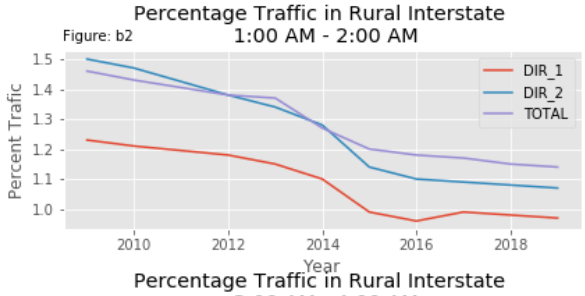
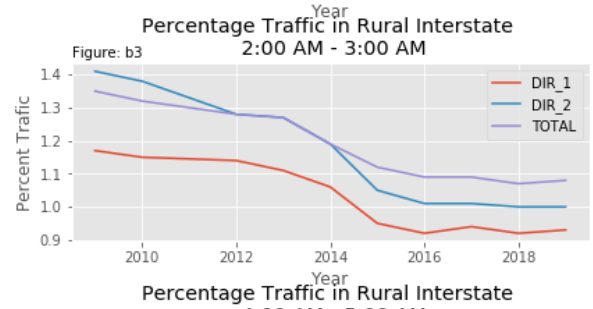
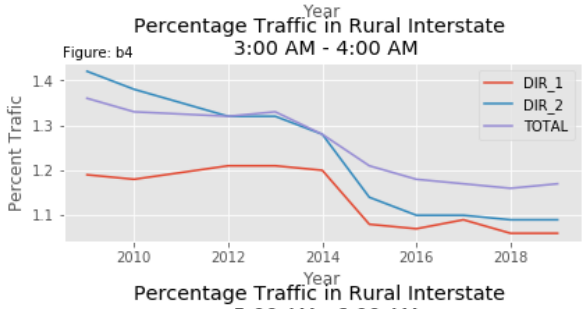


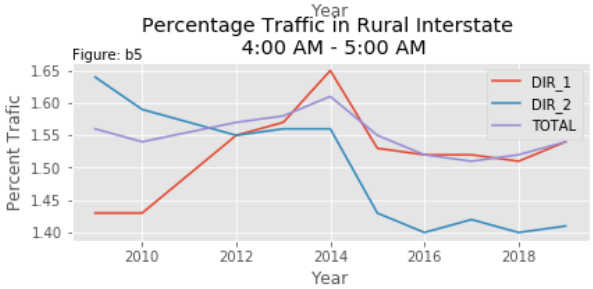
TPG2, Hourly Percentage of Traffic (Rural Interstate)

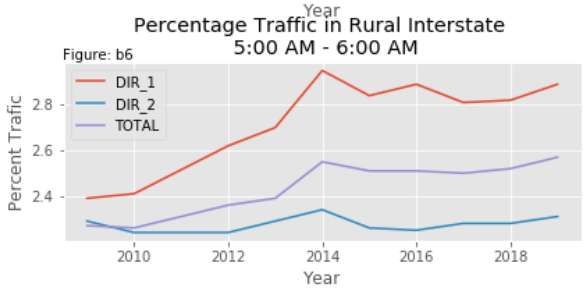


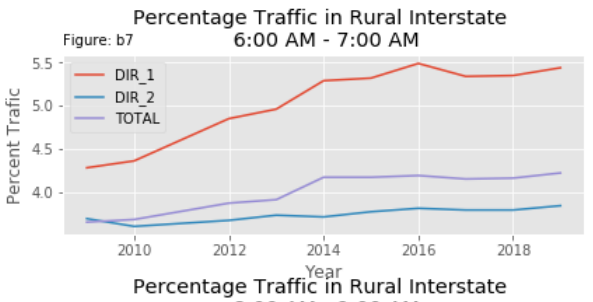


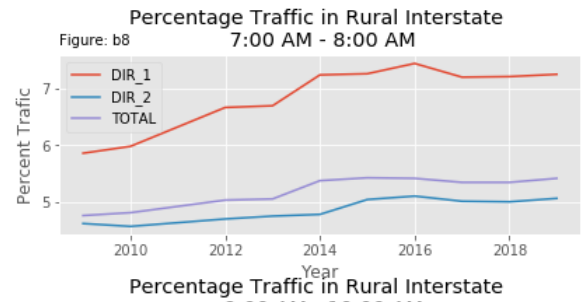


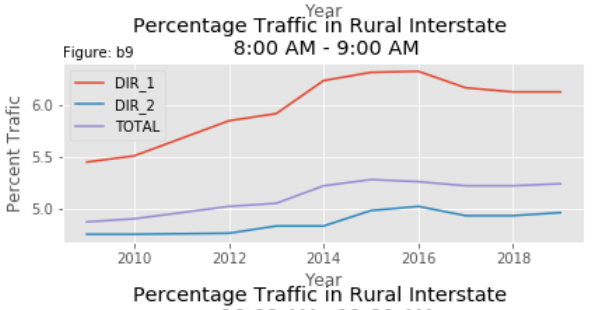


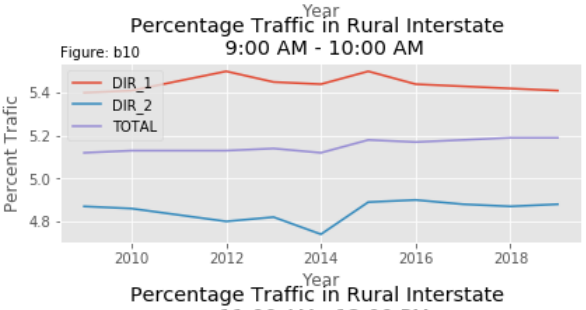


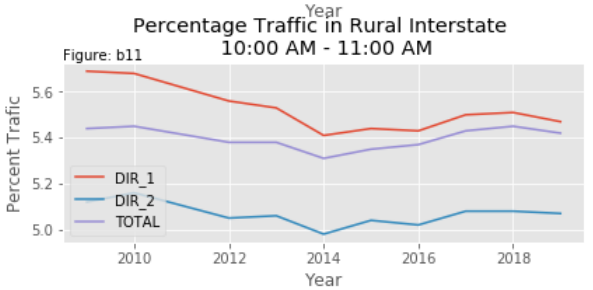


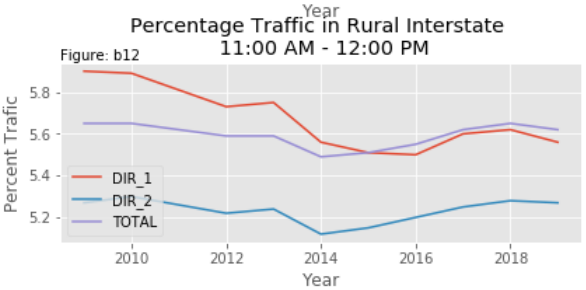












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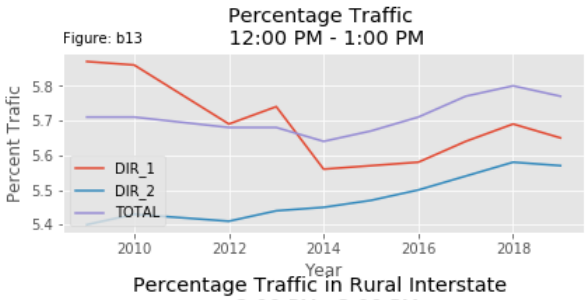

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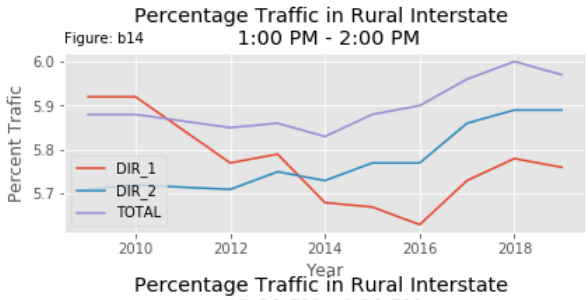

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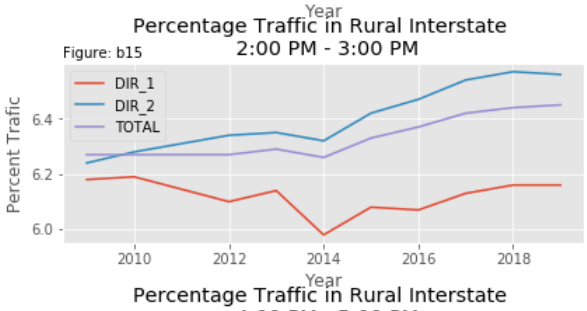

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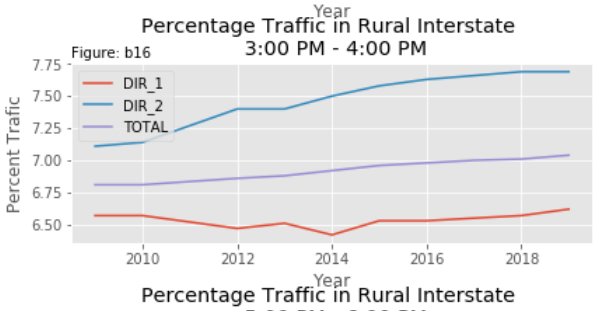

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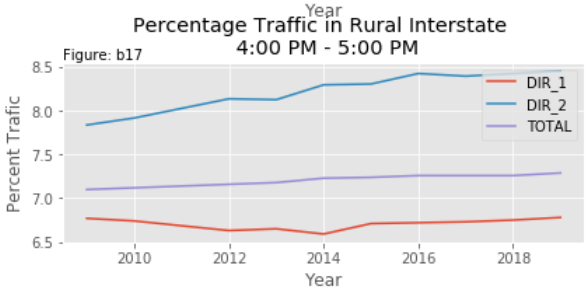

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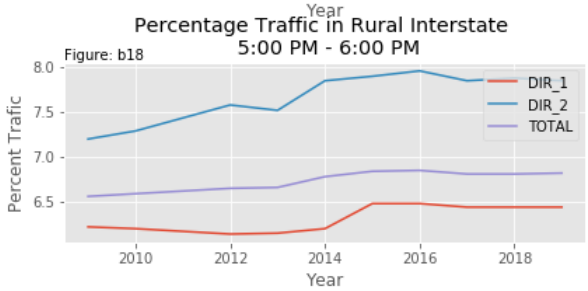

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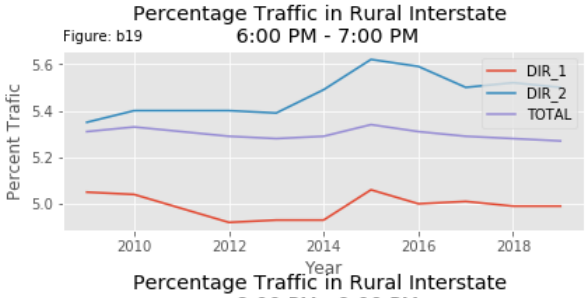

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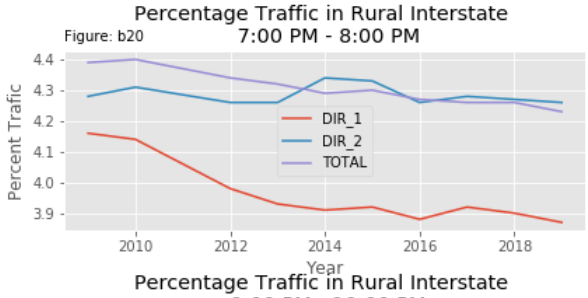

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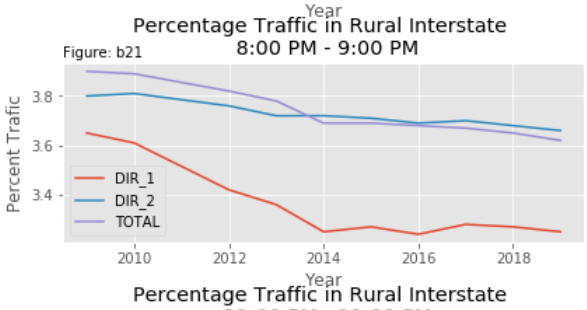


Figure: b22

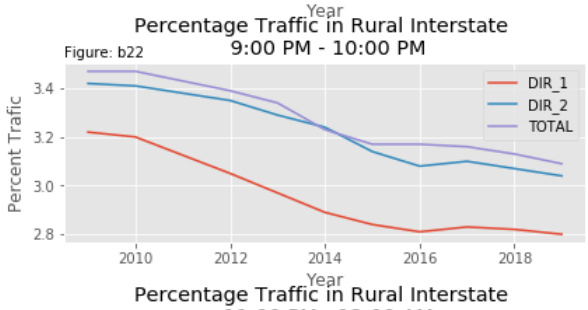


Figure: b23

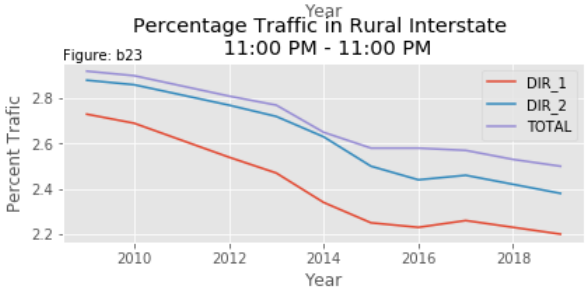


Figure: b24

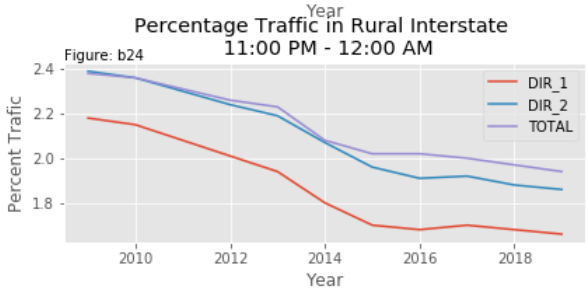


Table 4. Urban Interstate Hourly Factors Regression Coefficients (slopes)

Sequence	Day Time Range	Total Slopes	Dir1 Slopes	Dir2 Slopes
1	12 AM - 01 AM	-0.018	-0.017	-0.017
2	01 AM - 02 AM	-0.011	-0.011	-0.011
3	02 AM - 03 AM	-0.010	-0.009	-0.010
4	03 AM - 04 AM	-0.002	-0.003	-0.006
5	04 AM - 05 AM	0.011	0.004	0.006
6	05 AM - 06 AM	0.038	0.030	0.020
7	06 AM - 07 AM	0.030	0.013	0.014
8	07 AM - 08 AM	0.017	0.016	0.024
9	08 AM - 09 AM	0.025	0.031	0.027
10	09 AM - 10 AM	0.014	0.018	0.015
11	10 AM - 11 AM	0.000	-0.006	0.003
12	11 AM - 12 PM	-0.004	-0.009	0.001
13	12 PM - 01 PM	-0.002	0.000	0.002
14	01 PM - 02 PM	0.007	0.005	0.010
15	02 PM - 03 PM	0.011	0.005	0.013
16	03 PM - 04 PM	0.006	0.005	0.012
17	04 PM - 05 PM	0.013	0.028	0.010
18	05 PM - 06 PM	0.011	0.030	0.013
19	06 PM - 07 PM	0.003	-0.004	0.017
20	07 PM - 08 PM	-0.015	-0.019	-0.010
21	08 PM - 09 PM	-0.024	-0.021	-0.027
22	09 PM - 10 PM	-0.037	-0.028	-0.041
23	10 PM - 11 PM	-0.032	-0.030	-0.031
24	11 PM - 12 AM	-0.029	-0.027	-0.030

Table 5. Rural Interstate Hourly Factors Regression Coefficients (slopes)

Sequence	Day Time Range	Total Slopes	Dir1_Slopes	Dir2_Slopes
1	12 AM - 01 AM	-0.0004	-0.0003	-0.0005
2	01 AM - 02 AM	-0.0003	-0.0003	-0.0005
3	02 AM - 03 AM	-0.0003	-0.0003	-0.0005
4	03 AM - 04 AM	-0.0002	-0.0001	-0.0004
5	04 AM - 05 AM	-0.0001	0.0001	-0.0003
6	05 AM - 06 AM	0.0003	0.0005	-0.0001
7	06 AM - 07 AM	0.0006	0.0014	0.0001
8	07 AM - 08 AM	0.0007	0.0019	0.0005
9	08 AM - 09 AM	0.0004	0.0010	0.0002
10	09 AM - 10 AM	0.0001	0.0000	0.0000
11	10 AM - 11 AM	-0.0001	-0.0003	-0.0001
12	11 AM - 12 PM	-0.0001	-0.0004	-0.0001
13	12 PM - 01 PM	0.0000	-0.0003	0.0001

14	01 PM - 02 PM	0.0001	-0.0003	0.0001
15	02 PM - 03 PM	0.0001	-0.0002	0.0003
16	03 PM - 04 PM	0.0002	-0.0001	0.0007
17	04 PM - 05 PM	0.0002	-0.0001	0.0008
18	05 PM - 06 PM	0.0003	0.0002	0.0010
19	06 PM - 07 PM	0.0000	-0.0001	0.0002
20	07 PM - 08 PM	-0.0001	-0.0003	0.0000
21	08 PM - 09 PM	-0.0003	-0.0005	-0.0002
22	09 PM - 10 PM	-0.0004	-0.0005	-0.0004
23	10 PM - 11 PM	-0.0004	-0.0006	-0.0005
24	11 PM - 12 AM	-0.0004	-0.0006	-0.0006

Figure: c1

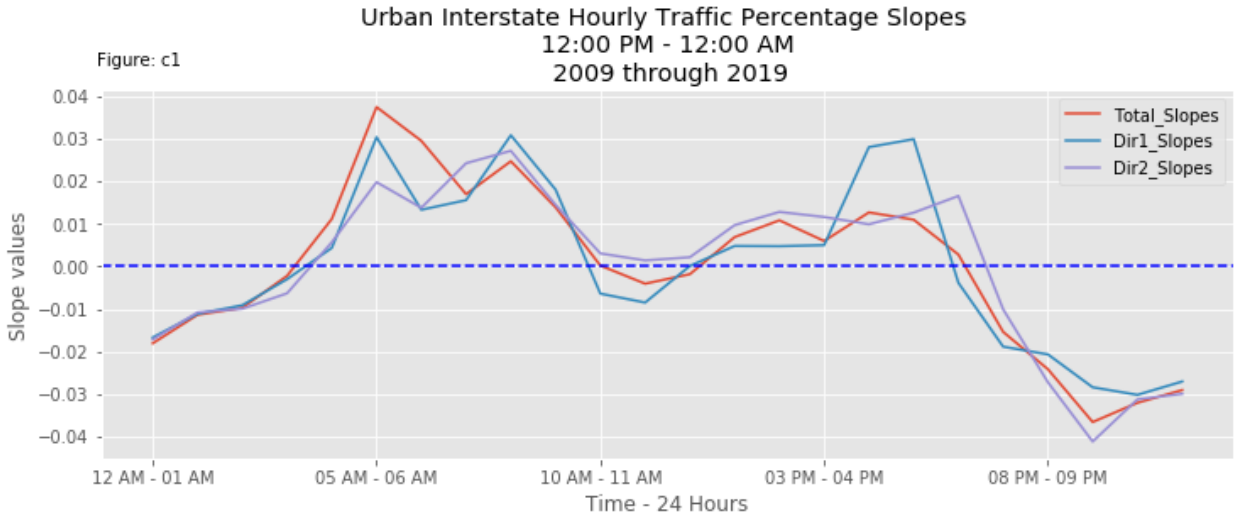
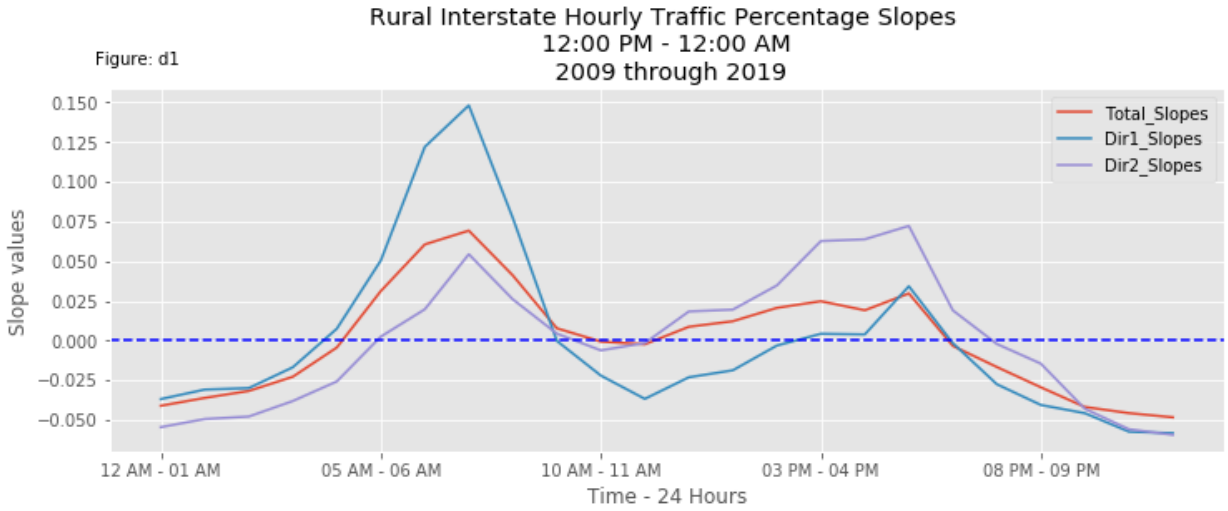


Figure: d1



4. Possible Cause for Change

As shown in the sections above, the changes in traffic factors in each hour is evident on Urban and Rural Interstate road system. There is significant decrease in hourly proportion in the off-peak hours (early morning, late night and mid-day) while a slight increase around the peak hours through the years considered in the analysis. The reason for this change is not clear and requires more corroborating and supportive data. However, starting from a few years back we have been observing several potential factors that affect traffic patterns. Among these potential causes, here are some.

- The emergence of Ride sharing such as Uber and Lyft, that takes many vehicles off the road in the off-peak hours.
- Land use pattern change; many households are moving back to downtown or closer areas to live. This may have encouraged use of public transportation instead of private vehicles.
- Change in behavior such as low enthusiasm to have private vehicles by certain age groups (example: Millennials).
- Development of more roads to have alternate routes etc.

5. Conclusion

Using the hourly factors that are available on the annual report of PennDOT, it was possible to look into the changes in proportion of hourly traffic in the years 2009 through 2019. This analysis was done on the traffic factors of Urban and Rural Interstates and the result shows changes in the factors. A decreasing trend in the factors for early and late hours of the day, and increase in the peak hours. This change may be caused by several reasons that range from the emerging ridesharing like Uber and Lyft, people moving and start living in the center of cities so that they take public transit to move around, younger generations are becoming less enthusiastic to own vehicles, and the tendency of many workers to start telecommuting. However, to precisely know the causes of these changes, getting more dataset that are related and affecting traffic pattens is essential. Knowledge about the patterns and road conditions help road engineers, transportation planners, policy makers and many others to design, create, improve and optimize transportation by reducing person hours travel.

Reference

1. Traffic Information, Traffic Data, Pennsylvania Traffic Information
   https://www.penndot.gov/ProjectAndPrograms/Planning/TrafficInformation/Pages/default.aspx
   (last visited, August 29,2020)

2. Traffic Data Report 2019
   Factoring process: Traffic Adjustment factors
   Table 350: Hourly Percentages Compiled for Total Vehicles
   https://www.penndot.gov/ProjectAndPrograms/Planning/TrafficInformation/Pages/2019Pennsylvania-Traffic-Data.aspx (last visited, August 29,2020)

   Note: In order to get the prior years' data, change the year in the link