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Dollars for lives: The effect of highway capital investments on traffic fatalities

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ABSTRACT

Introduction: This study examines the effect of highway capital investments on highway fatalities. *Methods:* We used state-level data from the 48 contiguous states in the United States from 1968 through 2010 to estimate the effects on highway fatalities of capital expenditures and highway capital stock. We estimated these effects by controlling for a set of control variables together with state and year dummy variables and state-specific linear time trends. *Results:* We found that capital expenditures and capital stock had significant and negative effects on highway fatalities. *Conclusion:* States faced with declines in gas tax revenues have already cut back drastically on spending on roads including on maintenance and capital outlay. If this trend continues, it may undermine traffic safety. *Practical application:* While states and local governments are currently fiscally strained, it is important for them to continue investments in roadways to enhance traffic safety and, more significantly, to save lives.

1. Introduction

Highway fatalities in the United States declined for decades. According to the Federal Highway Administration's (FHWA) annual Highway Statistics reports, the total number of highway deaths in the nation fell from 53,816 in 1970 to 32,885 in 2010.[2] Despite this falling trend in highway fatalities, motor vehicle traffic crashes remain as a leading cause of death in the country. The most recent available reports (Heron, 2013; Subramanian, 2012) indicated that motor vehicle crashes ranked eleventh as a cause of death in 2010, and even fifth in terms of years of life lost (the number of remaining years that a person would have expectedly lived had (s)he not died) in 2009. Highway fatalities seem to have recently climbed back up. Relative to 2010, highway fatalities increased in 2012 by 2.1% to 33,561, equivalent to an average daily death toll of nearly 92. The 3.3% increase in 2012 from a death toll of 32,479 in 2011 represented the first increase in highway fatalities since 2005 (National Highway Traffic Safety Administration, 2013).

Substantial research has focused on factors that could enhance traffic safety. As reviewed in the proceeding section, some of these factors are state-determined, including minimum legal drinking age, maximum speed limit, seat belt use, and state highway expenditures on law enforcement. However, no study has ever been conducted to explore the effects of investments in highway capital on traffic fatalities. This study is designed to fill this gap in the literature. To examine the effects of capital expenditures on highway fatalities, we utilized state-level data for all 48 contiguous states in the U.S. between 1968 and 2010. To preview our results, we found strong evidence that investments in highway capital reduced highway fatalities. Specifically, both the highway capital stock (to be defined formally later) and current capital expenditures had negative and significant effects on highway fatalities. We also found that the effect of capital expenditures was dependent on the existing level of the capital stock. States that had higher levels of highway capital stock had smaller marginal effects from capital expenditures.

This paper begins with some background on traffic fatalities as well as a theoretical explanation of how investments in highway capital can affect fatalities. Section 3 presents our estimation methods including a description of our robustness tests and a presentation of the data we used in this study. Section 4 discusses the results of our main specification and of the robustness tests. Section 5 summarizes and concludes our study with an implication for public policy.

2. Background

There is a large body of literature on the determinants of highway fatalities in the United States. While some state-level studies investigate highway fatality-related factors that are not state-mandated such as gasoline prices (Grabowski & Morrisey, 2004), unemployment (Leigh & Waldon, 1991), and precipitation (Eisenberg, 2004), we, for parsimony, now focus on our discussions on studies examining major state-mandated determinants, namely, speed limit, safety belt use, and

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[2] As in Highway Statistics, the term "highway" used in this study includes state-administered highways, other arterials and collectors, and local roads.

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minimum legal drinking age. Increases in speed limits have been found to have negative safety consequences on traffic fatalities (Baum, Wells, & Lund, 1990; Farmer, Retting, & Lund, 1999; Patterson, Frith, Povey, & Keall, 2002). Studies also found that mandatory seatbelt laws, especially with primary enforcement, decrease traffic fatalities (Cohen & Einav, 2003; Farmer & Williams, 2005; Houston & Richardson, 2006; Wagenaar, Maybee, & Sullivan, 1988). While Asch and Levy (1987) found no evidence on the influence of state minimum drinking age on traffic fatalities, more recent studies found that higher minimum legal drinking ages reduce highway deaths (Fell, Fisher, Voas, Blackman, & Tippetts, 2008; McCartt, Hellinga, & Kirley, 2010; Voas, Tippetts, & Fell, 2003).

In addition to those state-mandated factors, a couple of studies provide some evidence on the effects of non-capital highway expenditures on traffic fatalities. Specifically, studies by Koushki, Yaseen, and Hulsey (1995) and Zlatoper (1991) found evidence that spending on highway law enforcement and safety was negatively related with traffic fatality rates. This study seeks to add to the traffic safety literature by examining the effects on highway fatalities of investments in highway capital in the form of highway capital expenditures and highway capital stock.

How might investments in highway capital affect highway fatalities? Any effect of highway capital investments on fatalities could come potentially from additions to, and improvements in (or lack thereof), various components of highway capital that may be correlated with highway fatalities, such as lane width, shoulder width, shoulder surface, fixed roadside objects (guardrails, light or overhead poles), and road surface quality. For example, in an analysis of 8,050 km of two-lane highways from seven states, Zegeer and Council (1995) found that lane widening could reduce traffic accidents by up to 40%, and shoulder widening could reduce related accidents by as much as 49%. Noland and Oh (2004) also found a negative association between outside shoulder width and traffic fatalities. Holdridge, Shankar, and Ulfarsson (2005) found that fixed roadside objects increased the propensity of fatal traffic injuries.

The condition of a road may matter as poor road conditions may cause problems with steering, breaking, maneuvering, and response that can lead to the loss of vehicle control (Al-Masaeid, 1997; Anastasopoulos, Tarko, & Mannering, 2008; Burns, 1981). Better roads do not however necessarily lead to lower fatalities. Regular drivers usually pay more attention to roads in poorer condition. In addition, speed may be lower on roads in poor condition. This possibility is supported by a study in Canada. Transport Canada (1995) found that 97% of road accidents took place on roads described as "good." In a study using the Highway Statistics series, Noland (2003) also found little effect of infrastructure improvements on highway fatalities. Ultimately, the effects of highway capital investments on fatalities are an empirical question that this study aims to answer.

3. Methods and data

3.1. Methods

We followed the literature on the determinants of traffic safety to model the effects of highway capital expenditures on highway fatalities. We defined total persons fatally injured, y, in state s in year t as a function of logged highway capital expenditures per capita (*Flow*), logged highway capital stock per capita (*Stock*), and a set of controls for economic conditions (*Economy*), driver characteristics (*Driver*), government regulations (*Government*), and locational factors (*Location*). The variables contained in these characteristics are summarized in Table 1. Our model is represented in Eq. (1):

$$y_{st} = f\left(\begin{array}{c} Flow_{st-1},\ Stock_{st-2},\ Economy_{st}, Driver_{st}, Government_{st}, \\ Location_{st}, State_{st}, Year_{st},\ Trend_{st}, Error_{st} \end{array}\right), \quad (1)$$

where *State*, *Year*, *Trend*, and *Error* represent a set of state dummy variables or fixed effects, a set of year dummy variables, a set of state-specific linear trends, and an idiosyncratic error term, respectively.

A key concern is the choice of an appropriate estimation method. Fatalities can be considered rare events (or count data) and are most likely to follow a Poisson or negative binomial distribution. We followed previous studies on traffic fatalities, such as Morrisey, Grabowski, Dee, and Campbell (2006), Noland (2003), Noland and Oh (2004), and Ossiander and Cummings (2002), and estimated the conditional maximum likelihood approach for negative binomial models, where the log of state total annual population was included as an offset variable with its coefficient being constrained to 1. Because negative binomial regression is more appropriate to correct for possible overdispersion, it was chosen over Poisson regression.

We included state dummies to control for state unobserved factors that do not change (or change very little) over time such as weather conditions (e.g., snowfall) that may affect both fatalities and capital expenditures. Year dummies control for common factors that affect highway fatalities across all the states in a year (e.g., safer vehicle models) that may bias our estimates of the effect of highway capital investments on highway fatalities. State-specific linear time trends control for observed underlying factors that follow a linear trend and are correlated with the error term. Our estimates of the key coefficients are based on the correlation between deviations from the state-specific trend in highway capital investments and deviations in highway fatalities.

State and year fixed effects and state-specific linear time trends did not control for variables associated with highway capital investments that changed over time nonlinearly within a state. As a result, we also controlled for a set of time-variant characteristics that measured economic conditions, driver characteristics, government regulations, and locational factors. Economic conditions were controlled for with a set of variables consisting of the unemployment rate, the log of per capita gross state product, the log of per capita personal income, and the log of the annual average retail price of a gallon of gas. Driver characteristics included the log of licensed drivers per capita, the log of registered vehicles per capita, and the share of trucks.[3] In terms of government regulations, we controlled for the presence and types (i.e., primary or secondary enforcement) of seatbelt laws, the maximum speed limits on rural and urban interstates, the enactment of child safety restraint laws, and the legal minimum age to purchase beer. Locational factors consisted of the log of total lane miles, the log of vehicle miles of travel (VMT) per million miles, the log of population density, and indices of annual precipitation and temperature.

The above list of control variables might leave out unobserved variables that are systematically correlated with both variables of interest (*Flow* and *Stock* that will be discussed in the proceeding paragraphs) and the dependent variable, but that are not captured by linear state-specific trends and state and year fixed effects. Such omitted variables, if existed, would bias our estimates. However, this scenario is unlikely.

Capital investments include both capital stock (*Stock*) and capital expenditures (*Flow*) made by both state and local governments. Capital stock represents the condition of highways *before* new investments in highway are made. Capital expenditures per capita include both capital outlay per capita (*Outlay*) and maintenance per capita (*Maintenance*). According to the Federal Highway Administration (2013), capital outlay refers to expenditures on highway improvements, additions, and betterments. More specifically, it includes costs of acquiring right-of-way, construction of roads and structures (e.g., bridges, viaducts, tunnels,

[3] We did not include a variable representing minimum legal driving age because we did not find a data source that tracks its state-by-state changes over the period of 1980–2010. However, it is highly unlikely that our estimates suffered from bias as a result of this omitted variable for two reasons. First, all states established laws on the minimum driving age as early as 1954 (long before 1980—the first year of our dataset). We therefore believe that this minimum driving age had little within-state variation during our sample period, and thus should be captured mostly by state fixed effects we included in the estimations. Second, we already controlled for licensed drivers per capita which should capture, at least partially, changes, if any, in the minimum driving age.