Analysis of Yearly Traffic Fluctuation on Latvian Highways

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Abstract. Average annual daily traffic and average annual truck traffic are two most used metrics for road management decisions. They are calculated from data gathered by continuous counting stations embedded in road pavement, manual counting sessions or mobile counting devices. Last two usually do not last longer than a couple of weeks so the information gathered is influenced by yearly traffic fluctuations.

Data containing a total of 8,186,871 vehicles or 1989 days from 4 WIM stations installed on highways in Latvia were used in this study. Each of the files was supposed to contain data from only 1 day and additional data were deleted. No other data cleaning steps were performed, which increased the number of vehicles as counting systems sometimes split vehicles into two.

Weekly traffic and weekly truck traffic was normalized against respective average values. Each weekly value was then plotted against its number in a year for better visual perception. Weekly traffic amplitudes were used to assess differences between different locations and standard deviations for fluctuation comparison of truck and regular traffic at the same location.

Results show that truck traffic fluctuates more than regular traffic during a year, especially around holidays. Differences between counting locations were larger for regular traffic than truck traffic. These results show that average annual daily traffic could be influenced more if short term counting results are adjusted by factors derived from unsuitable continuous counting stations, but truck traffic is more influenced by the time of year in which counting is done.

1. Introduction

Traffic intensity is arguably the most widely used metric for road management decisions. Two different metrics are the most common – average annual daily traffic (AADT) and average annual truck traffic (AATT). AADT best describes traffic flow from traffic organization and planning viewpoint, AATT is best used to calculate necessary strength, modulus of elasticity and other road pavement parameters.

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Such data are gathered at static vehicle counting stations embedded in the pavement or calculated from short term traffic counting sessions. Permanent counting stations are expensive to install and require constant maintenance during their lifetime, therefore, they are usually only installed on large highways. On smaller roads, counting sessions lasting from a couple of hours to few weeks long are used. Data from them are influenced by the time of a year/week/day the counting took place.

This influence can be corrected by calculating average daily traffic (ADT) and then using simple coefficients that increase or decrease it depending on the time of year. These coefficients have to be calculated from continuous counting station data that has been running for at least one whole year. Also traffic changes within a year can differ between different spots, therefore it is important to make sure that information from one place is suitable for drawing conclusions about another location.

This study uses data from 4 WIM stations in Latvia to assess the fluctuations in weekly traffic and weekly truck traffic depending on the time of year. Traffic recorded in all four places is then compared to see if data from one could be used to describe traffic in other places.

2. Related works

Few works about this topic can be found as this matter is usually presented in the so called "white papers". Latvian road design standards [1] presents a way to calculate ADT from both peak hour traffic and traffic counted from 3 PM to 7 PM. Both methods are used by road designers, however, neither gives AADT. And, as the following text will show, traffic varies greatly in a span of a single year.

Traffic patterns are studied in [2]. Authors show that difference between highest (August) and lowest (January) monthly traffic is about ten percent and attribute these fluctuations to seasonal migration. Similar fluctuations can be seen in the data used in this paper. However, they also note that traffic in metropolitan areas are studied. Results from less densely populated areas can be different [3]. States the need to correct the data from short-duration counting sessions and describes usage of seasonal adjustment factors. 12 factors are provided, one for each month. As following chapters will show, traffic fluctuates most around national holidays so one factor for each month might give misleading results if traffic is counted near these holidays, like in December between Christmas and New Year. It also notes that location of both counting places and differences between traffic volumes and roadway types must be taken into account.

Traffic density and its fluctuations are studied in [4]. While that is a different approach, daily traffic is easily calculable from density, therefore, similar approach is usable for assessment of traffic fluctuations. In the article coefficients are based on time series data and given for different times of day, days of week and months of year. The author also concludes that urban traffic is different from non-urban and coefficients derived from one should not be used to describe the other.

3. Available WIM data

Data from 4 WIM systems on highways A1, A3, A7 and P80 that use piezo-electric sensors were used. Stations were installed on two lane bi-directional highways so the data contained mixed traffic of both cars and trucks in the same lane, also vehicles going in the opposite of lane's direction were observed due to the same reason. Vehicles were automatically sorted into classes, based on their axle count, axle spacings and length. Records contained information about vehicle timestamps, length, wheelbase, gross vehicle weight (GVW), pavement temperature, axle loads and spacings. A total of 8,186,871 vehicles were recorded. Vehicle count, start and end date of recording period, and the number of days recorded on each of the highways are presented in table 1.

WIM systems stored each day's data in a single file. A simple check showed that 29 August 2014. records from A7 contained 5 days' worth of data. Additional vehicles were just duplicates from other days so the file was cleaned leaving only the vehicles from the correct date in it. This led to deletion of 57,151 vehicles. Files from 28 February2015 – 06 March2015 (A3), 30 March2015 (P80), 29 July 2013 (A1) were missing due to repairs.

Data cleaning usually uses a set of filters for various vehicle properties to select only those vehicles that authors are interested in, i.e. trucks, permit vehicles. etc. and delete the rest. In this case authors were interested in all of the vehicles as the variability in the amount of traffic is studied, so even if some records contained erroneous length or weight they were kept. We assumed that this would increase the amount of traffic slightly as split or duplicated vehicles would not be filtered, but the increase was considered insignificant.

Table 1. WIM data.

Highway	Number of vehicles	Start date	End date	Total days
A1	3,887,062	14.07.2012.	31.03.2015.	990
A3	1,351,800	05.09.2013.	31.03.2015.	566
A7	1,868,750	27.08.2014.	31.03.2015.	217
P80	1,079,259	27.08.2014.	31.03.2015.	216
∑	**8,186,871**			**1989**

4. Methods

The authors studied yearly fluctuations of traffic. Two different cases were considered in this period – all vehicles (regular traffic) and only trucks (truck traffic), here defined as any vehicle with gross vehicle weight over 3,500 kg.

Fluctuation analysis was based on weekly periods for which average traffic and average truck traffic was calculated. In case some of the days were missing, the authors calculated values from the available data. Then traffic values were plotted against data from different highways. For better data comparison, the obtained values were normalized against average weekly traffic [5] and plotted with their respective week of the year.

Variability in truck and regular traffic was analyzed both between different sites and locally. Between different sites variability was defined as difference between maximum and minimum normalized values in the same week, thus at most 52 values were calculated per year. Calculated truck and regular traffic values were then compared. Locally standard deviations were calculated for data from each highway and each year. These were then compared to illustrate the differences between truck and regular traffic.

5. Results

Data splitting in weeks yielded 286 periods of data – 142 from A1, 82 from A3, 31 from both A7 and P80. Figure 1 shows normalized average traffic in these periods. A1 data has a huge jump each year from about middle of June to beginning of September, during this time several large festivals take place in a nearby town, which increases average traffic considerably. The authors found that 22 days with highest traffic (11,799 to 6,916 vehicles per day) were recorded within ± 2 days from these festivals. Also average daily traffic on A1 is the lowest amount among all four highways (3,938 vehicles per day), which increases the relative size of any deviation in the normalized data. Also

highway A1 runs along Latvian coastline, so people going to the beach would also increase the traffic in summer.

Figure 2 shows that outside of few weeks in the middle of summer normalized traffic is quite similar from one site to another. Maximum and average differences between maximum and minimum weekly traffic values are shown in table 2. In addition, traffic outside of summer months follows the same pattern on all four highways: a gradual fall in traffic during autumn to winter (weeks 35 to 49), a rise in traffic around Christmas (weeks 49 to 51) and a sharp fall in the last week of a year followed by a strong rise till the middle of January (week 2) and a gradual rise till at least the end of March. It is hard to say anything about traffic patterns during the rest of the year as the data are available from only 2 sites.

Truck traffic was split into weekly periods and normalized average weekly truck traffic was calculated as described in the previous chapter. Figure 3 shows the plotted results. The same sudden drop as in regular traffic near New Year was observed. This drop, however, is more severe for truck traffic (truck traffic drops to around 40% of yearly average traffic, but regular traffic drops only to about 55% of yearly average). Plotted graphs show bottom in week 25 or 26 that is not present in regular traffic. Midsummer's Eve, which is a major holiday in Latvia, occurs during week 25 or 26. This would explain a drop in truck traffic as fewer businesses operate during this time, but regular traffic stays the same as people are still driving during holidays.

Figure 3 illustrates that truck traffic is less variable than regular traffic from site to site. Table 2 shows calculated average and maximum amplitudes between regular and truck traffic, they are twice as large for regular traffic if compared year by year.

Data shows that regular traffic is less fluctuating locally on all highways except A1. Table 3 displays standard deviation calculated for each year's data from each site. Comparison tells that in most cases truck traffic locally varies around 1.5 times more than regular traffic.
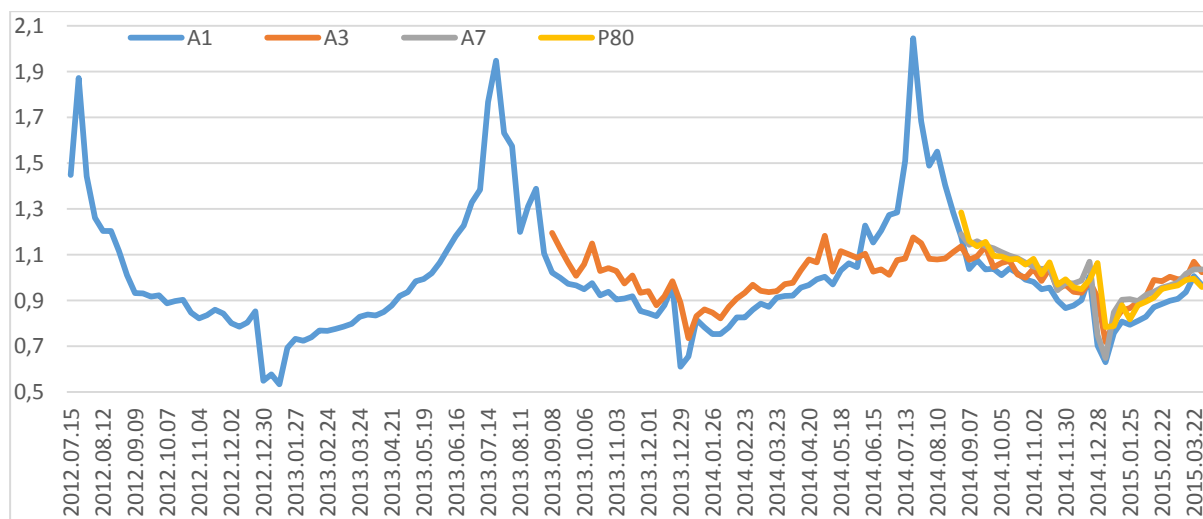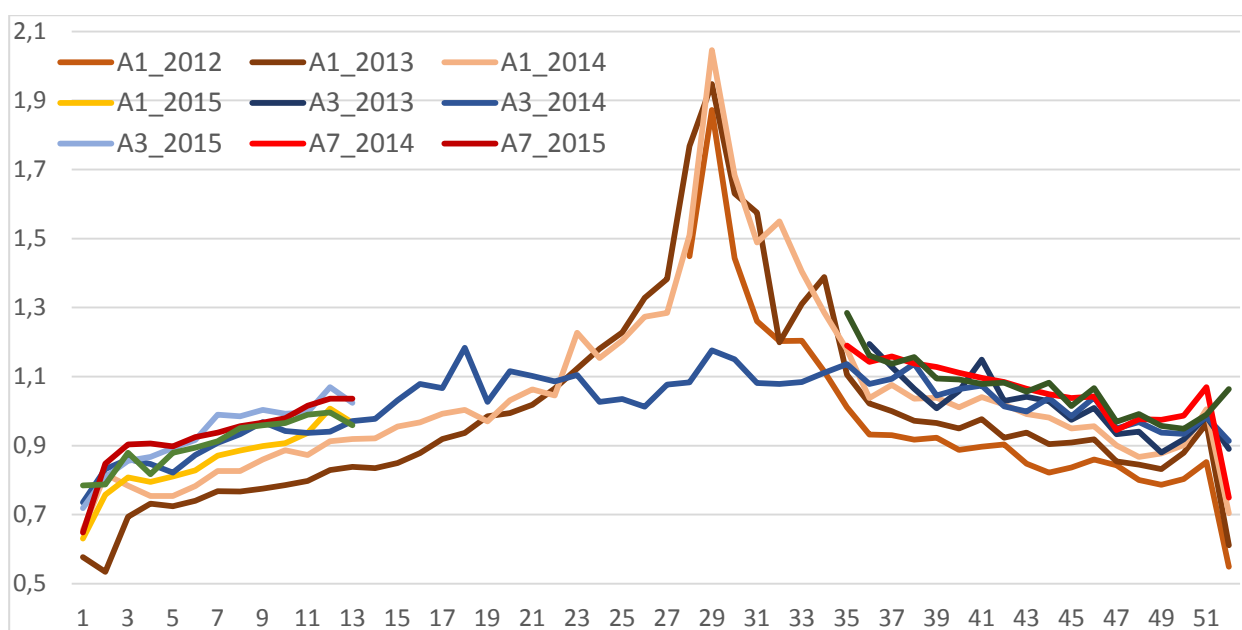

Figure 1. Weekly traffic variability on Latvian highways.

Table 2. Average and maximum amplitudes between normalized weekly traffic and normalized weekly truck traffic.

	All years		2013		2014		2015	
	All	Trucks	All	Trucks	All	Trucks	All	Trucks
Maximum	0.8699	0.4839	0.2796	0.2529	0.8699	0.3175	0.1536	0.1346
Average	0.2486	0.1659	0.1043	0.1091	0.1484	0.0795	0.0979	0.0383

Table 3. Standard deviations of normalized weekly traffic and truck traffic.

Year	Highway	Truck traffic	Regular traffic	Difference
2012	A1	0.1365	0.2779	-0.1414
2013	A1	0.1426	0.2881	-0.1455
	A3	0.1630	0.0888	0.0742
2014	A1	0.1382	0.2611	-0.1229
	A3	0.1361	0.0973	0.0388
	A7	0.1606	0.1024	0.0582
	P80	0.1120	0.0844	0.0276
2015	A1	0.1799	0.0984	0.0815
	A3	0.1986	0.0995	0.0991
	A7	0.1739	0.1012	0.0727
	P80	0.1680	0.0733	0.0947

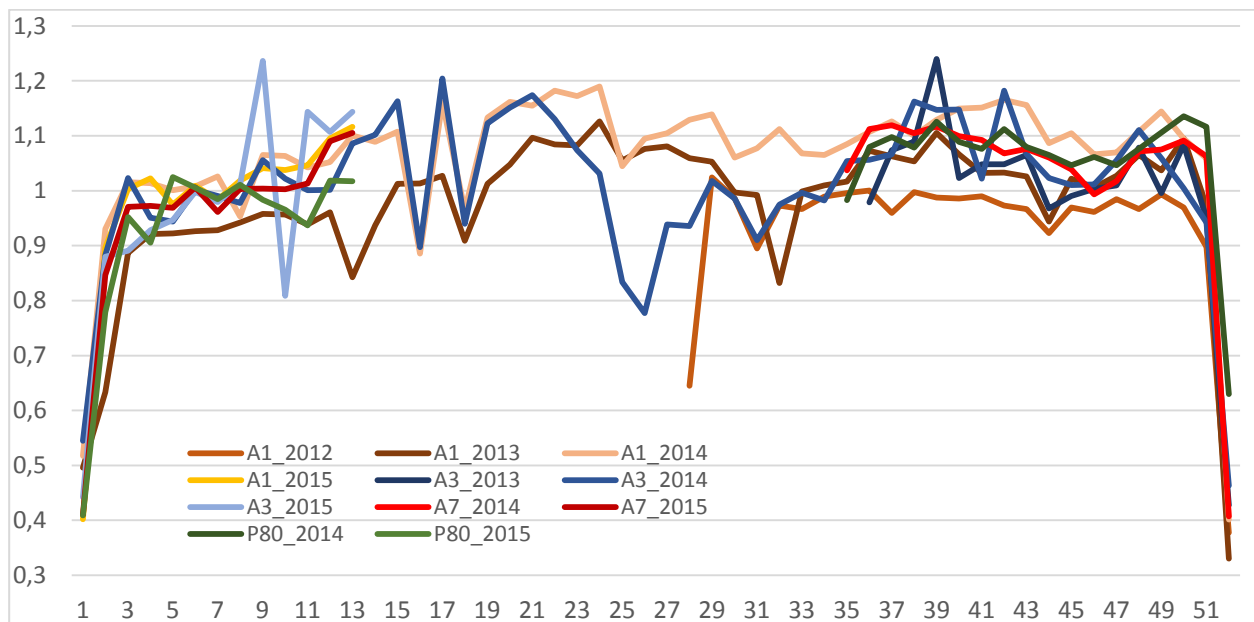**Figure 2.** Normalized weekly traffic depending on the week of a year.

Figure 3. Normalized weekly truck traffic depending on the week of a year.

6. Conclusions and discussion

A study of weekly traffic and weekly truck traffic fluctuations using the data from 4 WIM stations (8,186,871 vehicles altogether) was done. Only two stations yielded the data for more than a year long period, which limited calculations and analysis itself.

Both truck and regular traffic show huge drops during the last and first two weeks of the year. The most likely explanation for this is that people use this time around Christmas and New Year for vacations and drive less. Also a drop in truck traffic is noticeable around Midsummer's Eve, which is a major holiday in Latvia, however, there is no drop in regular traffic. It could be caused by people having holidays and vacations during this time, thus driving less trucks, but the same or increased number (as there is no drop in traffic consisting of all vehicles) of cars. Traffic counting should not be done during these two lows as it might skew the data.

In highway's A1 case it is shown that local factors (festivals in nearby towns, close proximity to the beach) can severely increase traffic in summer. Local factors should definitely be considered if WIM data from such stations are used elsewhere.

Largest average amplitude of normalized traffic between two highways in one week was found to be around 25%, however, in this case the data for the entire year were used for calculations. If only single year's data is used then it drops to 15% and less. This goes to show that traffic from one site is not all that different from other sites. Thus these graphs and data from local vehicle counting could be used to predict the amount of traffic at a later date in some other location. If only truck traffic is considered then these average values are even lower (11% and less), so there is even less difference between sites if only truck traffic is considered.

Truck traffic is more variable locally than regular traffic, as shown in table 3. Less cyclicality is observable in truck traffic, however, each separate week differs more than separate weeks in regular traffic. If any predictions from the limited traffic counting data are made, engineers should adjust for

potential low week. The exception for this rule is highway A1, this shows that local factors might have some influence.

The authors recommend that a larger study is carried out as the present analysis used the data from only 4 stations of which only 2 had more than one year of data available.

7. References

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Acknowledgments