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Determinants of state diesel fuel excise tax rates: the political economy of fuel taxation in the United States

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Abstract Ever-escalating gasoline and diesel fuel prices in the United States (US) are prompting some states to temporarily suspend the collections of gasoline, and in fewer instances, diesel fuel, taxes. The focus of this paper is on the determinants of US state excise taxes levied specifically on diesel fuel. Among other things, we find the freight trucking industry's contribution to total state employment is a highly significant determinant of a state's diesel tax rate, consistently suggesting that the greater this contribution, the lower the tax rate, *ceteris paribus*. We find little evidence that the degree of freight transportation usage on state highways impacts diesel tax rates. These two findings taken together suggest that state legislators, when determining the diesel tax rate, exhibit behavior consistent with Stigler's (Bell J Econ Manag Sci 2: 3–21, 1971) economic or positive theory of regulation. Moreover, state law makers appear less concerned over the impact that heavy freight transportation has on highway infrastructure, which appears to be at odds with the public interest or normative theory of regulation as articulated by Posner (Bell J Econ Manag Sci 4: 335–358, 1974).

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1 Introduction

Since the summer of 2000, the United States (US), along with many other countries, have been experiencing escalating fuel prices with no apparent end in sight. This, combined with the current political environment, has substantially revitalized interest among economists and policy analysts on the economic impact of rising energy costs on the US economy. Gasoline is not the only energy commodity experiencing substantial price increases. Home heating fuel and natural gas prices are rising as well, and, importantly, the price of diesel fuel, too, has increased dramatically.

Fearing that high and escalating gas prices will disrupt economic growth, many states in the US, as well as the US federal government, are debating the merits of suspending gas tax collections for a period of time. According to a recent *Wall Street Journal* article by Robert Matthews (2005), the state of Georgia suspended its 7.5 cent excise tax and its 4 percent sales tax on gasoline in the Fall of 2005.[1] Other states at this time had also considered similar actions. This is not the first time states have suspended gas tax collections. Declaring an "energy emergency" in June of 2000, Indiana's late Governor Frank O'Bannon suspended that state's gasoline sales tax for a period of 60 days and later that summer extended the suspension an additional 15 days, a move that was estimated to have cost the state between US $22 and US $30 million in lost revenue collections.[2] After O'Bannon suspended the Indiana tax, Governor George Ryan of Illinois, observing Illinois residents crossing into Indiana to fill their gas tanks, followed suit and suspended that state's gas tax temporarily as well (Adhicary 2000).

Whether or not such tax suspensions will have a substantive impact on a state's economic performance is subject to debate.[3] However, if the goal is to support the economic vitality of a state, it is somewhat perplexing why the focus has largely been on gasoline tax suspensions and not on, say, diesel tax suspensions. Many major industries are heavy users of diesel fuel such as the mining and construction industries and the trucking services industries.[4] Taken together, these three industrial sectors alone account for 8 percent of total GDP in the US, and in some states, this percentage is much higher. It is also important to keep in mind that the growth of these industries will have substantial "spillover" effects on the rest of the economy. According to the US Bureau of Economic Analysis, the Motor Freight Transportation and Warehousing

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[1] See Robert Guy Matthews, Rising Gas Prices May Force States To Suspend Tax. The Wall Street Journal, September 6, 2005, A2.

[2] See Indianapolis Star, 2000: Governor Suspends Gas Tax, taken from Indystar.com at http://www.indystart.com, accessed on line by authors on June 2002.

[3] Several studies exist, referenced below, that attempt to measure such impacts. Recent evidence strongly suggests that the efficacy of a gas tax suspension will have little impact on a state's economy (see, e.g. Decker and Wohar 2005).

[4] Agricultural equipment is also generally fueled with diesel. However, most US states exempt such equipment from taxation.

multiplier is 2.3168. This implies that a US $1,000 increase in final demand in this industry alone will have ripple effects throughout the economy, ultimately resulting in a US $2,317 increase in aggregate economic activity, more than double the initial effect.[5]

Moreover, there is evidence suggesting that the trucking industry in the US is suffering from these high diesel prices. It is true that for the major freight transportation companies, some of this additional cost has been recouped from consumers in the form of increased surcharges. However, it's unclear, and no studies to our knowledge have investigated this issue, as to how much of the surcharge covered these increased fuel costs. While such evidence is scant, some anecdotal information is available. For instance, according to a recent *Associated Press* article, for every five cent increase in fuel cost there is a one cent per mile fuel surcharge increase.[6] It is unlikely, then, that the full cost of the fuel price increase is being covered by an increase in surcharges.[7] Even if freight companies can recoup some of this cost increase, most independent truckers, operating in much more competitive environments, do not have the luxury of assessing surcharges. These freight transporters are completely at the mercy of the diesel fuel market.

With the greater emphasis on the gas tax suspensions over the diesel tax suspensions by most states, it seems natural to postulate that the determinants of a state's gasoline tax differ from those of a diesel tax. There are a number of states, for instance, where the diesel tax exceeds the gas tax. A reasonable explanation for higher diesel fuel tax rates is that freight vehicle transportation creates a greater degree of wear and tear on highway and road infrastructure. This higher cost imposed on roads and highways may therefore justify a higher tax rate on fuels used by semi trucks and other heavier vehicles.[8] However, there are likely to be other rationales for higher rates and it is not clear how the concern over the state of road infrastructure would explain those instances where the diesel tax is actually lower than the gasoline tax.

Research on the determinants of fuel taxation, whether it is gasoline or diesel, appears to be rather scant. Studies that investigate the determinants of gasoline taxation have considered both US and European countries. The few studies that have focused on diesel taxation have examined European countries, with none, to our knowledge, investigating the US experience. Building on this

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[5] This figure comes from the BEA's RIMS II Regional Input Output Multipliers User Handbook which can be found at http://www.bea.gov/bea/regional/rims/. The multiplier provided above is supplied free of charge in BEA's documentation but is specific to the Kansas City Missouri Metropolitan Statistical Area. While this multiplier is likely to vary from region to region, this figure is certainly illustrative of the point that this sector is integrally linked with other sectors in the economy.

[6] See William Poovey, "Truckers hit with higher diesel costs," found at BusinessWeek Online, http://www.businessweek.com/ap, September 6, 2005.

[7] It is also likely that, to the extent that haulers contract in advance of delivery, these companies may not be able to quickly pass increased transportation costs onto consumers.

[8] Indeed, this explains why toll road rates are higher for heavier vehicles as well.

existing work, our focus is on the determinants of US state excise taxes levied on diesel fuel. Among other variables, we find the freight trucking industry's contribution to total state employment has a highly significant and negative effect on a state's diesel tax rate, consistently suggesting that the greater this contribution, the lower the tax rate, *ceteris paribus*. This finding suggests that state legislators, when determining the diesel tax rate, exhibit behavior consistent with Stigler's (1971) economic or positive theory of regulation, sensitive to (indeed perhaps responsive to) the trucking industry's contribution to a state's economy. Moreover, we find little evidence that the degree of freight transportation usage on state highways impacts diesel tax rates. Hence, state law makers appear less concerned over the impact that heavy freight transportation has on the highway infrastructure. This result seems contrary to the public interest or normative theory of regulation, as articulated by Posner (1974), asserting that law makers act in a way consistent with social welfare maximization.

The remainder of this paper is organized as follows. In Sect. 2, we briefly review the relevant literature. In Sect. 3 we develop our econometric model. In Sect. 4 we discuss the data and various econometric methodology and issues. Section 5 contains a discussion of the estimation results and Sect. 6 concludes.

2 Literature review

Much of the literature on fuel taxation is primarily concerned with the impact that such taxes have on general economic growth, tax incidence, or market efficiency.[9] That said, there are a few studies that have looked at, either directly or indirectly, the determinants of gasoline taxes (see, e.g. Nelson 2002; Goel and Morey 1993; Shmanske 1990).[10] Building on this research, more recent studies have reported tax levels to be sensitive to a variety of political and economic conditions. Hammar et al. (2004) for instance, investigate the determinants of gasoline tax rates across a panel of Western European countries, the United States, and New Zealand and find that while low taxes encourage greater gasoline consumption, high levels of consumption lead to substantial pressure against tax rate increases. Additionally, they find other governmental variables influence tax rates, such as the level of government debt. However, Hammar et al. (2004) focused exclusively on gasoline tax rates. In contrast, Rietveld and van Woudenberg (2005) used a cross section of 100 countries to investigate fuel tax differentials between these countries and investigated both

[9] For fuel tax impacts on growth and employment, see Uri and Boyd (1998) and Decker and Wohar (2005). For the incidence of gasoline taxation, see Chauinard and Perloff (2004) and Chernick and Reschovsky (1997). Finally, Sipes and Mendlesohn (2001) investigate the effectiveness of gas taxes on air pollution.

[10] Shmanske's study is of particular importance to our study because his study seems to be one of the few that considered the impact that specific industries, most notably trucking, has on fuel tax rates. While he finds that the trucking interest does not have a statistically significant impact on such taxes, it should be pointed out that his study focused exclusively on gasoline tax rates, not diesel tax rates.

the gasoline and diesel tax question. They find that for both gasoline and diesel, smaller countries tend towards lower tax rates than larger countries. Moreover, fuel taxes tend to be higher in countries with proportionally larger government spending and greater degrees of income inequality. However, they find no evidence that fuel taxes tend to be higher in countries with higher automobile usage, calling into question the hypothesis that fuel taxes are set in part to curb certain external costs such as air pollution. While offering important insights, the study by Rietveld and van Woudenberg (2005) estimated gasoline and diesel prices as a function of various determinants and then made inferences as to tax rates based on those results, rather than directly modeling gasoline and diesel tax rates, as we do in this paper.

With a different geographic and conceptual focus, and with direct attention to gasoline tax rates themselves, Goel and Nelson (1999) attempt to explain tax rate differentials between US States. To motivate their empirical analysis, the authors develop a theoretical model much in the spirit of Peltzman's (1976) extension of Stigler's capture theory that suggests law makers and regulators are motivated to make decisions so as to maximize the net positive feedback, in the form of political support, from a population of vested stakeholders. To this end, and guided by modeling conventions laid out by Hettich and Winer (1988), Goel and Nelson (1999) construct a model where a vote-maximizing legislator weighs the costs and benefits of imposing additional taxes. With voters exerting pressure on legislators to limit fuel prices and price increases, their model predicts that higher gasoline prices should be accompanied by lower tax rates. Indeed their empirical analysis confirms this result.

Political support, however, can take a variety of forms, particularly when considering industry's influence on candidates seeking political office. Whether it be campaign contributions or public endorsements, such activities will, in principle, increases votes. Hence, while voter maximization seems a reasonable objective, the model is ultimately silent as to the *source* of political support. While this may not be as significant an issue when considering the determinants of gasoline tax rates, as this tax impacts nearly every group in an economy, it is of importance when considering the determinants of diesel tax rates as the primary uses of diesel fuel are not end-user residential consumers but rather commercial interests.

3 The empirical model and data

With our attention on diesel tax rates, our empirical model adopts the basic elements of Goel and Nelson's (1999), hereafter GN, but augments it in an attempt to identify similarities between the determinants of gasoline and diesel tax rates as well as to ferret out what political influences might be present in diesel tax determination. To this end, we collected state-level data on a variety of variables from several different sources, constructed a panel dataset, and estimated a number of variations of the following equation:

$$\begin{aligned} \ln(DTAX_{i,t}) = {} & \alpha_i + \beta_1 \ln(\mathrm{DPRICE\_AVG}_{i,t}) + \beta_2 \ln(\mathrm{CPI\_AVG}_{i,t}) \\ & + \beta_3 \ln(\mathrm{DTAXUS\_AVG}_t) + \beta_4 \ln(\mathrm{TOTROAD}_{i,t}/\mathrm{POP}_{i,t}) \\ & + \beta_5 \ln(\mathrm{HFUNDS}_{i,t}/\mathrm{POP}_{i,t}) \\ & + \beta_6 \ln(\mathrm{HWAY}_{i,t}/\mathrm{TOTROAD}_{i,t} \times 100) \\ & + \beta_7 \ln(\mathrm{EMPMIN\&CON}_{i,t-1}/\mathrm{EMPTOT}_{i,t-1} \times 100) \\ & + \beta_8 \ln(\mathrm{EMPTR}_{i,t-1}/\mathrm{EMPTOT}_{i,t-1}) \\ & + \beta_9 \ln(\mathrm{NONATTAIN}_{i,t}/\mathrm{POP}_{i,t}) \\ & \times \beta_{10} \ln(\mathrm{DTAX\_ADJ}_{i,t-1}) + e_{i,t} \end{aligned} \quad (1)$$

The dataset covers all 50 US states over the period 1992 to 2001.[11] Further definitions of each variable, their respective means and standard deviations, and their corresponding data sources can be found in Table 1. The dependent variable, DTAX, is the excise tax levied on diesel purchases in state i, in year t. Note, following GN, we initially model the state diesel tax in nominal terms as this is the variable which state law makers have direct control over.[12] However, since it is also reasonable to presume legislative consideration of an inflation adjusted tax rate, we model the diesel tax in real terms as well. Thus, we report results for a nominal version given as (1) above and a real version which converts DTAX into real terms.[13]

The variable DPRICE_AVG measures a 2 year moving average of the real diesel price in state *i* minus any federal and state excise taxes.[14] We introduce this variable as a moving average, embodying both historical and contemporaneous movements in price, recognizing that it takes time for legislators to

[11] Data prior to 1992 are difficult to obtain for a variety of variables, such as road and highway infrastructure miles. Moreover, price data more recent than 2001 at the state level for all 50 states was not available at the time of this writing.

[12] While we tend to follow GN reasonably closely, our analysis also differs from theirs in a number of ways. For instance, GN estimate a linear model whereas we follow Hammar et al. (2004) and estimate all of our models in log-linear form so that the resulting coefficients can be interpreted as elasticities. This facilitates a discussion of both absolute magnitudes of effect as well as allows for a comparison of magnitudes across independent variables. That said, we did estimate our model using a linear form and the signs and significance levels of all coefficients in the model were consistent with the log linear form.

[13] Lacking a reasonable state-level price deflator, we follow conventional practice and deflate all nominal values using the US All Urban Consumer Price Index (CPI).

[14] Note here that our fuel price variable is state specific, unlike GN. This seems reasonable since prices can vary significantly from state to state and it seems likely that state legislators would be more inclined to consider local area price information when considering tax changes. That said, we also estimated (1) using a national diesel price level. The results were similar to the ones presented here but the overall fit of the equations, as measured by an adjusted R^2, were lower. It is important to note, however, that obtaining pre-tax state level data on fuel prices is rather difficult. Fortunately, the US Department of Energy's Energy Information Administration (EIA) does publish annual data on state level prices for a variety of fuels, including transportation-sector distillate, which as EIA note, is essentially diesel fuel. This data is nominal, includes federal, state and local taxes, and is denominated in dollars per million British Thermal Units. Therefore, using standard conversion factors, we converted the data to dollars per gallon, subtracted state and federal excise taxes, and deflated the series using the CPI.

Table 1 Summary statistics

Variable	Definition	Data source	Mean	St. div.
DTAX (cents per gallon)	The diesel excise tax, measured in cents per gallon, levied on diesel purchases in state *i* and year *t*.	Highway Statistics (various years), Office of Highway Policy Information, Federal Highway Administration, US Department of Transportation, available at http://www.fhwa.dot.gov/policy/ohpi/hss/index.htm.	19.72	4.74
CPI	Consumer Price Index, all urban (base year 1982), in year *t*.	US Bureau of Labor Statistics, available at www.bls.gov.	1.58	0.11
DPRICE (dollars per gallon)[a]	Inflation adjusted diesel price in state *i* minus any federal and state excise taxes.	Energy Information Administration (EIA), US Department of Energy, available at http://www.eia.doe.gov/emeu/states/_price_multistate.html.	0.60	0.09
DTAXUS (cents per gallon)	Inflation adjusted federal diesel tax rate in year *t*.	Highway Statistics (various years), Office of Highway Policy Information, Federal Highway Administration, US Department of Transportation, available at http://www.fhwa.dot.gov/policy/ohpi/hss/index.htm.	23.96	1.29
TOTROAD	Total state highway agency administered roads and highways in state *i* and year t	Highway Statistics (various years), Office of Highway Policy Information, Federal Highway Administration, US Department of Transportation, available at http://www.fhwa.dot.gov/policy/ohpi/hss/index.htm.	15,363.48	16,890.93.
POP (1,000 residents)	Population in state *i* and year *t*.	Bureau of Economic Analysis, US Census Bureau, available at http://www.bea.gov/bea/regional/data.htm.	5,408.58	5,896.12
HFUNDS[b]	Inflation adjusted funding for highways from sources other than tax collections in state *i* and year *t*.	Highway Statistics (various years), Office of Highway Policy Information, Federal Highway Administration, US Department of Transportation, available at http://www.fhwa.dot.gov/policy/ohpi/hss/index.htm.	472,192.76	454,653.37
HWAY/TOTROAD×100	Ratio of highway miles to total road miles in state *i* and year *t*.	Highway Statistics (various years), Office of Highway Policy Information, Federal Highway Administration, US Department of Transportation, available at http://www.fhwa.dot.gov/policy/ohpi/hss/index.htm. available at http://www.fhwa.dot.gov/policy/ohpi/hss/index.htm.	8.50	4.72
EMPM&C/EMPTOT×100	Ratio of total employment in mining and construction to total employment in state *i* and year *t*.	Bureau of Economic Analysis, US Census Bureau, available at http://www.bea.gov/bea/regional/data.htm.	6.39	1.66

Table 1 continued

Variable	Definition	Data source	Mean	St. div.
EMTR/EMPTOT×100	Ratio of total employment in the trucking services industry to total employment in state *i* and year *t*.	Bureau of Economic Analysis, US Census Bureau, available at http://www.bea.gov/bea/regional/data.htm.	1.54	0.49
	The proportion of a state's population living in counties that are not meeting US EPA ambient air quality standards in state *i* and year *t*.	For counties in nonattainment: The Green Book Nonattainment Areas for Criteria Pollutants, US Environmental Protection agency, available at http://www.epa.gov/oar/oaqps/greenbk/. For the county and state population: Bureau of Economic Analysis, US Census Bureau, available at http://www.bea.gov/bea/regional/data.htm.	25.57	17.39
DTAX_ADJ	The average diesel excise tax of all states bordering a given state *i*, in a given year *t*, measured in cents per gallon.	Authors' calculations based on data from Highway Statistics (various years), Office of Highway Policy Information, Federal Highway Administration, US Department of Transportation, available at http://www.fhwa.dot.gov/policy/ohpi/hss/index.htm.	17.79	4.58

[a] Measured as the real price per gallon excluding the state and federal diesel tax rates

[b] Measured as the real value of highway funds collected by each state which includes tolls, revenues from bond initiatives, and other minor sources. but excludes tax revenues collected

react to price changes.[15] From GN's model, we would expect the coefficient associated with DPRICE_AVG to be negative indicating an inverse relation to the diesel tax. As prices increase, political pressure from state residents should prompt law makers to lower the tax rate. For the nominal version of Eq. (1) we include CPI_AVG, which measures the 2-year moving average of this price index. On the on hand, following GN's logic (p 53), we might find a positive coefficient here reflecting reduced political difficulties associated with tax rate increases in a generally inflationary environment. On the other hand, inflation may result in political pressure, prompting legislators to lower rates. Empirical analysis should reveal which likely outcome obtains.

The variable DTAXUS_AVG measures the 2 year moving average in the inflation adjusted federal diesel tax rate. This variable's expected impact is unclear. On the one hand, we might expect a positive effect in that state regulators may be able increase state taxes and not incur as much political damage if the federal government has raised taxes proportionately more. This may be a particular attractive strategy during periods of budget tightening. On the other hand, a negative effect would suggest that state legislators can significantly build political capital if the voting public recognizes the state's attempt to counter rising federal tax rates. The purpose of the moving average accounts for the state government's likely position of following federal action.[16]

Our regression model includes TOTROAD/POP which measures total state highway agency administered roads and highways on a per capita basis. We would expect that a greater volume of road infrastructure would prompt state law makers to levy a higher diesel tax to maintain these existing roads.

Most states earmark gasoline and diesel tax collections for the purposes of road construction and repair. However, there are other sources of funding available for this purpose such as road and crossing tolls as well as state bond proceeds. The variable HFUNDS/POP measures sources of inflation adjusted funding for highways other than tax collections on a per capita basis. The expected effect that this variable is likely to have on the diesel tax rate is negative if legislators view these sources as substitutes for diesel tax collections. Alternatively, if legislators view these funds as complementary sources of funding with diesel tax collections, we would expect a positive sign.[17]

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[15] GN introduce their gas price variable with a 2 year lag, also arguing that it takes time for law makers to respond to market conditions. However, it does seem reasonable upon further reflection not to ignore the possibility that law makers, when debating the merits of a tax change, consider contemporaneous information on fuel price movements as these prices do tend to fluctuate significantly in a short period of time. That said, we also tried estimating (1) by explicitly including contemporaneous, 1 and 2 year lagged real diesel price levels in our specification. The results were relatively poor for these three variables, largely due to a fair degree of correlation between them. Hence, we opted for the moving average structure of this variable.

[16] Introducing this variable as a moving average or lagged 1 or 2 years does not qualitatively change the results.

[17] We also included the motor gasoline tax in our estimation of (1) in an earlier specification, postulating that the gas tax may substitute for diesel. However, since gas and diesel taxes are so highly correlated and that a number of independent variables are correlated with the gas tax (not

While the precedes collected from the diesel tax itself are typically earmarked for road construction and repair, levying such a tax would in theory result in less diesel fuel consumption (at least to some degree) and therefore may be used to control pollution emissions (Sipes and Mendelsohn 2001). To control for this potential, we include the proportion of a state's population living in counties that are not meeting US EPA ambient air quality standards (NONATTAIN/POP). We expect a higher tax rate in those states with a greater proportion of the population living in these non-attainment counties.

Until now, we have essentially discussed variables believed to impact the diesel tax rate that were also determinants of GN's gas tax model. We now focus on determinants that are more unique to diesel tax determination. Clearly, one major issue that arises with the diesel tax rate specifically is the degree to which it could be used to cover costs of highway repair. Larger vehicles have a much larger impact on roads and highways than do cars and other smaller vehicles. States with substantially more trucking traffic would therefore experience greater wear and tear on their roads, suggesting benefits to a higher diesel fuel tax. Truck traffic by state over time is difficult to come by. However, annual truck traffic is highly correlated with the proportion of highway miles to total road miles (HWAY/TOTOAD) in a state. Such data is available over time and we thus use it to proxy for trucking usage rates. Under the presumption that legislators behave in a way consistent with the normative theory of regulation (Posner 1974), we would expect a positive coefficient associated with this variable. An increasing cost imposed on a social good such as roadway infrastructure should be met with a higher tax placed on those considered responsible for the higher damage caused.

As discussed earlier, political influence can manifest itself in many ways. Commercial interests that are heavy users of diesel fuel may be in a position to pressure legislators to keep diesel taxes low in an effort to control operating costs and maintain higher profit margins. The ability of these interests to succeed in this effort may vary from state to state depending on the degree of "importance" that state law-makers place on these commercial interests, or put differently, the degree to which these interests have convinced law makers of their relative importance.

To capture some of these effects, we include two variables designed to proxy for political influence within a state. There are a number of industries that are heavy users of diesel fuel. Both the construction and mining sectors utilize very large trucking and other mobile equipment that are largely powered by diesel fuel. Moreover, the freight trucking transportation service sector is also a heavy consumer of diesel fuel. For these sectors, we calculated the proportion of employment in construction and mining to total employment (EMPM&CON/EMPTOT) and the proportion of trucking to total employ-

surprising since many of these variables were included in GN's model), we chose not to keep the gas tax as an independent variable.

ment (EMPTR/EMPTOT).[18] These commercial interests are likely to be in a position to exert more effective pressure on legislators if they account for a larger proportion of economic activity in a state. Therefore, if the desire is for lower diesel fuel tax rates, we should expect to see a negative impact of these variables on the tax rate.[19]

Note that we introduce these employment variables lagged 1 year. This is done in part to avoid potential issues related to endogeneity. For instance, as stated above, we expect that the diesel tax rate is endogenously determined by employment levels such that greater employment in certain sectors will result in lower diesel tax rates. However, one could argue that the diesel tax rate influences employment levels such that lower diesel tax rates might induce some firms to locate in a particular state, thereby lifting employment. If the variables are introduced into the econometric model contemporaneously, the causal direction is unclear. However, with the lagged variables on employment included, it is more likely that a diesel tax in period t is influenced by employment levels in period $t-1$. By contrast, it is less likely that a diesel tax in period t would prompt substantial industrial employment increases in period $t-1$.[20]

In addition, we also test if there is a "border-tax" effect with respect to diesel; that is, whether or not neighboring state's diesel tax rates influence a given state' diesel tax policy. Nelson (2002) for instance, finds that when it comes to taxes on gasoline, alcohol, tobacco products, and insurance premiums, state legislators are strongly influenced by adjacent state's taxation policies. To test this potential for diesel taxes specifically, we constructed, similar to Nelson (2002), DTAX_ADJ, which measures for a given state the average diesel tax rate of all bordering states. One might anticipate either a positive or negative effect, depending on the nature of the "fiscal competition" across states. Cast in game-theoretic language, a negative effect would indicate diesel tax policies are "strategic substitutes" in that state legislators meet higher taxes set by bordering states aggressively with lower tax rates. A positive effect would indicate "stra-

[18] The trucking sector is labeled "Trucking and Warehousing Services" but there is no further breakdown than this. We had also considered adding railroad freight service to the analysis but, at the state level, we encountered numerous discloser instances where the data was suppressed. We decided to consider mining and construction together largely because these two sectors are more similar to one another, in the sense that they both use a wide spectrum of very large mobile equipment for industrial development purposes. By contrast, trucking uses a more specialized diesel powered vehicle and is largely a service oriented sector that is likely more mobile in terms of the location of fleet headquarters.

[19] It should be emphasized that, like so many empirical models, ours does not truly test Stigler's theory. This is a very difficult test to implement. We simply offer a suggestion as to what our results might imply about this theory. Note that a positive coefficient might also be consistent with Stigler's theory in that an industry might demand higher diesel tax rates to inhibit entry. While this is a possibility, it is not very likely, in our judgment, as our focus is on a state's diesel tax and the construction and trucking sectors, like many markets, are largely regional or national in delineation. Attempting to prevent entry into a particular state by lobbying for higher diesel taxes does not seem, then, to be a very efficacious strategy.

[20] It should be noted that simply lagging dependent variables does not solve endogeneity problems. We therefore conducted a Hausman test following a procedure proposed by Davidson and MacKinnon (1989) and found no statistical evidence of endogeneity.

tegic complements" whereby state legislators take advantage of the higher tax rates set by its neighbors by raising its tax rates, typically by some amount less than their neighbors. Indeed, Nelson (2002) finds strategic complementarities in excise tax policies; higher border state taxes in effect prompt state legislators to raise their tax levels. Again, similar to Nelson (2002), we assume legislators formulate tax policy in period t based upon neighboring state's pre-set tax rates in year $t-1$.

Finally, since it is highly unlikely that the above variables capture all the state-specific factors that might influence the diesel tax policy, our specification allows for state-specific dummy variables, α_i, to capture these additional effects.

4 Econometric methodology and issues

To estimate our empirical model we first employ a fixed effects (FE) construct:

$$y_{i,t} = \alpha_i + \beta X_{i,t} + \varepsilon_{i,t}, \tag{2}$$

where $y_{i,t}$ is each state is DTAX for years t = 1992 through 2001, α_i are the time-invariant estimated state constant variables, and $X_{i,t}$ is the matrix of independent variables as discussed above.[21]

As is understood, FE is appropriate when we are confident that the cross section units can be viewed as parametric shifts in the regression. However, if the cross section and time series constant terms are random variables distributed across cross sectional and time series units, then the random effects (RE) model, $y_{i,t} = \alpha + u_i + \beta X_{i,t} + \varepsilon_{i,t}$, is appropriate. We test for the appropriateness of FE versus RE via a standard Hausman statistic.

One final econometric issue relates to cross-sectional heteroscedasticity. Analysis of the estimated regression residuals for each variation of our model suggested that the error variance differed substantially between states, thus violating standard assumptions necessary to insure reliable regression statistics. Therefore a correction is in order, in particular to avoid biases in our estimated standard errors. To do so we employed White's cross-section method that treats the pool regression as a multivariate regression with an equation for each cross-section, i.e. for each state.[22]

5 Results

We estimate four variations of our basic empirical model. Our estimation results are presented in Table 2. Models 1 and 3 explain the variation in the nominal diesel tax rate and models 2 and 4 explain variation in the real tax rate. As we

[21] We do not include in our estimation yearly dummy variables since we, following GN's specification, include the national diesel tax rates which only vary over time and is not specific to particular states. In a real sense, then, our model does control for time-specific patterns.

[22] See Greene (1993, pp 448–452) for a detailed discussion of this issue and procedure.

Table 2 Estimation results

Dependent variable	Model 1 ln(DTAX)				Model 2 ln(DTAX/CPI)				Model 3 ln(DTAX)				Model 4 ln(DTAX/CPI)			
	f.e.		r.e.		f.e.		r.e.		f.e.		r.e.		f.e.		r.e.	
Constant	1.78	***	2.15	***	0.97	***	1.52	***	1.68	***	2.06	***	0.94	***	1.47	***
	(0.32)		(0.29)		(0.19)		(0.29)		(0.30)		(0.30)		(0.19)		(0.32)	
ln(DPRICE_AVG)	−0.04	***	−0.03	***	−0.04	***	−0.01		–		–		–		–	
	(0.01)		(0.01)		(0.01)		(0.02)		–		–		–		–	
ln(CPI_AVG)	0.71	***	0.65	***	–		–		0.45	***	0.44	***	–		–	
	(0.07)		(0.06)		–		–		(0.06)		(0.02)		–		–	
ln(DTAXUS_AVG)	−0.04		−0.03		0.01		0.08		−0.003		0.003		0.04		0.09	
	(0.02)		(0.02)		(0.06)		(0.08)		(0.02)		(0.01)		(0.06)		(0.08)	
ln(TOTROAD/POP)	0.09		0.02		0.27	***	0.10	**	0.09		0.02		0.25	***	0.10	**
	(0.07)		(0.06)		(0.05)		(0.050)		(0.07)		(0.07)		(0.05)		(0.05)	
ln(HFUNDS/POP)	0.03	***	0.03	***	0.03	***	0.02	**	0.03	***	0.03	***	0.03	**	0.02	**
	(0.01)		(0.01)		(0.01)		(0.01)		(0.01)		(0.01)		(0.01)		(0.01)	
ln((HWAY/TOTROAD)×100)	0.05		0.004		0.09	**	0.04		0.05		0.01		0.08	*	0.04	
	(0.04)		(0.05)		(0.05)		(0.05)		(0.04)		(0.05)		(0.05)		(0.04)	
ln((EMPM&C($t-1$)/	−0.003		−0.04		−0.02		−0. 13	*	0.001		−0.04		−0.02		−0.12	**
EMPTOT($t-1$))×100)	(0.04)		(0.05)		(0.04)		(0.06)		(0.04)		(0.05)		(0.04)		(0.05)	
ln((EMPTR($t-1$)/	−0.23	***	−0.21	***	−0.30	***	−0.33	***	−0.23	***	−0.21	***	−0.30	***	−0.33	***
EMPTOT($t-1$))×100)	(0.04)		(0.04)		(0.04)		(0.07)		(0.04)		(0.04)		(0.04)		(0.07)	
ln(NONATTAIN/POP)	0.08		0.06		0.11	**	0.11	***	0.08	*	0.06	*	0.11	**	0.11	***
	(0.05)		(0.04)		(0.04)		(0.03)		(0.05)		(0.04)		(0.05)		(0.03)	
Ln(DTAX_ADJ($t-1$))[a]	0.27	***	0.23	***	0.41	***	0.31	***	0.28	***	0.23	***	0.41	***	0. 32	***
	(0.09)		(0.05)		(0.09)		(0.05)		(0.09)		(0.05)		(0.09)		(0.05)	

Table 2 continued

Dependent variable	Model 1 ln(DTAX)				Model 2 ln(DTAX/CPI)				Model 3 ln(DTAX)				Model 4 ln(DTAX/CPI)			
	f.e.		r.e.		f.e.		r.e.		f.e.		r.e.		f.e.		r.e.	
Adj. R^2	0.95		0.23		0.95		0.30		0.95		0.12		0.94		0.30	
F Statistic	155.13	***	15.52	***	156.50	***	24.36	***	157.90	***	17. 23	***	159.20	***	27.65	***
Hausman statistic[b]	13.85				37.85	***			9.21				53.24	***		

Standard errors reported in parentheses

[a] For Models 2 and 4, DIESEL_TAX_ADJ($t-1$) was adjusted for inflation using CPI($t-1$). For Models 1 and 3, DIESEL_TAX_ADJ($t-1$) is nominal

[b] Larger values favor FE over RE

* Significant at the 10 percent level

** Significant at the 5 percent level

*** Significant at the 1 percent level

indicated earlier, for each model we estimated both a FE and RE specification. While there is a substantial degree of consistency in the sign, magnitude and statistical significance between these two specifications across our model variants, an analysis of the Hausman statistics suggest that for the models 2 and 4 (the real tax specification), the FE is the preferred specification. Moreover, based on our adjusted R^2 statistics for the FE specifications, our models capture between 94 and 95 percent of the variation in state diesel tax rates, much in line with other studies in this literature. Based on our model's F statistics, for all model variations we can safely reject the null hypothesis that estimated coefficients are jointly zero but, again, the FE models tend to provide better overall results.

In terms of the point estimates, we find EMPTR/EMPTOT, lagged 1 year, to have a negative impact on both the real and nominal tax rate and is statistically significant across all model variants. Moreover, the magnitudes of the estimated elasticities appear to be economically meaningful as well. Focusing on the real diesel tax rate (models 2 and 4) we find elasticities on the order of about 0.3, suggesting that a 10 percent increase in this sector's share of total employment would results in a 3 percent decline in the real diesel tax. It does appear that trucking interests do have an impact on state legislature's diesel tax rate decisions in a way favorable to that sector. By contrast, however, we find little evidence that mining and construction interests impact such taxes. While the estimated coefficients are generally negative, the magnitudes of these elasticities are relatively small and rarely does the variable achieve statistical significance at conventional levels.

While these results imply the trucking industry does wield some political influence, consistent with, although not necessarily proving, Stigler's (1971) positive theory of regulation, Baron (2000) reminds us that interest group success in the political arena depends on the relative benefits and costs of political action for each interest group. Typically, groups fewer in number, with commonality of political interests, and with sufficiently large per capita money resources, tend to be more successful in influencing policy than other groups.[23] While a complete accounting of the benefits and costs of all relevant groups interested in diesel tax policy for each state is well beyond the scope of our paper, it is interesting to note that according to US Census data, in New Jersey, which has one of the lowest diesel tax rates in the United States at 13.5 cents a gallon and relatively few establishments in the trucking industry, total value of shipments per establishment is about US $1.7 million. The total value of shipments per establishment in the mining and construction industries, by contrast, is roughly US $1.4 million. These figures suggest that trucking interests are likely to have a greater influence than mining and construction firms. Further, it is interesting to note that in New York, which has one of the highest diesel tax rates in the nation at 27.11 cents per gallon, trucking shipments per establishment amount to US $1.07 million, quite a bit less than the New Jersey figure, and has more trucking establishments than does New Jersey. With the trucking industry's potential for

[23] Baron (2000, pp 165–185) offers a well articulated and complete summary of the benefits and costs of political influence.

political power diluted in New York relative to New Jersey, perhaps it is not too surprising, in light of our regression results, that New York's diesel tax rate is higher than that in New Jersey.

The other variable that proves to be statistically significant across all model variants is HFUND/POP. Our results indicate that there is a positive relationship between diesel tax rates and the real per-capita level of highway funds generated from revenue sources other than tax receipts. This result, consistent with GN's findings, suggests that state legislators' view such alternative sources as complementary assets to diesel tax collections.

There is some, albeit weaker, evidence suggesting that diesel tax rates are sensitive to air quality. Indeed, focusing on models 2 and 4 again, we find that a 10 percent increase the state's share of residents located in EPA-designated non-attainment states results in roughly a 1.1 percent increase in the diesel tax rate. This effect, too, appears to be consistent to some degree with GN and other studies.

While the trucking employment effects are consistent with expectations, we find scant evidence that state legislatures are sensitive to trucking usage, as proxied by the share of a state's interstate highway miles to total road mileage (HWAY/TOTROAD), when setting the diesel tax. Indeed, this variable is only statistically significant in the real diesel tax models (2 and 4), and only for the FE specification. Moreover, the estimated elasticities are fairly small. From model 2, for instance, we find the elasticity to be 0.09, suggesting a 10 percent increase in a state's share of highways to total roads will prompt a relatively small 0.9 percent increase in the diesel tax. This seems at odds with the normative theory of regulation that would hypothesize that, as larger freight trucks cause greater wear and tear on a roadway system, this greater harm should prompt a higher diesel tax rate.[24]

Moreover, we find that state legislators are indeed influenced by border state diesel tax policies. In all specifications, consistent with Nelson's (2002) findings, lagged DTAX_ADJ, has a positive and statistically significant effect on DTAX. Diesel tax policies appear, then, to be strategic complements in that state regulators tend to raise diesel taxes in response to increases in adjacent states' diesel tax, albeit by a smaller amount. For instance, using results from Model 2, we

[24] In the same way we cannot assert that we have proven the economic theory of regulation with our findings, we also cannot assert that our results allow us to dispense completely the public interest or normative theory. One could argue, for instance, that a negative coefficient on EMPTR/EMPTOT may very well be consistent with the social welfare maximization if a lower diesel tax rate, say, promotes job growth and tenure for society. However, while we cannot dismiss the theory out-right, we do believe that the results found in this study cast doubt on the normative theory. For instance, if lower diesel rates are in place to support job growth and tenure, then one would expect better results on the mining and construction job variable as well, even though there are more such establishments with less per establishment revenues (see text above), thereby diluting these sectors' political influence. In other words, why should regulators motivated to maximize social welfare necessarily single out trucking employment and not be sensitive to employment conditions in other sectors of the economy? Thus, the statistical significance of EMPTR/EMPTOT, combined with the poor results for both EMPM&C/EMPTOT and, importantly HYWAY/TOTROAD (see text), weaken the case for the normative theory, at least when applied to diesel taxes.

find that a 10 percent increase in the average diesel tax rate of adjacent states in year $t-1$ cause a state to increase its diesel tax in year t by only 4 percent.

Finally, our results do not generally support GN's voter maximization model. Their model predicted a negative relationship between the gasoline excise tax and gasoline price, for which they found empirical support. However, with respect to diesel, this relationship does not seem to hold. As discussed earlier, under a voter maximization model there may be some reason to suspect correlation between diesel prices and employment share data. Employees in the mining, construction, and trucking industries are as likely as any to vote, hence, the inclusion of both, as in Models 1 and 2, may generate biases in our estimated coefficients. This concern about bias prompted estimation of model variations 3 and 4, where we omit DPRICE_AVG from the specification to see if this alters the estimated coefficients associated with the (previously significant) employment variables in the mining and construction industries. We find that dropping this price variable has little impact on the overall results. Employment in mining and construction still appear not to impact the diesel tax whereas trucking employment does.[25]

6 Conclusion

The focus of this paper has been on the determinants of US state excise taxes levied specifically on diesel fuel. Previous studies that have focused on diesel taxation have investigated European countries, with none, to our knowledge, investigating the US experience. The potential negative impact that ever-escalating gasoline and diesel fuel prices are likely to have on a state's economy are prompting some states in the US to temporarily suspend their gasoline and diesel fuel taxes. The most prominent finding of this paper is that the proportion of the freight trucking industry's employment to total state employment is a highly significant determinant of a state's diesel tax rate. Specifically, our results are robust to different model specifications and indicate that the greater the contri-

[25] It is important to note two results at this point. First, because the insignificance of DPRICE_AVG is at odds with GN's results, we estimated all four models by dropping the employment variables and retaining DPRICE_AVG. In all cases, the variation in diesel prices did not prove to have a negative coefficient associated with it nor was it statistically significant. In short, our results suggest that the diesel tax is not influenced by the diesel price. Second, we also collected data on the gasoline tax and gasoline prices by state. We then estimated four models that attempted to explain variations in the gasoline tax as a function of gasoline prices and all other explanatory variables defined in Eq. 1. When this was done, we did indeed find that the moving average of gasoline prices negatively impacted the gasoline tax, just as GN predicted. Hence, GN's theoretical model is verified (with more recent data), but only with respect to the gasoline tax. Moreover, we should point out that the trucking sectors' state of total employment also negatively impacted the gasoline tax. This result suggests a number of issues. First, it may be that the trucking interests efforts to limit the diesel tax have a spillover effect on gasoline. It also might suggest that the trucking interests desire lower gasoline tax rates as well, particularly if some percentage of their fleets are smaller vehicles that run on gasoline. Irrespective of which of these hypotheses is true, we note that the estimated elasticity between trucking employment share and the gas tax is much less than that for diesel. These results, not presented here, are available upon request.

bution of freight trucking employment to total state employment, the lower the diesel tax rate, *ceteris paribus*. In contrast, we find little evidence that the degree of freight transportation usage on state highways affects diesel tax rates. Taken together, these findings, while not necessarily proving Stigler's (1971) positive theory of regulation, suggest state legislators, when determining the diesel tax rate, exhibit behavior that appears to be consistent with this theory. Our results indicate that state law makers are less concerned over the impact that freight transportation has on highway infrastructure, which appears to be at odds with the public interest or normative theory of regulation.

There are a number of potentially fruitful avenues of future research. For instance, similar to Rietveld and van Woudenberg's (2005) work, one might consider a cross-country comparison of diesel tax rates, particularly in rapidly developing countries such as China and India where vary little empirical work on this issue has been conducted. It also would be of interest to investigate further the fiscal competition issue. Both ours and Nelson's (2002) study find that legislators respond to higher adjacent tax rates by increasing state tax rates. The theoretical foundations of these, not immediately obvious, results are not well understood and deserve attention. We leave these considerations for future research.

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