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Posted speed limit: To include or not to include in operating speed models

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ABSTRACT

Models of motorized vehicle operating speeds are used to assess the design consistency of planned or existing highway alignments or to quantify the potential speed outcomes of a design or traffic control decision. These models generally estimate the mean or 85th-percentile speed of free-flow vehicles as a function of the geometric design elements, traffic control, or other features present along the roadway. Models for measures of speed dispersion (e.g., standard deviation of speed) have been considered in more recent research. There are differing viewpoints concerning the inclusion of the posted speed limit as an independent variable in operating speed models. Some have excluded posted speed limit from operating speed prediction models, indicating that it was highly correlated with the geometric design elements also included as independent variables in the model. The other viewpoint is that the posted speed limit logically influences operating speeds, and should therefore be included in speed prediction models. This paper explores this issue using an econometric modeling approach, considering irrelevant variables, multicollinearity, omitted variable bias, and endogeneity bias. The results suggest that the posted speed limit should be treated as an exogenous variable in models of operating speed, including models of speed magnitude and speed dispersion.

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1. Introduction

A significant body of literature exists on evaluating design consistency of rural, two-lane highways. A majority of the published research makes use of linear regression models to predict operating speeds along horizontal alignment features (i.e., horizontal curves and tangents). Model estimated operating speeds on adjacent highway features are compared to each other or to the designated design speed to evaluate design consistency. The 85th percentile of the free-flow speed distribution is commonly used to represent the operating speed for design consistency evaluations.

Speed prediction models are typically estimated to determine the relationship between highway geometric design features and vehicle operating speeds. In some cases, researchers have argued that the posted speed limit should be excluded from the model specification. The rationale for this argument is that the posted speed limit may be correlated with roadway features (e.g., tighter horizontal curves or narrower cross-sections may be associated with lower posted speed limits). Advocates of excluding the posted speed limit from operating speed models contend that a true representation of the relationship

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between operating speeds and geometric variables cannot be established when the posted speed limit is included in a model. Proponents of including the posted speed limit in operating speed models do so based on the high level of statistical correlation between the speed limit and the operating speed – a theoretical justification for this decision has not been offered to date. Based on the differing views presented above, a consensus has not been reached regarding the inclusion of the posted speed limit in operating speed prediction models.

To determine whether or not the posted speed limit should be included in operating speed prediction models, a theoretically-guided econometric approach is considered in this paper. Modeling issues are described in detail and related to possible estimation outcomes. Two primary issues described are omitted variable bias and endogeneity. Omitted variable bias may occur if the posted speed limit is not included in the model specification, but does influence vehicle operating speeds. The magnitude of the omitted variable bias increases with the correlation between posted speed limit and variables included in the model. This is potentially a more serious modeling issue than correlation between explanatory variables when a posted speed limit variable is included as an independent variable in a model of operating speeds. Endogeneity bias results when an explanatory variable is not independent of the model disturbance. Endogeneity is considered in the present study using a simultaneous equations approach.

1.1. Background

Leisch and Leisch (1977) argued in the 1970s that the design speed should be selected independently of the posted speed limit, since the posted speed limit can change over the life of a highway. However, a recent survey of state transportation agencies by Skszek (2004) found that the design speed was the most common consideration when setting speed limits (35 of the 47 responding agencies replied as such). Other surveys (Fitzpatrick et al., 1996; ITE, 2001; Parker, 1985) have found that the 85th percentile operating speed is the most common consideration when setting the posted speed limit. The 2009 version of the Manual on Uniform Traffic Control Devices (MUTCD) (2009) states that the posted speed limit is "...established by law, ordinance, regulation, or as adopted by the authorized agency based on the engineering study." Maximum speed limits are established by statute (maximum speed that is established by state law) or as altered speed zones that are based on engineering studies. For speed zones, the MUTCD states that the speed limit "should be within 5 mph [8 km/h] of the 85th-percentile speed of free-flowing traffic (MUTCD, 2009)." The MUTCD also presents other factors that may be considered when establishing a posted speed limit. These include:

- Road characteristics, shoulder condition, grade, alignment, and sight distance;
- The pace speed;
- Roadside development and environment;
- Parking practices and pedestrian activity; and
- Reported crash experience for at least a 12 month period.

The practice of considering the design speed when setting posted speed limits, and the direct association between design speeds and several geometric design criteria (e.g., horizontal curve radius, stopping sight distance), has led previous researchers to omit the posted speed limit as an independent variable when estimating models of operating speed. The basis for doing so is the probable correlation between the posted speed limit and roadway design features. Wang et al. (2006) noted that since the design speed is usually based upon a proposed posted speed limit (e.g., posted speed limit is 8 km/h less than design speed), geometric design elements will be correlated with the design speed of the road. This was used as justification for excluding the posted speed limit from a statistical model used to estimate the association between operating speeds and various roadway characteristics.

Other authors have included the posted speed limit in statistical models of operating speeds. For example, Fitzpatrick et al. (2003) found that the posted speed has the greatest influence on operating speeds for 78 combined urban, suburban and rural roadways – no other geometric design, traffic control, or roadside features were found to be significantly associated with 85th-percentile operating speeds. Fitzpatrick et al. (2001) also found the posted speed limit to have the greatest influence on operating speeds along suburban arterial horizontal curve and tangent segments. When the posted speed limit was included in the horizontal curve operating speed model, the curve deflection angle and approach density were also statistically significant. When the posted speed limit was not included in the model, median presence and several roadside land use variables were statistically significant in the 85th-percentile operating speed model. In the tangent segments model, only the posted speed limit was statistically significant when included in the model. However, if the posted speed limit was not included in the 85th-percentile operating speed model, then the lane width was found to be statistically significant.

Himes and Donnell (2010) included the posted speed limit as an indicator variable in a model predicting operating speeds on rural and urban multilane roadways. The posted speed limit was found to be associated with both left- and right-lane mean speeds, as well as right-lane speed deviation. Figueroa-Medina and Tarko (2004) found that the posted speed limit had the strongest effect on operating speeds along rural, two-lane tangent segments and rural/suburban multi-lane segments. The authors also noted that other speed-geometric design associations (such as the effect of traveled way width, or gravel shoulder width) become more apparent when the posted speed limit was included in the model. However, these associations were not consistent across different posted speed limits. For example, operating speeds were positively associated with gravel shoulder width on roadway segments with a 90 km/h posted speed limit, but there was a negative

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