A STATISTICAL MODEL ON VARIATIONS IN STATE GASOLINE TAXES

ETHAN TROTZ, UNIVERSITY OF GEORGIA

Abstract

State gasoline and diesel fuel taxes are the most important sources of state transportation funding for highway maintenance and repairs. Thirty-six states levy a fixed-rate tax that has been in place for extended periods of time while others impose a variable tax rate. The primary objective of this study is to develop a multivariable econometric model to explain factors associated with variations in state gasoline taxes across 48 states. Three years of panel data, 2008, 2009, and 2010, were used to estimate the model, which controls for economic, climatic, and demographic factors at the state level. Three of the hypothesized variables were statistically significant. All of the hypothesized variables had the expected sign, with the exception of Income Per Capita. Results indicate that as the average temperature in the state declined one degree, the gasoline tax increased by $0.00451 per gallon. As per capita income increased, the gasoline tax decreased by $0.00000310 per gallon. As energy-related carbon dioxide emissions increased, the gas tax increased by $0.000000162 per gallon. The results of this analysis will have significant policy implications for revenue generation, highway maintenance, and transportation infrastructure.

United States (US) highways are in need of maintenance, repair, and expansion in order to keep transportation costs low for farmers, businesses, and the traveling public. The recent severe winter weather stressed the highway system, creating potholes and failing roads and bridges. With individuals and businesses so interconnected, properly functioning highway systems are of critical importance to the future development and success of the US.

Gasoline taxes are the most important sources of state transportation funding (Figure 1). States levy their own gasoline taxes in addition to the federal gasoline tax. Gasoline tax revenues go towards maintaining and constructing new transportation infrastructure as well as any administrative expenses incurred by states' respective departments of transportation (DOTs). States also divert gasoline tax revenue to spending unrelated to roads, highways, and bridges such as debt service, education, and Medicaid (Paletta 2014). Thirty-six states levy a fixed-rate tax, a rate that has remained constant for extended periods of time (Figure 2). Among these 36 states, 17.2 years have passed on average since the gasoline tax was raised.

In recent years, state gasoline tax revenues have declined relative to the increasing costs of maintaining and constructing new transportation infrastructure in addition to increasing administrative costs. Additionally, since 1993 inflation has "eroded the purchasing power of the $0.184 per gallon federal gasoline tax by more than 30 percent" (Geddes and Wassink 2014). With stricter air pollution standards cars are now more fuel-efficient than ever before and can travel greater distances using lower volumes of gasoline. As a result of these factors, among others, most states suffer from insufficient gasoline tax revenues. This system is not sustainable and requires an overhaul in order to narrow the increasing gap between state gasoline tax revenues and the increasing costs of highway maintenance, repair, and expansion.

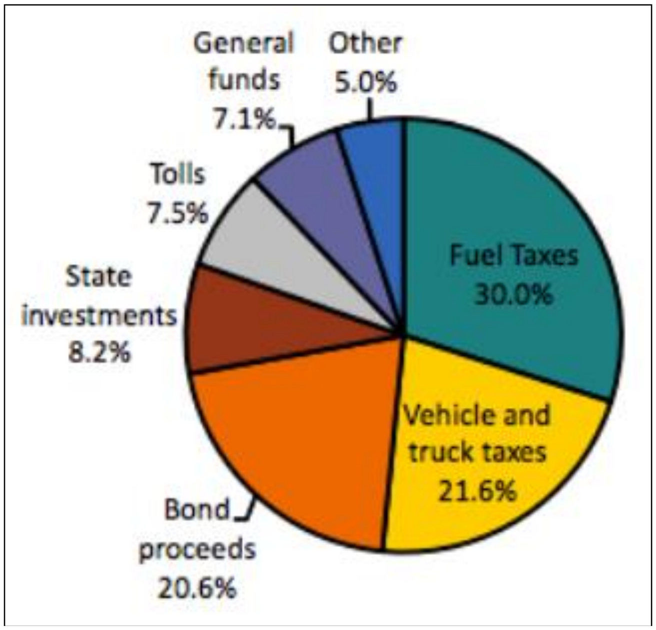

Figure 1. State sources of transportation revenue.

Because many states levy a fixed-rate gasoline tax while others levy a gasoline tax adjusted for inflation, state gasoline taxes, measured in this study as cents per gallon, will inherently vary. Moreover, these taxes can differ greatly, as New Jersey levies the lowest rate at $0.145 per gallon while California collects the highest rate at $0.5289 per gallon, representing a 72.6 percent difference between the two (see Figure 3). Why does California impose such a larger gasoline tax than New Jersey? Such a difference must be attributed to economic, political, and infrastructure factors. This study attempts to explain variations in state gasoline taxes for highway maintenance, repair, and construction.

Literature Review

The problem of gasoline tax revenues inadequately funding transportation infrastructure projects is not new. Christopher Wells (2012) outlines the historical nature of this issue. When car ownership burgeoned in the late 1910s and early 1920s, gasoline taxes provided a seemingly inexhaustible source of revenue, allowing states to begin aggressive infrastructure campaigns. When some state governments attempted to allocate gasoline tax revenue towards non-transportation projects, opponents successfully earmarked these revenues for highway expenditures, effectively creating "self-funded" highways. "By the end of World War I, traditional revenue sources could no longer keep up with the escalating costs of road construction" (Wells 2012). This system of self-funded highways relied on what was considered at the time a cheap, unlimited supply of gasoline. As a result, a major issue emerged: "Gas taxes funded more and better roads, more and better roads generated new traffic and longer trips, new traffic and longer trips consumed more gas, higher gas consumption created more tax revenue, and more tax revenue funded more and better roads" (Wells 2012). In addition to a flawed system, major obstacles to gasoline tax increases remained widespread, including lifestyles, high incomes, low population densities, the presence of oil industries, and urban sprawl (Hammer, Lofgren, and Sterner 2004).

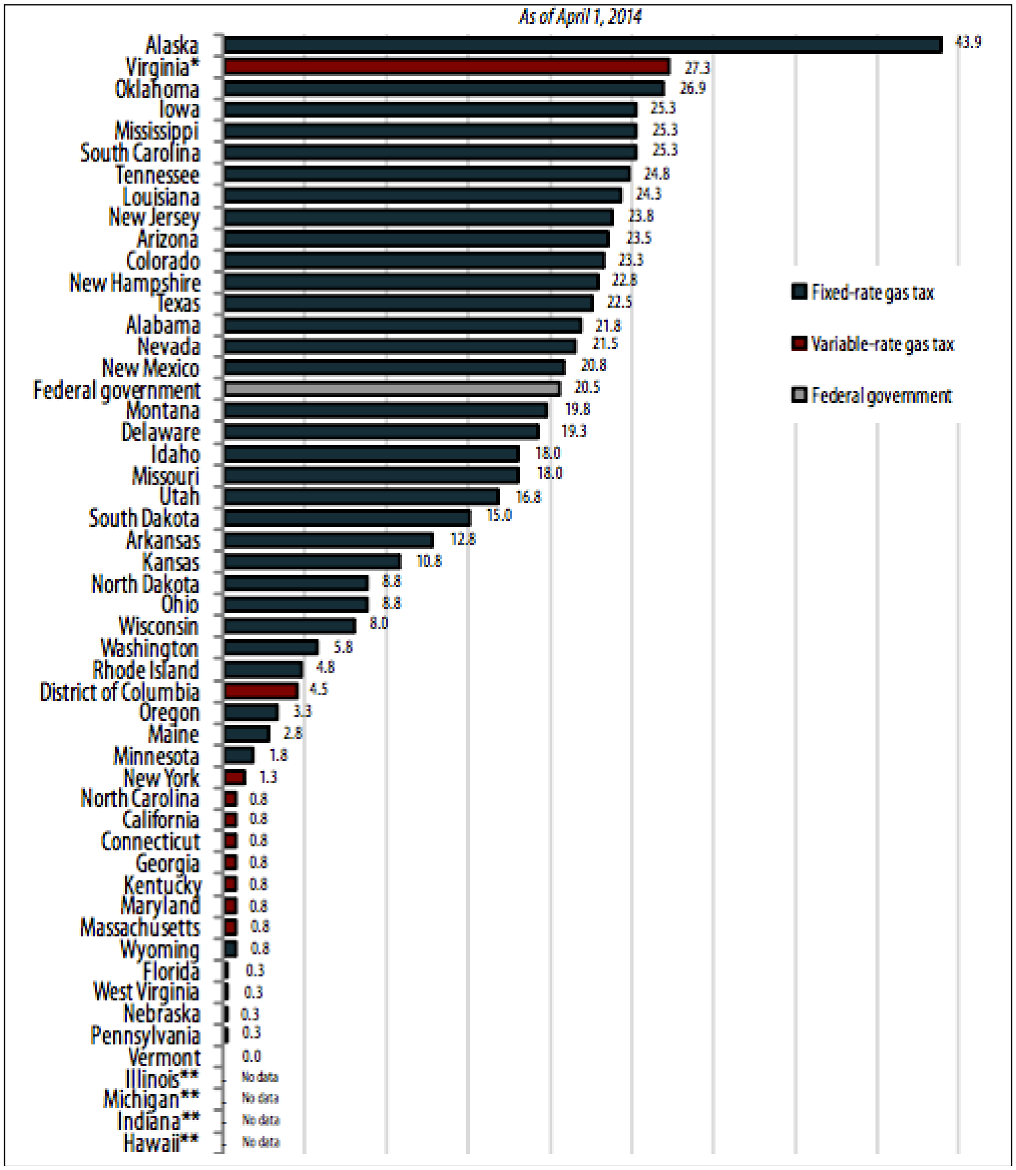

Figure 2. Years since last gasoline tax increase.
Source: http://www.itep.org/pdf/gastaxincreases0414.pdf.

A study conducted by Hartgen, Fields, and San José (2013) describes some of the issues regarding infrastructure maintenance. Factors affecting state highway systems include climate, geography, urban congestion, and state budget circumstances. As recently as 2010, twenty states reported more than 25 percent of their bridges as deficient, adding to the belief of many researchers that the overall highway system of the United States is crumbling. Other estimates claim that one of every nine bridges in the United States is structurally deficient (Reid 2014). In

2013, for the ninth straight year vehicle miles traveled (VMT) decreased (Geddes and Wassink 2014). If VMT decreases, gasoline consumption and gasoline tax revenue decreases. Proof of the dire state of highway funding is clear through the actions of Congress. Since 2008, Congress has allocated $54 billion to cover shortfalls in the Highway Trust Fund. The Trust Fund is projected to spend $97 billion more than it brings in during the next decade (Geddes and Wassink 2014).

Jay Landers (2013) details the emerging need of states to raise additional gasoline-based tax revenue. While many states continue to refrain from increasing gasoline taxes, several states recently enacted or attempted to enact legislation to increase gasoline taxes to raise more transportation revenue (as seen in Figure 2). Whether these acts will turn into a strong trend remains to be seen. In the first few months of 2013, Wyoming, Virginia, Maryland, and Vermont enacted legislation to increase their respective excise or sales taxes on gasoline. Wyoming increased its gasoline tax by $0.10 per gallon and expects to raise around $72 million in 2014.

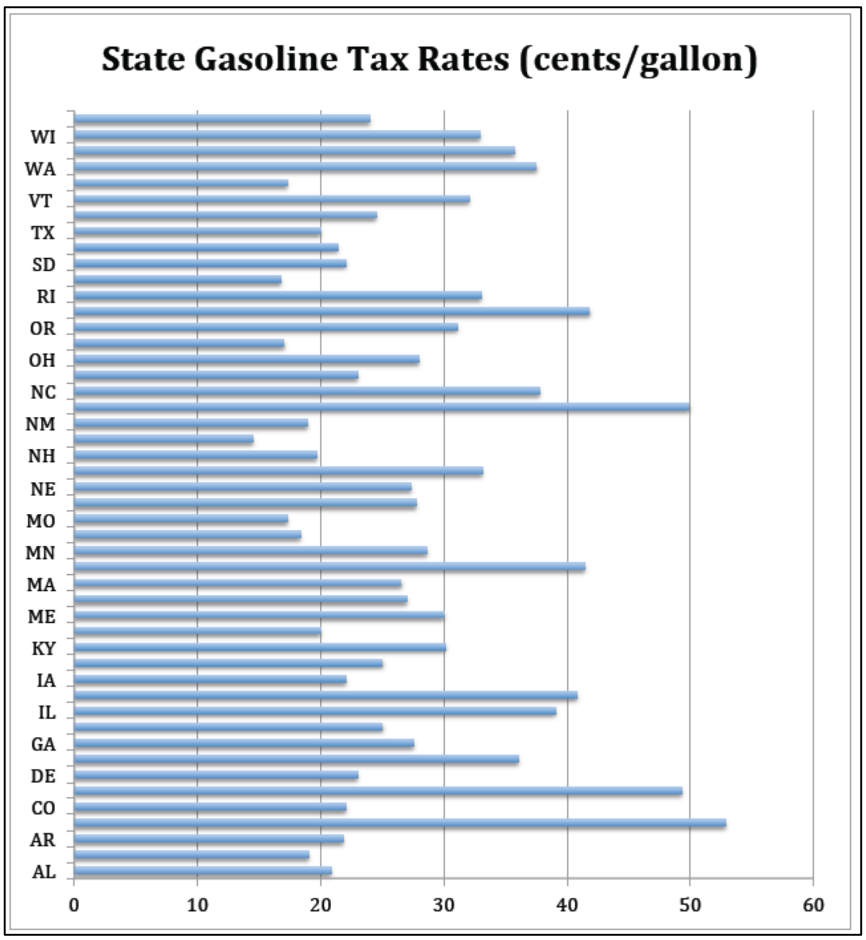

Figure 3. State gasoline tax rates as of April 25, 2014.

Source: http://www.api.org/oil-and-natural-gas-overview/industry-economics/~/media/Files/Statistics/StateMotorFuel-OnePagers-Oct-2014.pdf.

Virginia policymakers set aside a portion of its sales tax revenue to direct toward transportation expenses, expecting to raise almost $6 billion over the next five years for transportation. Policymakers in Maryland raised the state's gasoline tax for the first time since 1992, phasing in a 3 percent sales tax on gasoline. The state gasoline tax of Vermont will increase by $0.03 per gallon over the next two years.

The need to pay for transportation is unlikely to subside in the near or long term. According to Landers (2013), states face a number of challenges regarding transportation funding including a widening gap between investment needs and outlays, growing demand for transportation services, declining revenues due to increased fuel efficiency, and uncertainty regarding federal funding for transportation.

Economic Theory

The most important variables for predicting a state's gasoline tax are economic and demographic. A road will degrade more quickly as the number of drivers on it increases. Thus, population density will likely be a key factor in explaining a state's gasoline tax rate. However, population density must be related to a state's road system. Population density is correlated with a reliance on private transportation as more spread out areas require greater travel distances and contain less developed public transit systems (Hammer, Lofgren, and Sterner 2004). The number of people per mile of highway will likely be a significant variable. We would expect a state's gasoline tax rate to be positively correlated with the number of people per mile of highway. An increase in the gasoline tax rate is necessary to compensate for the increase in wear and tear on roads due to more miles traveled.

Weather can significantly impact the condition of highway infrastructure as harsh conditions will stimulate its degradation. Harsh weather, in this sense, involves colder temperatures. In northern states colder temperatures bring about snow and ice and repeatedly freeze roads and bridges. Such increased degradation of transportation infrastructure is likely to be accompanied by a higher gasoline tax rate to compensate for the incremental damage. As a result, we would expect a state's annual average temperature to be inversely correlated with a state's gasoline tax rate.

The effect of toll roads on a state's gasoline tax rate is difficult to predict. States that receive revenue from tolls might have lower state gasoline tax rates as a result; however, states with tolls may need more revenues in general, spurring these states to levy higher gasoline taxes even though they receive revenue from tolls. Therefore, we hypothesize that tolls will have a positive effect on a state's gasoline tax rate.

Empirical Model of State Gasoline Sales Tax

In the empirical model used for this study, the dependent variable is a state's gasoline tax rate measured in cents per gallon (T_G) deflated by the national CPI using a base year of 1982. Independent factors hypothesized to impact gasoline tax rates include state gross domestic product (GDP) per capita and highway miles per square mile of land. Ultimately, the independent variables included account for population density, weather, tolls, per capita energy-related carbon dioxide emissions, and per capita income. The model chosen is as follows:

$$(1) \qquad T_G = \beta_0 + \beta_1(AvTemp) + \beta_2(TollD) + \beta_3(PCI) + \beta_4(CO_2) + \beta_5(PPMH) + \varepsilon$$

The people per mile of highway variable (*PPMH*) was calculated by dividing a state's total population by the total number of highway miles in that state. The average temperature (*AvTemp*) of a state is simply the average daily temperature recorded in a given state in a given year. For the toll dummy variable (*TollD*), those states with at least one toll road receive a value of 1 and those states without a toll road receive a value of 0. Per capita income (*PCI*) reflects the tax base in each state. States with higher per capita incomes were expected to have higher gasoline taxes. The variable CO_2 represents the energy-related carbon dioxide emissions divided by total population.

Data

Data were collected largely from government agencies and databases including the National Oceanic and Atmospheric Administration (NOAA), Federal Housing Administration (FHA), Bureau of Economic Analysis (BEA), and the US Census Bureau. Additional data were collected from third-party sources such as the Tax Foundation. Each variable includes three years of data per state, 2008, 2009, and 2010, for a total of 144 observations. Alaska and Hawaii were excluded from this study since they differ greatly from the rest of the states in many ways and could have skewed the results. Data descriptions and summary statistics are found in Table 1.

Before coming to a final model, tests for multicollinearity were conducted. A correlation matrix (Table 2) and variance inflation factor (VIF) test (Table 3) were both performed. The highest VIF was 2.59, indicating an absence of multicollinearity. Furthermore, correlation coefficients did not display any high correlation among independent variables.

Table 1. Descriptive statistics of ordinary least squares variables.

Variable	Observations	Mean	Std. Dev.	Minimum	Maximum
T_G	144	24.42	6.26	8.18	41.58
AvTemp	144	52.09	7.88	38.9	71
PCI	144	42376.83	6184.02	33274.58	62131.59
TollD	144	0.65	0.48	0	1
CO_2	144	3142.04	34911.94	88	419170
PPMH	144	78.84	54.75	7.39	224.22

Table 2. Correlation matrix for variables in the model of gasoline tax rates.

	T_G	*AvTemp*	*PCI*	*CO2*	*PPMH*	*TollD*
T_G	1					
AvTemp	-0.4282	1				
PCI	-0.0269	-0.2823	1			
CO2	0.1179	-0.0198	0.0333	1		
PPMH	-0.1103	0.2468	0.6005	0.1290	1	
TollD	-0.0208	0.1998	0.1854	0.0596	0.4477	1

Table 3. VIF Test.

Variable	VIF	1/VIF
AvTemp	1.56	0.6411
PCI	2.30	0.4351
CO_2	1.03	0.9701
PPMH	2.59	0.3859
TollD	1.27	0.7870

Notes: VIF (Variance Inflation Factor) is a measure of multicollinearity. The maximum VIF value accepted is generally 10.

Results

Three independent explanatory variables are significant at the 1 percent level as seen in Table 4. Although variable *PPMH* was not statistically significant, the coefficient yielded the expected sign. The more people per mile of highway, the higher a state's gasoline tax. *AvTemp* also has the expected coefficient sign. As a state's average temperature decreases, a state's gasoline tax increases. The dummy variable for the presence of tolls in a state is expected to increase a state's gasoline tax rate. However, this dummy variable was not statistically significant. The sign of the coefficient on *PCI* is opposite to what was expected. While significant at the 5 percent level, the sign of the coefficient for the per capita income variable indicates that as income per capita increases, a state's gasoline tax rate decreases. As income rises, taxes in general should rise, given that higher income states have the ability to pay more. The sign of this coefficient could partially be explained by the fact that sales taxes are regressive taxes (Krugman and Wells 2013). Sales taxes fall heaviest on low-income taxpayers and those states with the lowest per capita income pay higher taxes as a share of total income, *ceteris paribus.* Energy-related carbon dioxide emissions yielded the expected sign. As a state's energy-related carbon dioxide emissions increase, so does its gasoline tax rate.

Table 4. Output of ordinary least squares regression.

Number of Observations	144
F (5, 138)	93.86
Prob > F	0.0000
R^2	0.2421
Root MSE	5.5433

T_G	Coefficient	Robust Std. Error	t-statistic	Prob > $\|t\|$	95% Confidence Interval
AvTemp	-0.4518	0.0639	-7.07	0.000	-0.5781, -0.3255
TollD	0.8779	1.0739	0.82	0.415	-1.2455, 3.0013
PCI	-0.0003	0.0001	-2.61	0.010	-0.0005, -0.00008
CO_2	0.0000162	0.00000287	5.65	0.000	0.0000106, 0.0000219
PPMH	0.0197	0.0139	1.42	0.159	-0.0078, 0.0472
Intercept	62.4734	6.2515	9.99	0.000	50.1123, 74.8345

Discussion

More observations could improve the results of this study. With only three years of data utilized totaling 144 observations across all states except Alaska and Hawaii, more significant results might be helpful in explaining the factors associated with a state's gasoline tax rate.

Economic theory suggests why each of these variables could significantly affect a state's gasoline tax rate. We can reasonably assume colder temperatures degrade highway infrastructure more quickly than warmer temperatures. In addition, we can reasonably assume more people per mile of highway leads to more drivers on roads and increased wear and tear on roads as a result. Thus, states with a larger population per mile of highway were expected to have higher gasoline taxes due to more vehicles on the road. We can reasonably assume states with tolls require additional revenue to meet transportation needs and levy higher gasoline taxes as a result of this need. These assumptions lead one to believe that states with these characteristics have higher gasoline taxes than other states.

Aside from increased observations, other modifications could enhance this study. Changing the dependent variable from a state's gasoline tax rate to state gasoline tax revenue per capita would allow researchers and policy makers to predict more easily a state's gasoline tax revenue and budget the following fiscal year accordingly. Another method involves investigating the variables dealing with highway infrastructure spending.

An important factor to note in this debate is the current trend of environmental awareness. "Reliance on the taxation of motor fuels as a source of program revenue in an era of growing concern about fuel efficiency and greenhouse gas emissions creates an unacceptable conflict among otherwise desirable public policy goals" (Wachs 2009). Thus, relying on increased consumption of gasoline generates obvious negative externalities that affect the environment. For example, encouraging motorists to drive hybrid and electric cars reduces the carbon footprint from automobiles but decreases the revenues raised for transportation projects. A nation cannot rely on gasoline consumption for transportation tax revenue when current trends are proceeding in other directions.

Conclusions

This study can serve as a point of reference for further research. Incorporating data from the past few decades should lead to much more accurate results, but the fact that many states have not changed their gasoline taxes for years may not lead to much improvement. Political factors, such as the presence of conservative lobbying groups, could be included in the model. Such a factor might explain why some states impose lower gasoline tax rates than others. Moreover, states continue to divert gasoline tax revenues to fund unrelated expenses such as debt service, education, Medicaid, and schools (Paletta 2014). Debt servicing for already completed projects places claims on state highway funding that will take decades to pay off, leaving less money for infrastructure repairs and new projects.

The necessity for states to raise additional funds for transportation needs is apparent. The roots of the current state of gasoline taxes can be traced all the way back to World War I. The system is unlikely to ever function sustainably, and the issues surrounding this problem are compounding annually. In order to reverse current trends of declining quality of highway infrastructure, change is necessary, either in the form of a simple increase in state gasoline tax rates or an entire overhaul of the system.

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