Differential Effects of Federal and State Gasoline Taxes on Gasoline Consumption*

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Abstract
Previous studies find that gasoline consumption is more responsive to gasoline taxes than to comparable changes in the tax-exclusive gasoline price. In this paper, we examine this topic more extensively by considering the differential effects on gasoline consumption of the tax-exclusive price and four specific taxes and fees levied on gasoline. We find that the response to changes in the federal excise tax is larger than the response to changes in state taxes, and the response to change in both taxes are greater than for changes in the tax-exclusive price. However, there is little difference across the three state taxes, state excise tax, state sales tax, and fees on gasoline.

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1. Introduction

The price of gasoline at the pump is the sum of the tax-exclusive price and various taxes, such as federal and state fuel excise taxes. Traditional economic theory suggests that a consumer's purchase decision should depend on the tax-inclusive price, and should not depend on the relative composition of the tax-exclusive price and excise taxes. Some recent work finds that gasoline consumption is more responsive to gasoline taxes than to comparable changes in the tax-exclusive gasoline price (Rivers and Schaufele, 2015; Scott, 2012; Baranzini and Weber, 2013; Davis and Kilian, 2011; Li, Linn, and Muehlegger, 2014).

Our study is closely related to Li, Linn, and Muehlegger (2014) (LLM). LLM consider only the sum of federal and state fuel excise taxes. However, many states also levy their sales tax on gasoline and several impose special fees on gasoline. We extend the analysis of LLM to explore whether consumers respond differentially to these various taxes.

We examine whether gasoline consumption responds differentially to various taxes. Four types of taxes and fees on gasoline, namely the federal excise tax, the state excise tax, sales taxes on gasoline, and special fees on gasoline, are considered. We find that the response to changes in the federal excise tax is larger than the response to changes in state taxes, and the response to change in both taxes are greater than for changes in the tax-exclusive price. However, there is little difference in responses across the three state taxes, state excise tax, state sales tax, and fees on gasoline.

The rest of the paper proceeds as follows. In the Section 2 we discuss the data we use. Our results are presented in Section 3, while a summary section concludes the paper.

2. Data and Empirical Methodology

We adopt a econometric strategy similar to LLM and estimate the following equation:

$$\ln(q_{sy}) = \alpha \ln(p_{sy}) + \beta_1 \ln(1 + \frac{\tau_{sy}^F}{p_{sy}}) + \beta_2 \ln(1 + \frac{\tau_{sy}^S}{p_{sy}}) + X_{sy}\Theta + \delta_s + \phi_y + e_{sy}, \qquad (1)$$

where q_{sy} is gasoline consumption per adult by state (s) and year (y); p_{sy} is the tax-exclusive gasoline price; τ_{sy}^F and τ_{sy}^S are federal and state gasoline taxes in cents per gallon, respectively; X_{sy} is a vector of state-level control variables,[1] and δ_s and ϕ_y are state and time fixed effects. We assume that p_{sy} does not change if τ_{sy} changes.[2] In LLM, the tax rate is the sum of total state and federal gasoline excise taxes in cents per gallon, i.e., $\tau_{sy}^F + \tau_{sy}^S$, divided by p_{sy}. Other than the tax variables, the variables we use are the same as in LLM.

We rely on the online data file of LLM for most of our data.[3] We augment those data with state sales taxes and state special fees that are imposed on gasoline purchases. We adopt a more detailed categorization of gasoline taxes than LLM. In addition to the federal fuel excise tax, we have three classifications of state taxes: state fuel excise taxes, special fees[4] on gasoline, and sales taxes imposed on gasoline. Special fees on gasoline in a state are generally inspection and environmental fees such as an Environmental Assurance Fee and a Groundwater Protection Trust Fee.

Not all states impose their sales tax on gasoline purchases. Information on state sales tax rates imposed on gasoline after 1979 is available in Highway Statistics. Using various sources,

[1] The control variables include average family size, log road miles per adult, log number of registered cars per capita, log number of registered trucks per capita, log number of licensed drivers per capita, log real income per capita, fraction of the population living in metro areas, and fraction of population living in metro areas with rail transport.
[2] Li, Linn, and Muehlegger (2012) regress tax inclusive price against the fuel tax find that the coefficient of tax on retail price is 1.03 and is statistically indistinguishable from 1. Their results are consistent with Marion and Muehlegger (2011), Chouinard and Perlo (2004), Alm, Sennoga, and Skidmore (2009), and Davis and Kilian (2011).
[3] The LLM data are available at https://www.aeaweb.org/articles.php?doi=10.1257/pol.6.4.302.
[4] We obtained information on state special fees imposed on gasoline from the footnotes in *Highway Statistics*. In some, but not all cases, these fees are included in the state excise tax reported by LLM. We revised LLM's excise tax values by deducting any special fee that was included in their value.

including government websites and contacting individual states, we identified for years prior 1979 which states applied their sales taxes to gasoline and their sales tax rates. Besides differences in the year the sales tax was first imposed on gasoline and in the sales tax rates, the nature of the tax base (i.e., the applicable price) on which the sales tax is imposed also differs across states. For example, Georgia, Michigan and New York apply the sales tax to the price inclusive of the federal motor-fuel tax. In California, the tax base is the sales price inclusive of both federal and state motor-fuel taxes. In Illinois, the tax base is the sales price exclusive of federal and state gasoline taxes. We calculate the price on which the sales tax for gasoline is imposed for each state under the assumption that consumers bear the entire tax burden. Using the taxable price and sales tax rate, we calculate a sales tax on a cents per gallon scale.

Thus we have four tax variables: federal fuel excise tax, state fuel excise taxes, special fees on gasoline, and state sales taxes imposed on gasoline. Gasoline excise taxes and special fees are reported in cents per gallon, while sales taxes were converted to cents per gallon. We divide the tax per gallon by the tax-exclusive price and add one to form tax ratios. Adding state sales taxes and any missing special fees increases the mean value of the total tax ratio by only 1.7 percent compared with LLM data.

The balanced state-year panel dataset consists of the various gasoline taxes, consumption, and prices, along with the other control variables for the period 1966 to 2008. The tax data are mainly from annual issues of the *Highway Statistics*, published by the Federal Highway Administration.

Certain rules for building up the taxes data need to be noted. First, there are tax changes within a year for certain states, but we use one tax rate for the entire year. Second, local government gasoline fuel excise taxes and local sales taxes are not included. Third, we found

typos in *Highway Statistics* and corrected them by referring to government documents and other data resources such as the American Petroleum Institute (API) *Motor Fuel Report*. Descriptive statistics for gasoline prices and the various taxes and fees are shown in Table 1.

3. Empirical Results

We report regressions that include state and time fixed effects, state quadratic trends, with robust standard errors clustered by state. We first re-estimated LLM's basic regression but using the our total gasoline tax ratio, which is the sum of the federal excise tax, the state excise tax, sales tax, and fees, i.e., the total excise tax ratio used by LLM adjusted for state sales taxes and fees. As expected, the results are very similar to those reported by LLM, i.e., the coefficient on the tax exclusive price variable is -0.112, while the coefficient on the tax variable is -0.291. These differences are statistically significant.

Our interest is in whether consumers respond differentially to the various taxes. We first separate out the total tax ratio into the federal tax ratio and the total state tax ratio, i.e., state excise tax plus the state sales tax and state fees. The results are found in column 1 of Table 2.

In column 1 the coefficients on the tax-exclusive price and two tax ratio variables are all negative and statistically significant. The coefficient on the tax-exclusive price is slightly larger than when only an aggregate tax rate is used. The coefficients on both the federal and state excise tax ratios are statistically significantly larger than that for the tax-exclusive price. This is consistent with LLM, who find that the coefficient on the tax variable is larger than the coefficient on the tax-exclusive price.

Our focus is on whether the coefficients on the two tax variables are different. As seen in Table 2, the coefficient on the federal excise tax variable is larger than that on the state tax

variable. The difference is statistically significant. Note that the coefficients on the tax variables in Table 2 bracket the coefficient on the tax variable in LLM's specification. Our results imply that consumers respond differentially to changes in the tax-exclusive gasoline price, the federal excise tax, and state taxes on gasoline.

The regression reported in column 2 of Table 2 breaks out the state tax into its three components, i.e., state excise tax, sales tax, and fees. The coefficients are all negative and, with the exception of the sales tax ratio, are statistically significant. As in column 1, the coefficient on the federal excise tax is larger than the coefficient on the tax-exclusive price. The coefficients on the three state tax ratios have values similar to the coefficient on total state tax ratio in equation 1, and are all statistically significantly difference than the coefficients on the federal tax variable and the tax-exclusive price.

We are not surprised regarding the coefficient on the sales tax ratio. At most there were 9 states with a sales tax that applied to gasoline purchases, and the average sales tax over the entire period for those states with a sales tax that applied to gasoline was 1.7 cents per gallon. On the other hand, we were somewhat surprised that the coefficients on the fee ratio was statistically significant since there were no states with a fee ratio until 1979, and then only one state until 1983. Between 1991 and 2008, there were sixteen states with a fee. With the exception of Pennsylvania and New York, the fees for the other 14 states averaged less than 1.4 cents per gallon.

Our time fixed effects are measured by two-year increments rather annually. We are unable to use one-year fixed effects because of multicollinearity. When we use one-year fixed effects, the some of the coefficients become positive and statistically insignificant. Since the federal excise tax per gallon is the same in all states in any given year, differences across states

in the federal gasoline excise tax ratio is due solely to differences in the tax exclusive price, which does not differ much across states. For example, for 2000 the variance of $\ln(1+\frac{\tau_{sy}^{F}}{p_{sy}})$ is 0.00007. Thus, multicollinearity is a problem in a regression that includes $\ln(1+\frac{\tau_{sy}^{F}}{p_{sy}})$ and year fixed effects. It is well known that when the key explanatory variable is essentially constant a fixed effect model cannot be used (Wooldridge 2002). This is a common problem, particularly in political science, since the value of many important explanatory variables do not change much over time (see the citations in Plümper and Troeger (2007)). We also estimated models with 5-year fixed effects, 11-year fixed effects, and with no time fixed effects. The magnitudes of the coefficients get larger as we go from 2-year fixed effects to no fixed effects, but the relative size of the coefficients and statistically significance remain the same.

4. Summary and Conclusions

In this paper, we examine whether gasoline consumption responds differentially to various taxes. We extend LLM analysis by considering whether consumers respond differentially to federal and state taxes, and find that they do. In particular, we find that consumers' response to changes in federal fuel excise tax are larger than to changes in state gasoline taxes. As do LLM, we find that the consumers' response to taxes is larger than to the tax-exclusive price.

One possible explanation for the findings is that federal excise taxes are more persistent than state taxes and price. Consumer decisions regarding automobile purchases could be affected by the perceived persistence of gasoline price. If taxes are more persistent than the tax-exclusive price, this could affect consumers' long-run response which affects the consumers' ability to make short-run changes in gasoline consumer (Scott, 2012; Li, Linn, and Muehlegger 2014.) Federal excise taxes are more persistent than state excise taxes. Over the 43-year period, the

federal excise tax changed 5 times, while states changed tax rates an average of 8.4 times. That might explain the differential effects of the two taxes.

Other possible explanations include that a change in the federal gasoline excise tax might get greater press coverage than a change in the state excise tax. In addition, the state excise tax is likely to change only if voters agree, which suggests that consumer would be less inclined to respond to a change in the state excise tax.

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Table 1. Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
log of gasoline consumption per adult	-0.431	0.153	-1.035	0.178
log of tax inclusive price	4.538	0.593	3.354	5.829
log of tax exclusive price	4.247	0.643	2.968	5.696
log(1+total state tax ratio)	0.182	0.068	0.034	0.358
log(1+fed excise tax ratio)	0.131	0.055	0.030	0.270
log(1+ state excise tax ratio)	0.176	0.070	0.014	0.358
log(1+ fees ratio)	0.004	0.020	0.000	0.261
log(1+ sales tax ratio)	0.003	0.012	0.000	0.141

Note: the number of observations is 2,064

Table 2. Regressions with Separate State Taxes and Fees

Variables	(1)	(2)
log(tax excl price)	-0.157***	-0.156***
	(0.013)	(0.013)
log(1+fed excise tax ratio)	-0.405***	-0.403***
	(0.060)	(0.061)
log(1+state total tax ratio	-0.231***	
	(0.068)	
log(1+ state excise tax ratio)		-0.221***
		(0.073)
log(1+ fees ratio)		-0.252***
		(0.067)
log(1+ sales tax ratio)		-0.185
		(0.181)
Constant	-0.817**	-0.823***
	(0.377)	(0.375)
State FE	X	X
Time FE	X	X
Covariates	X	X
State quadratic trend	X	X
Observations	2,064	2,064
R-squared	0.971	0.971

Notes: The dependent variable is log(gasoline consumption per adult).
Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1