Alternative Seasonal Factor Estimation Methods and Their Accuracy in Predicting Annual Average Daily Traffic

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Introduction

- The allocation of U.S. federal government funds to states for developing their road transportation system is based on highway performance data collected by the states.
- For comparability of such data, the Federal Highway Administration (FHWA) requires every state Department of Transportation (DOT) to have in place a **Traffic Monitoring Program (TMP)** whose procedures are consistent with recommendations made in FHWA's Traffic Monitoring Guide.
- One key performance measure that informs funding decisions is the ***Annual Average Daily Traffic (AADT)***, which is estimated from traffic volume counts made over an entire year on each section of roadway.
- Ideally, obtaining AADT for all road sections would require the placement of expensive count equipment on every road section. Given the large scale of any state's roadway system, this would be expensive and impractical.
- Sampling is used to address this concern. It results in two components of a TMP:

1. **Permanent Traffic Count (PTC) Program**
   - Only a relatively small number of road sections are selected under this program for continuous counts all year round. These are called PTC stations; and a
2. **Short Period Traffic Count (SPTC) Program**
   - Covers the remaining numerous road sections at which counts are made for only a short period of time, typically, one to seven days
   - Data from the PTC program are used to compute Annual Average Daily Traffic (AADT), and seasonal/temporal variation factors that are used to adjust the short period counts into AADT estimates
   - AADT estimate = $V_{ij} \times SF^{y}_{m_j d_i}$

Figure 1: Inductive Loop Detector Embedded in the Road Pavement used in PTC Program

Figure 2: Portable Traffic Counter Used in SPTC Program

- FHWA recommends that states compute the final seasonal factors (SFs) used to adjust the short period counts made in a calendar year using PTC data collected in that same calendar year only.
- On the other hand, Tennessee Department of Transportation (TDOT) determines its final seasonal factors by taking the arithmetic mean of the SFs determined in the calendar year of interest and in each of the immediately preceding four calendar years.
- Both approaches are supported by good reason. Upfront, it is unclear which of them yields more accurate estimates of AADT for the different road sections. However, TDOT's approach implicitly assumes equal reliability of the seasonal factors across the five calendar years, an assumption that may be quite restrictive and not supported by data collected at PTC stations.

Research Objectives

From the above, the objectives of the research were as follows:

- **Objective 1:** To ***develop an alternative procedure*** for combining SFs from multiple consecutive years of PTC data which relaxes the assumption of equal reliability of SFs implicitly embedded in TDOT's procedure
- **Objective 2:** To ***investigate empirically the performance of SFs*** estimated from the following ***three alternative methods*** in predicting AADT estimates: **FHWA's method** (which computes SFs from a Single year only i.e. the most recent full calendar year), **TDOT's method** (which computes SFs from a simple average of 5 calendar years of PTC data) and the **newly developed alternative procedure in this study** (which uses a Weighted Average procedure for 5 calendar years of PTC data)

Literature Review/State of Practice

- **Focus** – how final seasonal factors used to adjust coverage counts into AADT estimates are determined
- **Findings**
  - FHWA recommends that final seasonal adjustment factors be computed from the most recent full calendar year of PTC data only
  - Among selected states, the number of years used for developing SFs varied
  - For states that used a multiple number of years, the simple average approach was adopted

Table 1: Number of Years of PTC data Used by Selected States for Computing Final SFs

State	Number of Years Used For Computing Final SFs
California	Simple Average of 2 years
Florida	Single year (Most recent calendar year's data)
Kentucky	Single year (Most recent calendar year's data)
Maryland	Single year (Most recent calendar year's data)
New York	Simple Average of 3 years
Ohio	Simple Average of 3 years
Virginia	Single year (Most recent calendar year's data)
Washington	Single year (Most recent calendar year's data)
Tennessee	Simple Average of 5 years

- **Gaps Identified**
  - Assumption underlying the simple average method – equal reliability of SFs across multiple calendar years
    - Not supported by PTC data collected in a year for each ATR group
  - No research in the open literature that examined alternative ways of combining multiple years of PTC data to generate final seasonal factors used in adjusting short term counts.

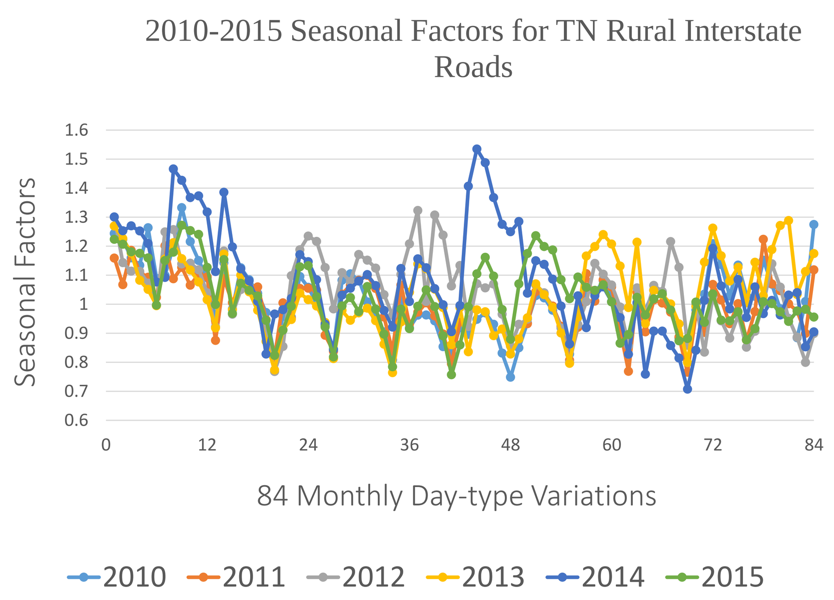


Figure 3: Graphical Plot of TN Seasonal Factors from 2010 - 2015

Data and Input Values for SF Computation

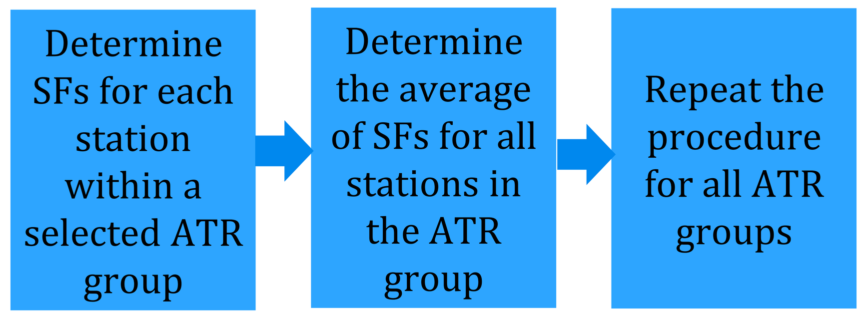
- **Data**
  - Sources of data: Tennessee (TN) and Maryland (MD)
  - Data Required: Minimum of five years of PTC data
  - Datasets Investigated: TN 2010 – 2014, MD 2010 – 2014, TN 2011 – 2015
- **Computation of AADT**
  - The AASHTO method (average of averages) was used: $$AADT = \frac{1}{7}\sum_{i=1}^{7}\left[\frac{1}{12}\sum_{j=1}^{12}\left(\frac{1}{n}\sum_{k=1}^{n} V_{ijk}\right)\right]$$

Where V_{ijk} is the volume for the k^{th} day (i.e., k = 1 for the first occurrence of that day-type in a given month, …, n number of day-type i occurrences during month j (usually between one and five) of day-type i (i.e., i = 1, 2, …, 7) within month j (i.e., j = 1, 2, …, 12).

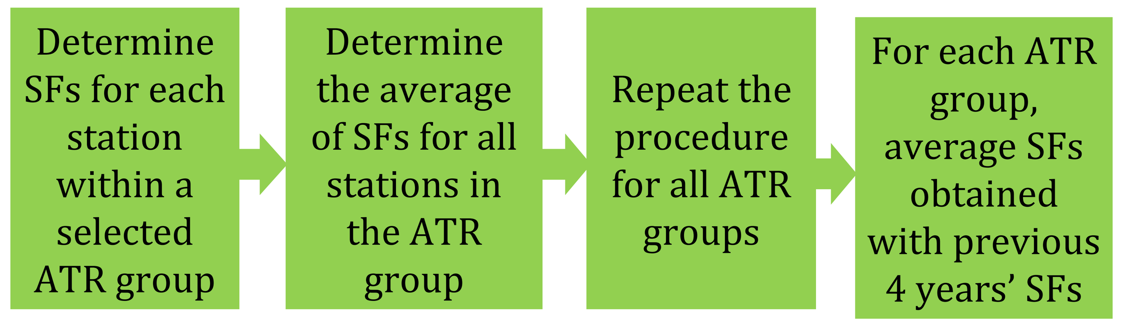
- **Computation of Seasonal Factors**
  - Index AADT to 84 monthly average day-type volumes to yield 84 SFs for each year for each ATR group.

Methodology – SF Estimation Methods

FHWA's Method



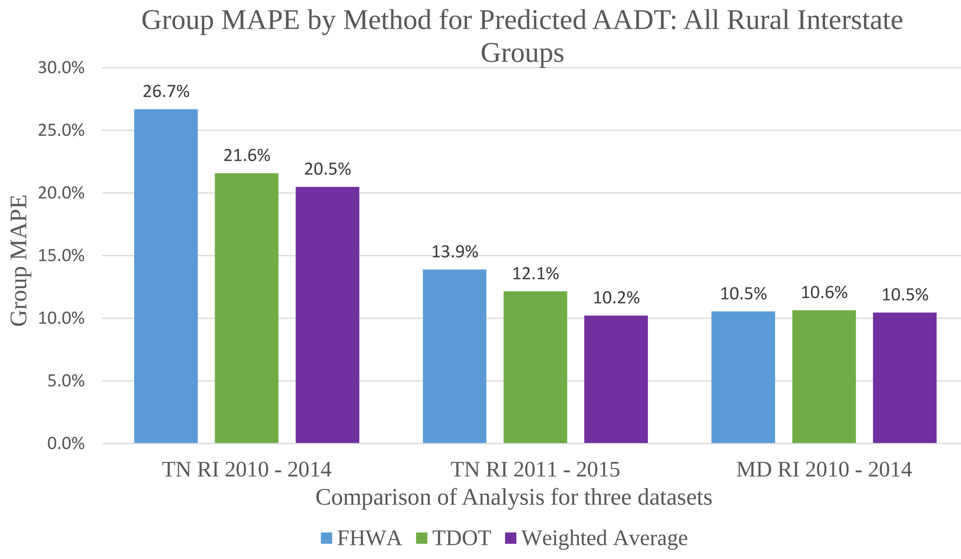
TDOT's method

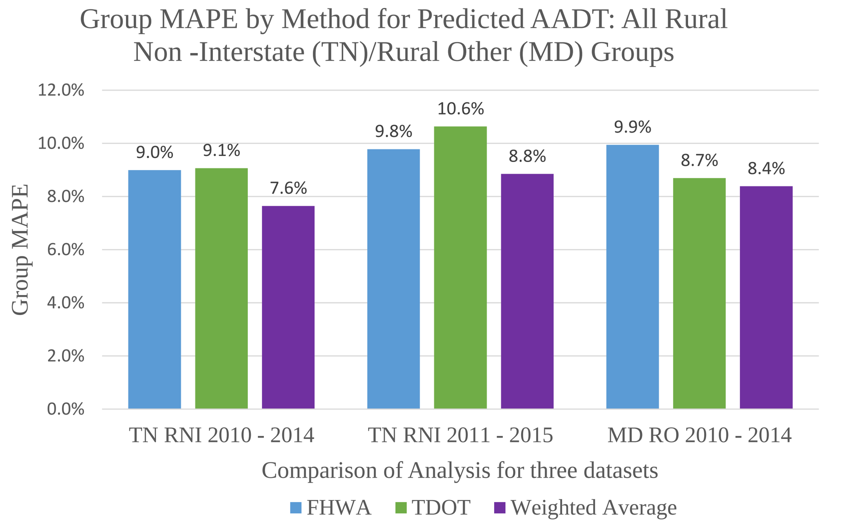


Weighted Average formula

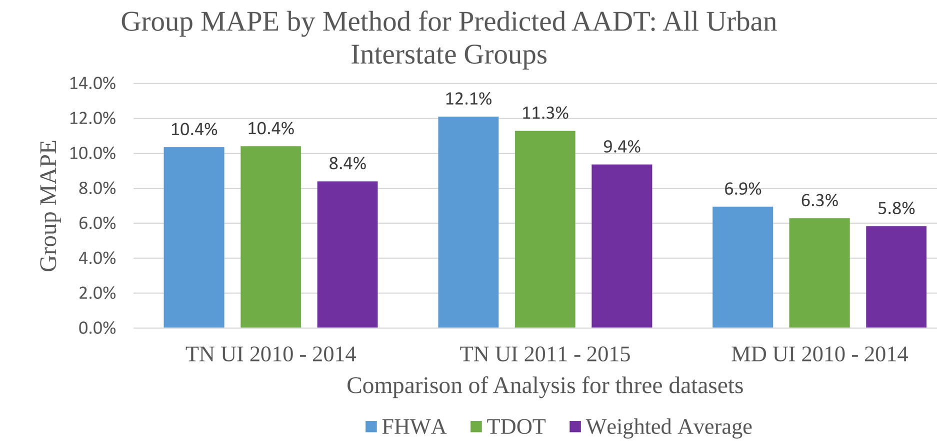
- Weights to be assigned to SFs from each year are determined such that each SF has minimum variance.
- Final SFs are determined such that:
  $$\overline{\overline{SF}}_{m_j d_i} = \alpha_1 \overline{SF}^{1}_{m_j d_i} + \alpha_2 \overline{SF}^{2}_{m_j d_i} + \dots + \alpha_5 \overline{SF}^{5}_{m_j d_i}$$
  Where; $\sum_{y=1}^{5} \alpha_y = 1$
- From the formula used for determining weights, the smaller the variance of SF from a given year, the greater the weight assigned to it and vice versa
  $$\alpha_y = \frac{\frac{1}{\sigma^2_{y,\overline{SF}_{m_j d_i}}}}{\frac{1}{\left(\frac{1}{\sigma^2_{1,\overline{SF}_{m_j d_i}}} + \frac{1}{\sigma^2_{2,\overline{SF}_{m_j d_i}}} + \frac{1}{\sigma^2_{3,\overline{SF}_{m_j d_i}}} + \frac{1}{\sigma^2_{4,\overline{SF}_{m_j d_i}}} + \frac{1}{\sigma^2_{5,\overline{SF}_{m_j d_i}}}\right)}} \quad y = 1 \dots 5$$
- **Test Procedure:** SFs obtained from the three alternative methods were applied in turn to short period traffic counts to predict AADTs.
  - Mean Absolute Percent Error (MAPE) was used as the performance measure. Group MAPEs were determined for all ATR groups for each method.

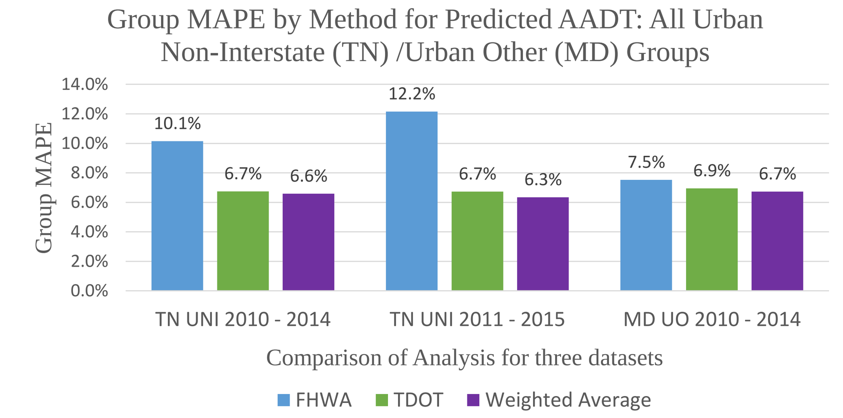
Results and Discussion





- Weighted Average method gave best performance – it resulted in AADT predictions that on average had the lowest MAPE values
- TDOT's method follows
- FHWA's method on average gave AADT predictions with the highest MAPE values





Conclusions/Contributions to Research

- **Conclusion 1**: An alternative method for determining final seasonal factors that accounts for within ATR-group variance has been successfully developed for combining PTC data spanning a five – year period. It is known as the Weighted Average method
- **Conclusion 2**: The use of five years of PTC data to develop seasonal factors is better than the use of only a single year of PTC data in AADT prediction. Also, results of the empirical test of the three SF estimation methods show that an explicit consideration of variances of calendar year seasonal factors yields superior AADT estimates at coverage count stations.

Future Studies

- Investigate alternative grouping of ATR stations into more specific sub-divisions of roadway functional classifications such as principal arterials, minor arterials, collectors and local roads prior to estimation of seasonal factors
- Investigate the number of calendar years of seasonal factors that result in AADT estimates at coverage count stations that give the lowest error.

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- Traffic Monitoring procedures/guides of the selected states

Acknowledgements

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