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What affects annual changes in traffic safety? A macroscopic perspective in Virginia

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ABSTRACT

Introduction: Virginia saw a 20% reduction in traffic fatalities in 2008, an unprecedented annual reduction since 1950, and safety stakeholders in Virginia were intrigued about what caused such large a reduction and more generally what affects traffic safety from a macroscopic perspective. *Method:* This study attempted to find factors associated with such a reduction using historical data of Virginia. Specifically, the study related 18 factors to seven traffic safety measures. *Results:* In terms of annual changes, the study found that typical crash exposures were not generally associated with the seven measures, while two economic indicators (unemployment rate and U.S. Consumer Price Index [CPI]) were strongly associated with most of them. *Conclusions:* Annual changes in the CPI and unemployment rate account for about half of the annual changes in total and fatal crash counts, respectively. On average, a 1 point increase in CPI and a 1% increase in the unemployment rate are associated with about 2,500 fewer traffic crashes and about 40 fewer fatal crashes annually in Virginia, respectively.

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1. Introduction

Many factors are associated with traffic safety including environmental, geometric, behavioral, vehicular, and socioeconomic factors. Examples of such factors are driving activities (e.g., vehicle miles traveled [VMT], speed, and fuel consumption); demographic characteristics (e.g., population and age distribution); economic conditions (e.g., sales, disposable income, and unemployment); and others (e.g., alcohol consumption; Hakim, Shefer, Hakkert, & Hocherman, 1991). Based on a review of studies using macro-level datasets, driving activities and demographic and economic factors are typically used to explain traffic crash consequences such as the number of fatalities in a region. For example, Partyka (1984) used population, labor force, and unemployment to predict traffic fatalities. Hedlund et al. (1984) found that economic factors appeared to contribute the most to the national fatality reduction in 1982, followed by alcohol and demographic factors. Hoxie, Skinner, and Wang (1984) used gasoline sales, gas price, unemployment, population, labor force size, and the production index as economic factors to explain the reduction in 1982.

Wagenaar (1984) found that an unemployment rate was associated with traffic crashes yet its impact on reduction in traffic crashes was small. Joksch (1984) reported a nearly linear relationship between changes in the industrial production indices and traffic fatalities using national data from 1950 through 1972. Kopits and Cropper (2005) linked per capita income to traffic fatalities. Fowles and Loeb (1995) included unemployment rate, real disposable personal income, and alcohol consumption as control factors, and Loeb (1987) examined various socioeconomic factors and identified beer consumption as one of influential factors in predicting fatality rate changes. However, in Kweon's (2008) examination of the validity of using crash/victim rates to measure traffic safety performance of Virginia, among 20 candidate crash/victim rates, only the injury rate per million drivers was found to be valid for a long-term comparison purpose in Virginia while the other 19 rates were invalid. According to the survey by Hakim et al. (1991), the unemployment rate appears to be the most commonly used factor in explaining traffic crash consequence measures from macro perspective and it is negatively associated with traffic crashes.

In 2008, all U.S. states except for four (Delaware, New Hampshire, Vermont, and Wyoming) saw a reduction in traffic fatalities, ranging from 1% in Colorado to 24% in Alaska (NHTSA, 2009). A 9.7% reduction (about 4,000 fewer fatalities) was recorded in the United States, and a 20% reduction (203 fewer fatalities) was recorded in Virginia. There was a 5.8% reduction in traffic injuries and a 3.5% reduction in total traffic crashes in the United States (NHTSA, 2009).

Such reductions led to the question: What factors were associated with them? This study attempted to answer this question using historical annual data. The study attempted to find factors associated with changes in seven traffic safety measures (e.g., numbers of fatalities and of fatal crashes). The study related 18 factors including several economic indicators to the seven crash/victim annual counts in terms of annual changes. Annual time-series data were collected on the 18 factors, and annual changes instead of annual raw values were used in a regression analysis with autocorrelation treatment in case serial correlations were present.

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2. Data

Empirical data were collected in Virginia and the United States on the 18 potential factors identified by a literature review. For some of the factors, data were aggregated for different intervals. For example, for Gross Value-weighted Industrial Production (GVIP), two-interval data, quarterly and yearly, were available. For consistent data analysis across all factors, a common data interval was recommended. Among the three typically found intervals (month, quarter, and year), the year interval was selected for this study mainly because annual data were available for all 18 factors.

Table 1 describes the study data, including a variable description, available data period, and source. Seven traffic safety measures (crash/victim counts) that are often used to describe traffic safety conditions were collected for 40 years or more. The 18 potential relevant factors cover various aspects relevant to traffic safety ranging from aspects directly reflecting traffic crash exposures (e.g., VMT) to aspects indirectly or distantly reflecting transportation activities (e.g., U.S. Consumer Price Index [CPI]). Four traffic crash exposure measures typically used to calculate crash/victim rates, such as fatality rate per million population, were included: VMT, population, number of drivers, and number of registered vehicles. Many economic and financial indicators were also included such as unemployment rate and CPI. Some of the 18 factors, such as CPI and Producer Price Index (PPI), were not available at the state level. Thus, such data were collected at the national level.

3. Analysis method

A regression analysis was selected to analyze yearly data mainly because it can relate a traffic safety measure to multiple relevant factors. In a regression analysis, there are various types of regression models available ranging from a classical linear regression to non-linear cross-sectional time-series regression. Since the data collected for this study were multivariate time-series data mostly for Virginia, cross-sectional time-series (also known as panel) regression models were not applicable. Fig. 1 is a flowchart showing how an appropriate regression model was chosen for the study.

3.1. Data aggregation period

Granger (1969) was initially considered after a review of Hoxie et al. (1984). However, it was discovered that the test would be inappropriate if data were aggregated over a period longer than a lag period of a cause–effect phenomenon (Hoxie et al., 1984). For example, if an effect was realized 1 month after a cause occurred, data should not be aggregated over a period longer than 1 month. Using data aggregated over a period longer than the lag period would lead to failure to discover a cause–effect relationship among the data if such relationship existed. Other studies (Gulasekaran & Abeysinghe, 2002; Maminggi, 1996) have warned about distortion of test results when data aggregation is involved.

Because the study data were prepared on an annual basis, any cause–effect relationship that might exist with a lag period less than 1 year would probably not be uncovered regardless of statistical analysis techniques. It was conjectured that if a change in values of any of the explanatory variables in Table 1 caused a change, for example, in the number of total crashes, the effect attributable to the cause would probably be realized in a period shorter than the aggregation interval (1 year). For example, if an increase in unemployment rate in a certain month were to result in a decrease in total crashes in the next month, the cause–effect relationship could not be found by Granger's causality test using the yearly aggregated unemployment rate and crash count data because the aggregation period (1 year) is longer than the cause–effect lag period (1 month).

3.2. Serial correlation

Since the data were time-series in nature, a serial correlation might well exist; if it did, it would interfere with a statistical significance of the relationship. Thus, a statistical test for serial correlations should be performed to detect the presence of such correlations. If serial correlations were found, a regression model that corrects for the correlations embedded in time-series data should be used. Serial correlations were found in all the variables listed in Table 1 based on the Durbin–Watson test. Thus, a regression model with correction for serial correlations was employed in the study.

Table 1
List of variables of annual data used.

Variable		Description	Period	Source
Traffic safety measures	Fatality	Number of fatalities	1951–2008	Virginia Department of Motor Vehicles
	Fatal crash	Number of fatal crashes	1969–2008	
	Injury	Number of injuries	1951–2008	
	Injury crash	Number of injury crashes	1969–2008	
	Fatality + injury (FI)	Sum of fatalities and Injuries	1951–2008	
	Fatal + injury (FI) Crash	Sum of fatal crash and injury crash	1969–2008	
	Crash	Number of total crashes	1951–2008	
Potential relevant factors	Beer	Per capita beer consumption (gallons)	1994–2008	Beer Institute
	CUI	Manufacturing Capacity Utilization Index: Base 2002	1967–2008	Board of Governors of the Federal Reserve System
	U.S. CPI	U.S. Consumer Price Index (all urban consumers)	1976–2008	U.S. Bureau of Labor Statistics
	Driver	Number of registered drivers	1971–2008	Virginia Department of Motor Vehicles
	Employment	Number of employed persons	1976–2008	U.S. Bureau of Labor Statistics
	U.S. gas price	U.S. gas price (cents)	1990–2008	U.S. Energy Information Administration
	Gas Production	Gasoline through company outlets volume by refiners (thousand gallons per day)	1985–2008	
	GVIP	Gross value-weighted industrial production: Base 2000	1972–2008	Board of Governors of the Federal Reserve System
	Income	Per capital disposable personal income	1958–2008	U.S. Bureau of Economic Analysis
	IPI	Industrial Production Index in manufacturing: Base 2000	1951–2008	Board of Governors of the Federal Reserve System
	Labor force	Number of persons in labor force	1976–2008	U.S. Bureau of Labor Statistics
	Population	Population	1968–2008	U.S. Census Bureau
	U.S. PPI	U.S. Producer Price Index (commodity)	1976–2008	U.S. Bureau of Labor Statistics
	Sales	Taxable sales	1985–2008	Weldon Cooper Center for Public Service
	Unemployment	Number of unemployed persons	1976–2008	U.S. Bureau of Labor Statistics
	Unemployment rate	Unemployment rate (=unemployment/labor force)	1976–2008	
	Vehicle	Number of registered vehicles	1951–2008	Virginia Department of Motor Vehicles
	VMT	Vehicle miles traveled	1951–2008	

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