Understanding the Impact of Gasoline Price Changes on Traffic Safety: A Time Geography Approach

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Abstract

The impact of gasoline price changes on traffic safety has received increasing attention in empirical studies. In this study, we use time geography to provide a theoretical framework for examining the effects of time-varying fluctuations in gasoline prices and their relationship to traffic safety in a case study of Mississippi from April 2004 to December 2010. Application of time geography theory suggests that gasoline prices act as one type of capability constraint of the space-time path. As gasoline prices increase (that is, as the capability constraint becomes stronger), we hypothesize traffic crash rates decrease, and they decrease more for groups for whom the constraint is stronger. The results corroborate the hypotheses and suggest that gasoline prices have stronger effects on reducing less severe crashes and negligible effects on reducing fatal crashes. Gasoline price effects on reducing crashes start at a 9-month lag, peak at a 12-month lag, and diminish after an 18-month lag.

Conceptual Framework

Recent gyrations in gasoline prices have resulted in complex social and spatial implications for travelers, the public, planners, and decision makers. One positive consequence of gasoline price increases is that it leads to improved traffic safety (in terms of lower levels of crash frequency and rates). Although a large body of literature has empirically examined the impact of gasoline price changes on traffic safety, the impact has not yet been explained from a conceptual or theoretical perspective. This study helps fill this gap in the literature by exploring the impact through the conceptual framework of time geography theory.

Time geography (Hägerstrand, 1970) is used as the conceptual framework to explain the link from higher gasoline prices to less driving and less aggressive driving to reduce traffic crash frequency and rates. Time geography theory studies the relationships between the behavioral possibilities of individuals and the various spatial and temporal constraints on those behaviors. We understand gasoline prices as one type of capability constraint, referring to biological and physical limitations that restrict an individual from participating in activities.

We expect that as gasoline prices increase (as the capability constraint becomes stronger), traffic crash frequency and rates will decrease. Higher gasoline prices reduce the amount of gasoline an individual can afford to consume, causing an individual to drive less distance, less frequently, or perhaps less aggressively, in turn reducing exposure to traffic crashes.

Gasoline price increases reduce transportation accessibility by reducing the lengths and frequencies of economically feasible space-time paths, which in turn leads to fewer traffic crashes. Furthermore, we expect that this capability constraint will be stronger for some drivers (those with lower incomes or weaker claims on household incomes) and will manifest itself in differential effects by age, gender, and race. Time geography provides the theoretical underpinnings for predictions of the effects of gasoline prices on traffic safety by producing testable hypotheses that the empirical analysis corroborates.

As we expect capability constraints to be differentially impactful, we expect that significant variations will exist across demographic categorizations of the population. We expect that gasoline price effects are stronger on 1) the traffic crash rate of younger drivers, who have greater capability constraints due to their lower incomes (Chi et al., 2010); 2) the traffic crash rate of women, who have greater elasticity in the nature of their trips due to the larger number of non-work trips that are not time and space fixed (Ren and Kwan, 2009); and 3) the traffic crash rate of whites, who have greater rates of ownership of private vehicles, greater travel distances by private vehicles (Raphael and Stoll, 2001), and more discretionary trips by auto to give up.

Data

Crash data, both total and fatal by age, gender, and race, were obtained from the Mississippi Highway Patrol at the monthly level from April 2004 until December 2010. Summary statistics are shown in Table 1. Data for monthly regular-grade gasoline prices in Mississippi were obtained from the Energy Information Administration and were adjusted for inflation in January 2011 dollars. Control variables included in the analysis are seat belt usage (Mississippi Department of Public Safety), alcohol sales (Beer Institute), state unemployment rate (U.S. Bureau of Labor Statistics), and precipitation and temperature (Southeast Regional Climate Center).

Table 1. Descriptive statistics of crashes at the monthly level in Mississippi, April 2004–December 2010

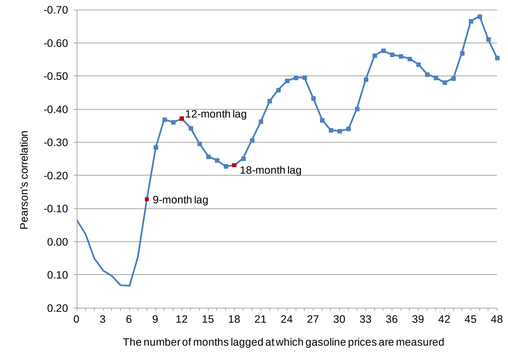
	Total crashes				Fatal crashes			
	Monthly Mean	Std. Dev.	Minimum	Maximum	Monthly Mean	Std. Dev.	Minimum	Maximum
Driver characteristics								
Age								
15–23	2,485	342	1,360	3,105	17	7	3	37
24+	7,471	775	4,679	9,303	63	14	29	96
Gender								
Male	5,243	639	3,085	6,784	58	14	25	105
Female	4,712	478	2,950	5,589	21	6	7	38
Race/Ethnicity								
Non-Hispanic white	6,490	733	3,970	8,056	46	12	15	76
Non-Hispanic black	3,465	361	2,076	4,201	24	7	7	44
Total	9,956	1,076	6,115	12,257	79	18	36	127

Methods

We first examine the temporal relationship between gasoline prices and traffic crashes by illustrating the correlation between monthly-lagged gasoline prices and crashes. Figure 1 tests the correlation of prices by month intervals and shows that the Pearson's correlation between gasoline prices and crashes is neither strong nor statistically significant prior to a 9-month lag at the $p \leq 0.05$ level. All the correlations at a 9-month lag and later are statistically significant. The correlation peaks at a 12-month lag and bottoms at an 18-month lag. After that, the correlation follows a general uptrend with seasonal variations. We suspect that gasoline price effects on traffic crashes are limited to an 18-month period and that the higher correlation after the 18-month period might be the result of a coincidence of secular changes and seasonal variation in gasoline prices and crashes.

Negative binomial regression models are used for all crash measures. Each model is a function of gasoline prices at the current time, a 9-month lag, a 12-month lag, and an 18-month lag, seat belt usage, state unemployment rate, alcohol sales, precipitation, and temperature.

Figure 1. Pearson's correlation between monthly total crashes and monthly-lagged gasoline prices in Mississippi, April 2004–December 2010



We use the gasoline price measures to examine their relationship with traffic crashes as well as crashes by age, gender, and race at the monthly level. Several population variables based on age, gender, and race are used as exposure variables in corresponding models. Thus, the models actually examine the effect of gasoline prices on crash rates (the number of crashes per capita) rather than on crash counts.

Results

Elasticities of crashes per capita with respect to gasoline prices are calculated at the mean price of $2.22 (for the studied period) and presented in Table 2 for the significant (at the $p \leq 0.10$ level) gasoline price variables. Gasoline price at the current time does not have significant effects on reducing total crashes. The three lagged gasoline prices do have significant effects on reducing total crashes. However, none of the four gasoline price variables have statistically significant effects on reducing fatal crashes.

Gasoline prices at the current time and at a 9-month lag have a significant effect on the traffic crash rate among the younger population; gasoline prices do not have significant effects on the crash rate at a 12-month lag and an 18-month lag. For the older population, gasoline prices do not have an immediate effect, but an intermediate-term effect on the crash rate of the older people was demonstrated. Gasoline prices have no significant effects on fatal crash rates of the younger or the older populations.

Gasoline prices have an intermediate-term effect, but not an immediate effect, on the traffic crash rate of men. The effect that gasoline prices have on reducing women's crash rate is limited to a 9-month lag. Gasoline prices have no significant effects on the fatal crash rate of male drivers but a significant effect on the fatal crash rate of female drivers at a 12-month lag.

Gasoline prices do not have an immediate effect, but an intermediate-term effect on the crash rate of whites was demonstrated. For blacks, gasoline prices only have effects on reducing the crash rate at a 12-month lag and an 18-month lag. Gasoline prices have an effect on reducing the fatal crash rate of white drivers at a 12-month lag and of black drivers immediately.

Table 2. Elasticities of crashes per capita with respect to gasoline prices estimated from negative binomial regression models, Mississippi, April 2004–December 2010

	Total	Age		Gender		Race	
		15–23 years	24+ years	Men	Women	White	Black
Total crashes							
Gasoline price at the current time		–0.1428					
Gasoline price at a 9-month lag	–0.1025	–0.1229	–0.0944	–0.0954	–0.1114	–0.1106	
Gasoline price at a 12-month lag	–0.1563		–0.1655	–0.1930		–0.1599	–0.1488
Gasoline price at a 18-month lag	–0.1232		–0.1333	–0.1476		–0.1267	–0.1171
Fatal crashes							
Gasoline price at the current time							–0.3260
Gasoline price at a 9-month lag							
Gasoline price at a 12-month lag					–0.5897	–0.2020	
Gasoline price at a 18-month lag							

Notes: Elasticities of crashes per capita with respect to gasoline prices are calculated at the mean price of $2.22 (for the studied period). They are presented only when the corresponding gasoline price variables are statistically significant at the $p \leq 0.10$ level.

Discussion

The findings highlight a complex relationship between temporal shifts in gasoline prices and their unique effects on traffic crashes that is further tempered by the availability of resources across specific demographic groups. Thus, we expect systematic variations in space-time paths that are directly related to the unique conditions experienced at the intersections of age, gender, and race. Time geography provides a framework in which we can conceptualize the potential impact of shifts in gasoline prices on traffic crashes and their relationship to group-specific adjustments to space-time paths.

This study contributes to the literature on gasoline prices and traffic safety and the application of time geography theory in three ways: 1) using data that covers a longer time period with both economic growth and decline, the results confirm that higher gasoline prices lead to higher levels of traffic safety; 2) the time intervals by which gasoline prices are associated with traffic crashes, which has not been addressed in previous research of gasoline prices and crashes; and 3) to explain gasoline price effects on traffic safety; prior research has not provided theoretical explanations for the effects.

The relationship between gasoline prices and traffic safety could be further investigated in at least four research directions: 1) the capability constraint argument of the time geography theory should be empirically tested; 2) how gasoline prices and traffic safety are associated temporarily should be comprehensively investigated; 3) future research could benefit from spatial regression analysis when gasoline price data below the state level become available; and 4) it might be promising to study the variation of gasoline price effects on traffic safety by socioeconomic groups.

Notes

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