Portland State UNIVERSITY

Predicting Average Daily Traffic on Local Roads: Parametric or Nonparametric Methods?

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Motivation

- MAP-21 and FAST Act Both Emphasize Importance of Data Collection and Applications for Prioritizing Investments
  - Traffic Counts
- In Oregon, This is Accomplished on Major Facilities Through Permanent or Short-Term Counts
  - For Minor or Local Facilities, These Counts Can be Expensive and Labor Intensive
- Short-Term Traffic Counts That Cover All Links is Not Practical Nor Economically Viable
- There is a Need to Develop Predictive Methods to Estimate Traffic Volumes on Minor and/or Local Roadway Segments
  - **The Premise for Prediction is to Classify Local Roadway Segments Into Specific Traffic Volume Ranges**

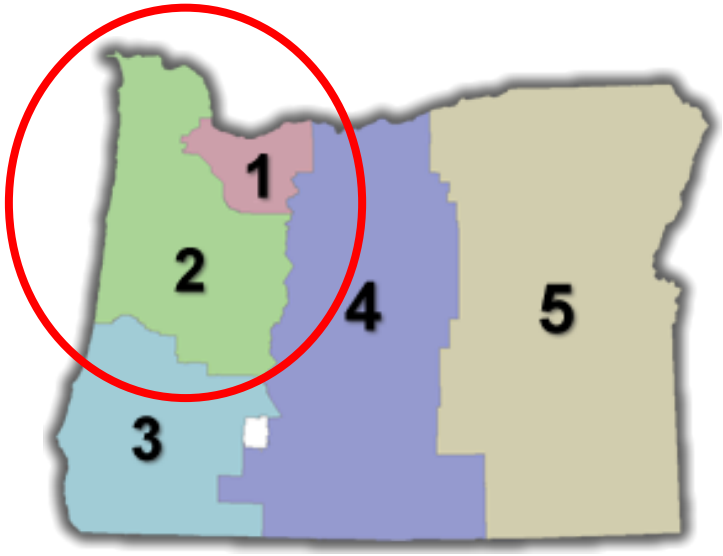
Motivation

- **Why Predict Volumes Ranges Over Continuous Values of Traffic Volume?**
- Classify Local Facilities Based on Specific Traffic Volume Ranges Based on a Variety of Factors
- Prediction of Traffic Volume Ranges Was More Intuitive and Informative to ODOT Practitioners
- Predicting Traffic Volume as a Continuous Variable Through Linear-Based Approaches Has Room to Be Improved
    - Results in High Errors and Low Prediction Accuracy
- Multiclassification and Binary Classification Considered

Data

- Average Daily Traffic (ADT) Counts for Local Roads Was Obtained Through an ODOT Database as Part of SPR-804
- At Time of Study, Most Recent Traffic Counts Were for 2016
- Of Particular Interest Were ADT Counts in ODOT Region 2

Clatsop County	Lincoln County
Columbia County	Benton County
Tillamook County	Linn County
Yamhill County	Lane County
Polk County	Washington County (Western Portion)
Marion County	



Data

- 426 Data Samples Were Collected

Variable	Example
Lane-Use Characteristics	• Primary ADT Generator Adjacent to Roadway • Primary Dominant Land-Use Adjacent to Roadway • Presence of Single-House Residences • Sub-Region (e.g., Coastal, Mountain, Valley, and MPO)
Type of Median	• Undivided • One-Way • Single Lane
Intersection Characteristics	• Presence of Right-Turn Lane • Presence of Left-Turn Lane • Presence of Traffic Signal
Roadway Characteristics	• Pavement Type • Presence of Horizontal Pavement Markings • Presence of Shoulder

Data

- 426 Data Samples Were Collected

Variable	Example
Roadway Characteristics (Cont.)	• Presence of Crosswalk • Presence of Sidewalk • Presence of Bike Lane • Presence of Bus Stop • Presence of Parking Lot • Presence of Calming Device
Signage Characteristics	• Presence of Stop Sign on the Crossroad • Presence of Stop Sign on Main Corridor • Presence of Sign, Other Than Stop Sign on Main Corridor
Demographic Characteristics	• Population Within 1,000 ft. of Main Corridor • Employment Within 1,000 ft. of Main Corridor

Prediction Methodology

- Multiclassification
- Traffic Volumes Were Classified Into Four Distinct Categories Based on Interest From ODOT
  - These Ranges Were the Dependent Variable in the Prediction Models

Summary of Traffic Volume Classifications				
	ADT Range			
ADT	0 to 250	250 to 500	500 to 1,000	Greater Than 1,000
Training	112	92	61	33
Test	49	38	27	14

Prediction Methodology

- Binary Classification
- Binary Classification Based on Interest From ODOT
  - These Ranges Were the Dependent Variable in the Prediction Models

Summary of Binary Traffic Volume Classification				
Variable	Mean	Std. Dev.	Frequency in Training Dataset	Frequency in Testing Dataset
1 if ADT Between 0 and 250, 0 Otherwise	0.38	0.49	112	49

Prediction Methodology

- Multiclassification
  - Parametric: Ordered Probit Model
  - Nonparametric: Multiclassification Support Vector Machine (SVM) Learning
    - One-Against-One Approach
- Binary Classification
  - Parametric: Binary Ordered Probit Model
  - Nonparametric: SVM
- Pros/Cons
  - Parametric: Interpretability of Results/Lower Prediction Accuracy
  - Nonparametric: Prediction Accuracy/Further Analysis Required to Interpret Important Predictors

Prediction Methodology

- Prediction Evaluation

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

$$\text{Sensitivty} = \frac{TP}{TP + FN}$$

$$\text{Specificity} = \frac{TN}{TN + FP}$$

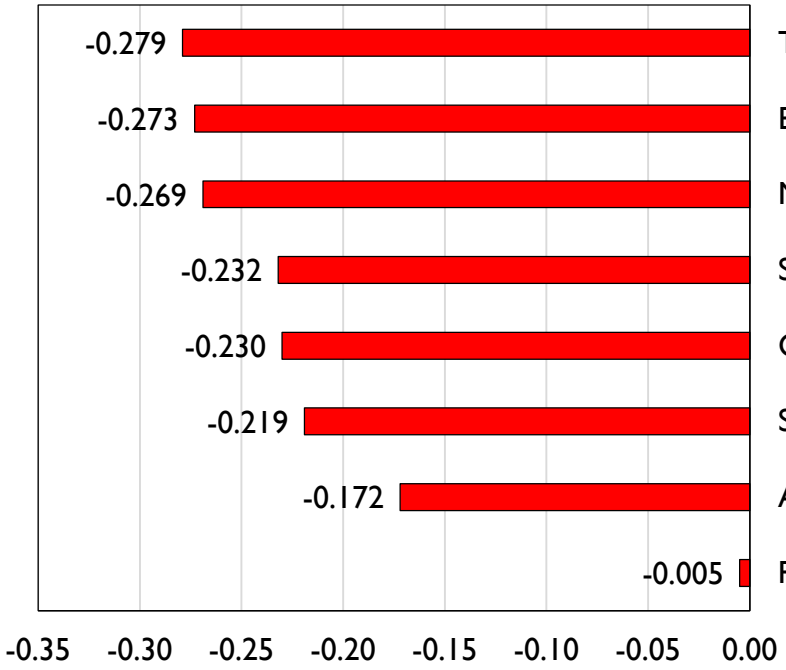
TP (True Positive)	**Samples Predicted as Positive and Are Truly Positive**
FP (False Positive)	**Samples Predicted as Negative, But are Truly Positive**
TN (True Negative)	**Samples Predicted as Negative and Are Truly Negative**
FN (False Negative)	**Samples Predicted as Negative, But Are Truly Positive**

Results (Multiclassification)

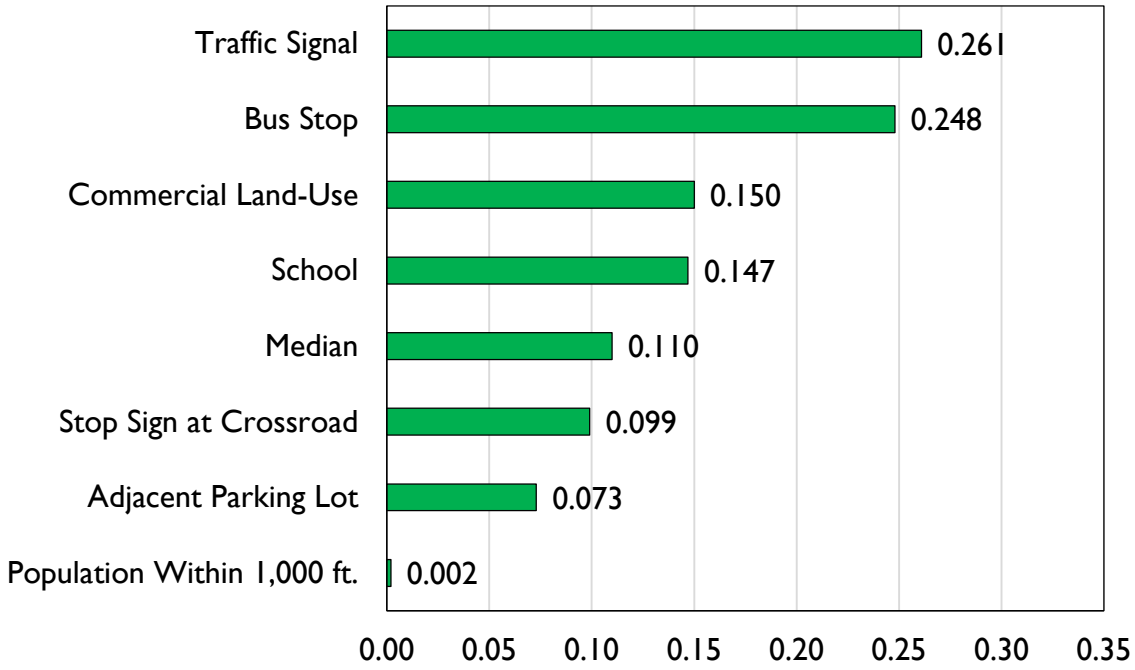
- Variable Effects Identified in the Ordered Probit Model

Ordered Probit Marginal Effects				
Variable	ADT Range			
	0 to 250	250 to 500	500 to 1,000	Greater Than 1,000
Generators				
1 if School, 0 Otherwise	-0.219	-0.055	0.128	0.147
Roadway Characteristics				
1 if Median Present, 0 Otherwise	-0.269	0.008	0.151	0.110
1 if Bus Stop Present, 0 Otherwise	-0.273	-0.119	0.145	0.248
1 if There is Adjacent Parking Lot, 0 Otherwise	-0.172	0.180	0.099	0.073
Intersection Characteristics				
1 if Traffic Signal Present, 0 Otherwise	-0.279	-0.127	0.145	0.261
Signage				
1 if Stop Sign at Crossroad, 0 Otherwise	-0.232	0.001	0.133	0.099
Land-Use				
1 if Commercial, 0 Otherwise	-0.230	-0.054	0.134	0.150
Demographic Characteristics				
Population Within 1,000 ft	0.005	0.000	0.003	0.002

Results (Multiclassification)



Negative Marginal Effects
(ADT Range: 0 to 250)



Positive Marginal Effects
(ADT Range: > 1,000)

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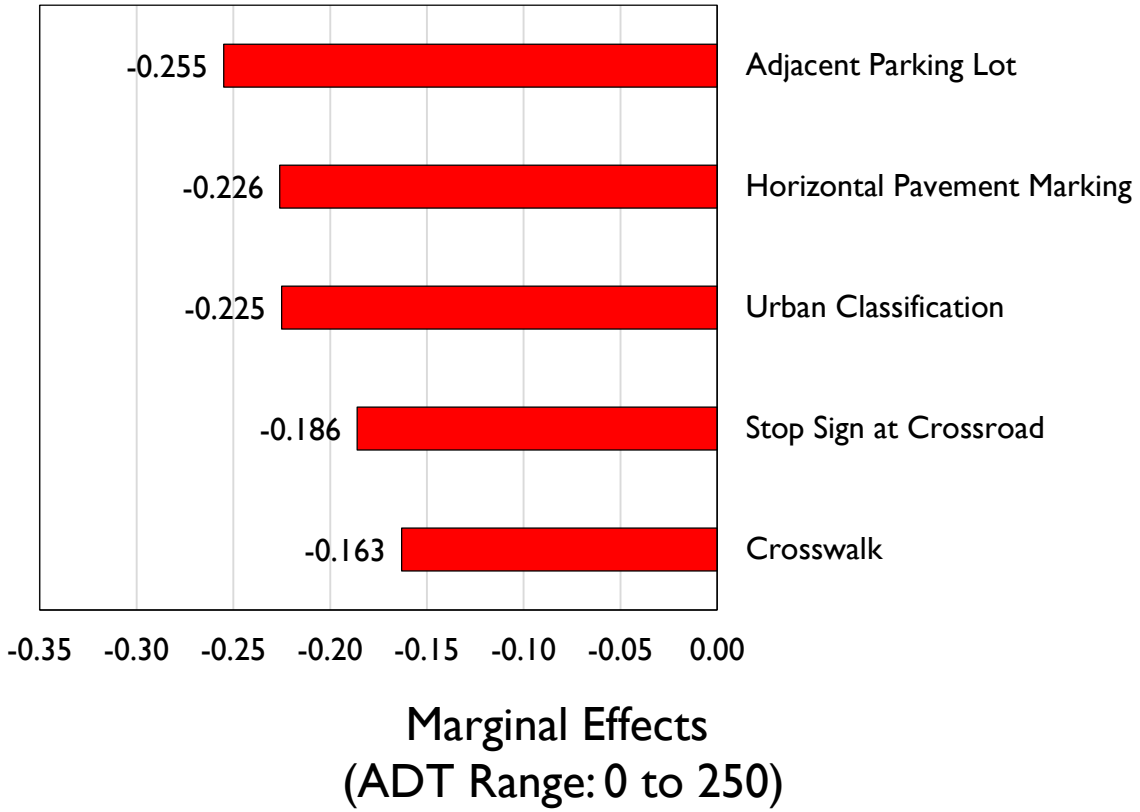
Results (Binary Classification)

- Significant Variables Identified in the Binary Probit Model

Binary Probit Model Specifications (Training Dataset)					
Variable	Coefficient	Std. Error	*t*-statistic	*p*-value	Marginal Effects
Constant	0.95	0.21	4.47	0.00	
Functional Classification					
1 if Urban, 0 Otherwise	-0.71	0.20	-3.52	0.00	-0.225
Roadway Characteristics					
1 if There is Adjacent Parking Lot, 0 Otherwise	-0.84	0.20	-4.08	0.00	-0.255
1 if Horizontal Pavement Marking, 0 Otherwise	-0.78	0.22	-3.59	0.00	-0.226
1 if Presence of Crosswalk, 0 Otherwise	-0.56	0.28	-1.99	0.05	-0.163
Signage					
1 if Stop Sign at Crossroad, 0 Otherwise	-0.59	0.17	-3.40	0.00	-0.186
McFadden Pseudo R-Squared	0.18				

Results (Binary Classification)



Results (Prediction Performance)

Comparison of Prediction Metrics for Multiclass and Binary Class Models			
Multiclassification			
Model	Accuracy	Sensitivity	Specificity
Ordered Probit	63.4%	45.2%	70.7%
SVM (Radial)	62.7%	35.4%	71.0%
SVM (Polynomial)	63.2%	40.3%	70.7%
Binary Classification			
Model	Accuracy	Sensitivity	Specificity
Binary Probit	60.9%	68.3%	48.9%
SVM (Radial)	71.1%	87.3%	44.9%
SVM (Polynomial)	71.1%	87.3%	44.9%

Results (Prediction Performance)

Comparison of Prediction Metrics for Multiclass and Binary Class Models			
Multiclassification			
Model	Accuracy	Sensitivity	Specificity
Ordered Probit	**63.4%**	**45.2%**	70.7%
SVM (Radial)	62.7%	35.4%	**71.0%**
SVM (Polynomial)	63.2%	40.3%	70.7%

Results (Prediction Performance)

Comparison of Prediction Metrics for Multiclass and Binary Class Models			
Binary Classification			
Model	Accuracy	Sensitivity	Specificity
Binary Probit	60.9%	68.3%	**48.9%**
SVM (Radial)	**71.1%**	**87.3%**	44.9%
SVM (Polynomial)	**71.1%**	**87.3%**	44.9%

Summary

- All Significant Variables Decreased The Probability of Observing Traffic Volume in the 0 to 250 Range
- For Multiclassification, the Parametric Model (Ordered Probit) Performed Better in Overall Accuracy and Sensitivity
  - SVM Performed Better in Specificity
- For Binary Classification, the Nonparametric Model (SVM) Performed Better in Overall Accuracy and Sensitivity
  - Probit Model Performed Better in Specificity
- In This Context, the Parametric Method is Preferred

Moving Forward

- Apply Comparisons to a Larger Sample Size
  - Attempt Varying Test/Training Proportions
  - Include an Advanced Linear-Based Approach
- Utilize Alternate Parametric Approach to Interpret "Middle" ADT Ranges (Multinomial Logit)
- Alternate Machine Learning Approaches for Multiclass Problem
  - Neural Networks
- Comparison Using Alternate Data Sources
  - Cellphone Probes

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  - Sara Urbina

Results (Multiclassification)

- Significant Variables Identified in the Ordered Probit Model

Ordered Probit Model Specifications (Training Dataset)				
Variable	Coefficient	Std. Error	*t*-statistic	*p*-value
Constant	-0.73	0.15	-4.77	0.00
Generators				
1 if School, 0 Otherwise	0.72	0.30	2.42	0.02
Roadway Characteristics				
1 if Median Present, 0 Otherwise	0.76	0.16	4.78	0.00
1 if Bus Stop Present, 0 Otherwise	1.03	0.46	2.26	0.02
1 if There is Adjacent Parking Lot, 0 Otherwise	0.49	0.17	2.95	0.00
Intersection Characteristics				
1 if Traffic Signal Present, 0 Otherwise	1.07	0.45	2.36	0.02
Signage				
1 if Stop Sign at Crossroad, 0 Otherwise	0.66	0.13	4.92	0.00
Land-Use				
1 if Commercial, 0 Otherwise	0.75	0.25	3.00	0.00
Demographic Characteristics				
Population Within 1,000 ft.	0.01	0.00	3.89	0.00