Tax Holidays and the Heterogeneous Pass-Through of Gasoline Taxes

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December 14, 2022

Abstract

The pass-through of gasoline taxes to retail prices plays a vital role in determining whether a fuel tax suspension policy is effective at providing financial relief to consumers. Given the increased interest in utilizing such "tax holidays" to mitigate the rise of gasoline prices, it is important to obtain updated and precise location-specific pass-through estimates that will inform the ongoing policy efforts. Using daily city-level data from a sample of 108 cities in 15 East Coast states and the District of Columbia during the period February 1, 2022-June 30, 2022, I estimate an average pass-through rate of gasoline taxes of 79%. My subsequent analysis reveals considerable heterogeneity across locations, with less than full pass-through in most "tax holiday" states. Consistent with the prior literature, I find evidence that gasoline content regulations, refinery capacity constraints, and wholesale storage constraints may have contributed to this heterogeneity.

Keywords: gasoline prices; gasoline tax; tax incidence; tax holiday

JEL classification: H22, H71, Q41, Q48

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1. Introduction

In the early months of 2022, a combination of demand-side (travel boom following the easing of COVID-19 restrictions) and supply-side (ban on oil imports from Russia, production cuts by OPEC Plus members) factors pushed global crude oil prices to their highest levels since 2008. This, in turn, triggered an increase in motor fuel prices. In the United States, production capacity constraints due to refinery closures during the COVID-19 pandemic further exacerbated the situation (EIA, 2022), ultimately leading to record high gasoline prices.[1]

In an effort to counter the rapid price increase, state and federal policymakers considered various measures aimed at relieving the financial burden on gasoline consumers. These policy measures ranged from mailing out rebates to temporarily removing certain taxes and fees. By early June 2022, four states had implemented a limited-time tax suspension policy, also referred to as a "fuel tax holiday." Specifically, House Bill (HB) 304 in Georgia and HB 1486 in Maryland temporarily eliminated each state's excise tax on motor fuel sales, starting from March 18. Soon afterwards, Connecticut passed HB 5501 that temporarily lifted the state's excise gasoline tax, effective from April 1. Lastly, New York State Senate Bill 8479 enacted a gasoline tax holiday beginning from June 1. In addition, proposals for fuel tax holidays were considered by a number of other states,[2] while the U.S. Congress deliberated a suspension of the federal gasoline tax of 18.4 cents per gallon.[3]

The primary goal of a gasoline tax holiday is to help consumers by reducing the costs they face at the pump. This is clearly stated in the discussion surrounding the institution of these policies. For instance, governor press releases announcing the onset of the tax moratorium in each of the above four states all highlight the goal of providing relief to consumers amidst rising prices.[4] Similarly, the proposal for suspending the federal gasoline tax also pointed out the price burden on consumers as a leading argument for implementing such a policy measure.[5]

In order to accomplish the above goal, it is necessary that tax reductions be passed onto consumers through corresponding reductions in gasoline prices at the pump. In some instances, this is made explicit through the language used in the legislative bills enforcing the tax holidays. For example, Connecticut HB 5501 stipulates that "each retail dealer shall reduce the per-gallon price of fuels [...] in an amount equal to the amount of the reduction in […] tax," and that failure to do so will be considered "an unfair or deceptive trade practice."[6] Similar language about the

[1] According to https://gasprices.aaa.com, the U.S. national average price of regular gasoline at the pump reached an all-time record of $4.17/gallon in early March 2022. In the following months, this level was further exceeded and a new all-time record of $5.02/gallon was set in June 2022.
[2] Florida and California eventually implemented gasoline and/or diesel tax suspensions during the second half of 2022. Colorado, Illinois, and Kentucky delayed previously planned increases to their state gasoline taxes.
[3] The proposed Gas Prices Relief Act of 2022 called for a federal gasoline tax holiday through the end of 2022 or until gasoline prices fall below $2.60 per gallon.
[4] Remarks by state governors at the official signing of each bill are consistent in their use of statements, such as "give Georgians relief at the pump" (Jordon, 2022), "provide some relief from the pain at the pump" (The Office of Governor Larry Hogan, 2022), "provide some relief to consumers as they face rising prices" (The Office of Governor Ned Lamont, 2022), and "it is crucial that we provide New Yorkers relief" (The Governor's Press Office, 2022).
[5] See https://www.congress.gov/bill/117th-congress/house-bill/6787/text.
[6] See https://www.cga.ct.gov/asp/CGABillStatus/cgabillstatus.asp?selBillType=Bill&bill_num=HB5501.

expected price reduction reflecting the amount of tax change also appears in New York Bill 8479, in Florida's proposed state tax holiday bill HB 7071, and in the proposal for a federal gasoline tax moratorium. These examples collectively underscore the policymakers' intent that the benefits from lower taxes fully accrue to consumers. Thus, the extent to which tax adjustments translate into price changes – i.e., the pass-through of taxes in this market – plays a vital role in determining whether a tax holiday policy is effective at achieving its intended purpose.

Earlier empirical studies on fuel tax incidence across the entire U.S. have indeed found that, on average, changes in state gasoline taxes are fully passed onto consumers (Chouinard and Perloff, 2004, 2007; Alm et al., 2009; Davis and Kilian, 2011; Marion and Muehlegger, 2011; Li et al., 2014). Nonetheless, some important caveats should be noted. First, such average result could potentially mask considerable heterogeneity in the rate of pass-through across locations, as shown in Marion and Muehlegger (2011). Second, while these studies rely on pre-2010 data, more recent U.S. gasoline market conditions could be plausibly different in the aftermath of COVID-19 and the 2022 crude oil supply crunch. Third, the above pass-through estimates are derived from monthly or annual data, whereas the temporary nature of the 2022 tax holidays suggests the necessity for higher-frequency data to quantify the short-run impact on price.

In addition, a number of studies have focused their incidence analyses on one or several specific states in the U.S. While Silvia and Taylor (2016) estimate a full pass-through in Washington, Barron et al. (2004), Doyle and Samphantharak (2008), and Kaufmann (2019) find evidence that in some states gasoline tax changes may not be fully passed onto retail prices.[7] These results further accentuate the extent of possible heterogeneity across different geographic regions and the importance of recognizing the role of local characteristics in tax incidence evaluations. A recent analysis by Harju et al. (2022) also demonstrates that failing to account for heterogeneity in pass-through could have significant welfare implications.

As already noted, knowing the extent to which tax changes would affect consumer prices is critical for evaluating the efficacy of tax suspension policies. Given the findings in the existing literature and the increased interest in utilizing tax holidays to mitigate the rise of retail fuel prices, it is essential to obtain updated and precise location-specific pass-through estimates that will inform the ongoing policy efforts. My goal in this paper is to provide this important information by examining gasoline tax incidence in 15 East Coast states and the District of Columbia. To this end, I use daily city-level data from 108 cities in the region during the period February 1, 2022-June 30, 2022. I exploit the spatial and temporal variation in state and local taxes due to the staggered implementation of tax holidays in Connecticut, Georgia, Maryland, and New York during this time period in order to estimate the pass-through onto regular gasoline prices paid at the pump, while controlling for location- and time-specific unobserved factors. Importantly, I explore the possibility that pass-through rates would vary by location and investigate potential contributing factors behind that heterogeneity.

[7] Furthermore, a recent online post by the Penn Wharton Budget Model estimates a less than full pass-through of the 2022 gasoline tax holidays in Connecticut, Georgia, and Maryland using data through May 31, 2022, although it is possible that some of the pass-through rate estimates in the report may not be statistically different from 100%. See https://budgetmodel.wharton.upenn.edu/issues/2022/6/15/effects-of-a-state-gasoline-tax-holiday.

Using my panel dataset, I find an average pass-through rate of gasoline taxes of 79%. This estimate, which is statistically different from 100%, suggests that at least in some of the tax holiday states, the benefits from tax suspension may not have been fully passed onto the consumers. My subsequent heterogeneity analysis shows that Georgia is in fact the only state with a full pass-through during the study period, while the pass-through rates in the remaining three tax holiday states vary between 39% and 87%. Lastly, consistent with Marion and Muehlegger (2011), I find evidence that gasoline content regulations, refinery capacity constraints, and wholesale storage constraints may have contributed to this heterogeneity.

This paper makes a number of contributions. To the best of my knowledge, this is the first study to use disaggregated city-level daily data to examine the pass-through in gasoline markets during the 2022 state tax holidays. This adds to the existing literature on gasoline tax incidence, whose results are derived from older data and/or based on state as the unit of analysis. Furthermore, the use of city-level price and tax data in my paper provides additional spatial variation that allows for a more thorough exploration of potential local drivers of pass-through heterogeneity, such as gasoline content regulations. Lastly, my findings speak directly to the varying efficacy of gasoline tax holidays across locations and over time and the importance of considering supply-side factors, which has valuable policy implications for the ongoing efforts of federal and state regulators to provide financial relief to consumers.

The rest of the paper is organized as follows. Section 2 presents a simple theoretical model of pass-through in retail gasoline markets. Section 3 describes the data and methodology used in my empirical analysis. Section 4 discusses the empirical results and their implications. Finally, Section 5 concludes.

2. Theoretical Model of Pass-Through

Retail delivery is the final stage in the supply chain of gasoline to consumers, following production, transportation, and storage. Gas stations in the retail market obtain fuel from wholesale terminals and sell it to individual drivers. In what follows, I present a simple theoretical model of the pass-through of a tax levied on retail suppliers to the price faced by consumers.

Consider a perfectly competitive retail gasoline market, where consumers and firms take prices as given. Let aggregate market demand be given by the function $D(p)$, where p denotes gasoline price at the pump (inclusive of all taxes) paid by consumers. Suppose that a per-unit tax τ is imposed on suppliers in this market. Market supply is then represented by the function $S(p-\tau)$. In equilibrium, the market clears at price p_e, so that

$$D(p_e) = S(p_e - \tau). \tag{1}$$

From (1), an expression for the pass-through rate ρ in this market can be derived as follows:

$$\rho \equiv \frac{dp_e}{d\tau} = \frac{S'}{S' - D'} = \frac{1}{1 - \frac{D'}{S'}} = \frac{1}{1 + \left|\frac{\epsilon_D}{\epsilon_S}\right|}, \tag{2}$$

where the derivative signs are $S' \geq 0$ and $D' \leq 0$, while ϵ_D and ϵ_S denote the price elasticity of demand and supply, respectively. The expression in (2) indicates that the degree of pass-through depends entirely on the relative elasticity of demand and supply. Furthermore, it is easy to see that the pass-through rate in this perfectly competitive market will be bounded between zero and one.[8]

Equation (2) implies that $\frac{d\rho}{d\epsilon_S} > 0$ if $|\epsilon_D| > 0$ and $\frac{d\rho}{d\epsilon_S} = 0$ if $|\epsilon_D| = 0$. This yields the following testable implication, summarized in Proposition 1.

Proposition 1: *All else equal, a more inelastic retail gasoline supply will at least weakly reduce the pass-through of taxes to consumers in the market.*

This implication will be explored further in Section 4.2.

Next, following Weyl and Fabinger (2013), I model the effect of a change in tax on consumer surplus. Let consumer surplus in equilibrium in this market be denoted by $CS(p_e)$, where

$$CS(p_e) = \int_{p_e}^{\infty} D(p)dp. \tag{3}$$

Equation (3) implies that the impact of a small change in tax on consumer surplus is given by:

$$\frac{dCS}{d\tau} = CS' \frac{dp_e}{d\tau} = -D(p_e)\rho. \tag{4}$$

Then, assuming that the pass-through rate is independent of the tax level (i.e., $\frac{d\rho}{d\tau} = 0$), the impact of a discrete tax change from τ_0 to τ_1 on consumer surplus can be expressed as:

$$\Delta CS = -\rho \int_{\tau_0}^{\tau_1} D\big(p_e(\tau)\big)d\tau. \tag{5}$$

In other words, the effect of a tax change on consumer surplus is proportional to the pass-through rate. Hence, if $\tau_1 < \tau_0$, a lower pass-through in a given market would imply smaller gains to consumers from the tax reduction.

3. Data and Methodology

3.1 Main Data Sources

I consider a 5-month period between February 1 and June 30, 2022. The geographic region examined during this period includes 15 East Coast states and the District of Columbia.[9] A map of the area is displayed in Figure 1.

[8] In the presence of market power, it is possible for the pass-through rate to exceed one (e.g., Pless and van Benthem, 2019).

[9] These 15 states are Connecticut, Delaware, Florida, Georgia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Rhode Island, South Carolina, Vermont, and Virginia.

The outcome variable in this study is the price of regular gasoline at the pump.[10] I obtain daily average price data at the city level from GasBuddy.com, a web-based company that acquires its data through user submissions from individual gas stations. GasBuddy offers rewards to incentivize fuel price reporting, which has resulted in up to two million price data points across the U.S. and Canada each day (Coffey, 2019; Tsvetanov and Slaria, 2021). Previous studies have shown that, when aggregated to daily market-level averages, these price series display minimal biases relative to other independently collected price data (Atkinson, 2008; Byrne, 2019).

Daily price data are available on GasBuddy.com for 108 cities in the study area. The locations of these cities are shown in Figure 1.[11] With the exception of the District of Columbia, New Hampshire, Rhode Island, and Vermont, each of the remaining states in the sample features multiple cities. In terms of location, the majority of cities in the sample (about 75%) are situated away from the coastline, and the average distance to the nearest state border is approximately 40 miles.

The primary covariate in my analysis is tax on motor gasoline. I collect tax data at the state level from the Federation of Tax Administrators (FTA).[12] In addition to state excise and sales taxes, I include any state-specific petroleum fees (e.g., cleanup or inspection fees), where applicable. For states that also levy local sales taxes on retail gasoline (Florida, Georgia, New York), I supplement that data from the web pages of the respective state Departments of Revenue. In addition, for each state in the sample, I calculate the daily minimum gasoline tax among its neighboring states.

During my study period, Connecticut, Georgia, Maryland, and New York temporarily suspended either a portion or all of their state gasoline taxes. These four states are shaded in dark in Figure 1. Specifically, Connecticut eliminated its 25 cents per gallon (cpg) excise tax on April 1, although motorists were still paying a 26.4 cpg petroleum products gross earnings tax. Starting from March 18, Georgia removed the state's 29.1 cpg excise tax, while Maryland temporarily eliminated its 36.1 cpg state tax. Finally, on June 1 New York suspended the state's 8 cpg sales tax and 8 cpg excise tax, leaving a 17.3 cpg petroleum business tax in place.[13] The tax holidays in Connecticut, Georgia, and New York lasted through the end of the study period, while Maryland reinstated its fuel tax on April 17.

Figure 2 displays 16 individual graphs of daily regular gasoline prices (in cents per gallon), averaged for each state. For Connecticut, Georgia, Maryland, and New York, the time period during which a tax holiday is in place is shaded in the graphs. Notably, the suspension of the fuel tax results in an almost immediate price drop in each of the four states. However, with the

[10] As noted by Kaufmann (2019), it is important to focus on the price of a single grade of gasoline instead of a "basket" price, because if higher taxes encourage consumers to switch from more expensive to less expensive grades (e.g., from premium to regular), this would lower the average price across grades, thereby confounding the actual effect of the tax on price.

[11] Among these, there are 18 coalitions consisting of two or three neighboring cities. My main results are robust to dropping such coalitions and re-running all regressions on a sample of 90 individual cities.

[12] See https://www.taxadmin.org/tax-rates.

[13] New York counties located within the Metropolitan Commuter Transportation District also eliminated their 0.75 cpg sales tax. In addition, a number of counties in the state capped their local gasoline sales taxes after June 1.

exception of Maryland, in the remaining tax holiday states fuel prices eventually begin rising again and ultimately exceed their pre-holiday levels. These distinctions could be due to local factors, as well as overall market trends, given the difference in timing of the tax suspensions. I explore this in more depth in my subsequent analysis. Lastly, average prices in the remaining states in the sample display similar trends over time. All graphs feature a steep increase at the beginning of March, followed by a gradual decline in the subsequent 6-8 weeks. There are further increases in early May and early June, separated by a brief plateau. The second half of June marks the beginning of another decline in prices.

In addition to gasoline price and tax information, I collect data on a number of relevant regional characteristics and match them to each city in the sample. In particular, I draw monthly county-level unemployment data from the U.S. Bureau of Labor Statistics (BLS). I collect weekly observations on refinery gasoline inventories from the U.S. Energy Information Administration (EIA), which are available for three regions within the study area: New England, Central Atlantic, and Lower Atlantic. I also collect data from the U.S. Environmental Protection Agency (EPA) on the presence of gasoline blend requirements in each city in the sample.[14] While these local requirements do not change during the study period, they could contribute to a varying degree of tax pass-through across locations and are explored in my heterogeneity analysis. Lastly, I obtain data from the EIA on daily West Texas Intermediate (WTI) crude oil spot prices and weekly East Coast refinery capacity utilization levels. Capacity utilization represents the percentage of total operable capacity that refineries in the region use in processing oil. Since WTI prices and capacity utilization do not vary by location, they are subsumed by the daily fixed effects in most specifications of my analysis, as shown below.

3.2 Exogeneity of the Tax Suspension Policy

Identification in my empirical analysis hinges on the exogeneity of the primary covariate, gasoline tax. The source of temporal variation in taxes during the 150-day study period are the tax holiday policies in four of the states, which are unlikely to have been imposed randomly. Hence, prior to beginning my formal analysis, it is important to rule out any potential endogeneity of the policymakers' choice to suspend gasoline taxes and the timing of the respective policy.

To this end, I gather additional data on state-level characteristics that that may be correlated with the imposition of a tax holiday. Specifically, I collect state-level demographic data (education, income, population) from the U.S. Census and political data (party affiliation of governor, state senators, and house representatives) from the National Governors Association (NGA) and OpenStates.org. Note that these data are time-invariant within my 5-month study period. In addition, I obtain quarterly real gross state product (GSP) values – total GSP and GSP by select industry (manufacturing, mining, and transportation) – from the Bureau of Economic Analysis (BEA). I convert quarterly values into monthly using a cubic spline interpolation method.[15] I then

[14] See https://www.epa.gov/gasoline-standards/reformulated-gasoline for more details.
[15] I fit a cubic polynomial through the three most recent quarterly GSP values for each state in the sample.

derive per-capita real GSP values using current state population data and calculate the GSP share by industry.

Using these state-level data, along with the remaining local characteristics described in Section 3.1, I conduct a few simple exercises to explore the potential endogeneity of tax suspension. First, it is possible that the four states which implemented this policy are systematically different from the rest of the sample. To test this, I compare the sample means of the characteristics of these four states versus the remaining 12 states in the study area. Table 1 presents the results from this comparison. All time-varying covariates are averaged over the study period before computing the group means. As shown in Table 1, both groups are very similar in terms of unemployment, educational attainment, political structure, and GSP. Although the tax holiday states are less likely to mandate the use of reformulated gasoline and feature higher minimum neighboring state tax, population count, income, and gasoline inventories, none of these differences are statistically significant.

In addition to the above "static" exercise, I examine whether there is contemporaneous correlation between changes in the gasoline tax during the study period and any of the time-varying characteristics. Because most data on relevant economic conditions – unemployment, GSP per capita, and GSP shares by industry – are available at the monthly level, I aggregate all time-varying data by city and month. Then, following Li et al. (2014) and Kopczuk et al. (2016), I run a first-differenced linear regression of tax on all time-varying covariates. I also include month fixed effects. The results are presented in the first column of Table 2. The estimated coefficients on the economic and market variables are not statistically significant individually or jointly, indicating that these covariates predict little of the variation in gasoline taxes beyond what is explained by the month fixed effects. I re-run the regression, this time replacing the tax rate variable with a binary indicator of a change in tax in the respective month. My results are qualitatively similar, as shown in the second column of Table 2. Thus, there is no evidence that tax changes are correlated with changes in local conditions, once all location-invariant shocks have been absorbed through the use of time fixed effects.

Finally, a potential endogeneity concern arises due to the fact that tax holidays are intended to combat increasing gasoline prices, which implies that the timing of such policy measures may depend on the price trend. Nonetheless, while the proposals for tax suspensions were indeed driven by the rise in prices, there is a delay between the initial policy deliberation and its ultimate approval and enforcement. What matters in my analysis is that the timing of *implementation* does not correlate with a disproportionately higher price increase in any of the tax holiday states relative to the rest of the sample. As shown in Figure 2, this does not appear to be the case. In the week leading up to the implementation of the tax moratorium in each of the four states, gasoline prices are either falling (Georgia, Maryland) or remain constant (Connecticut, New York). To test this more formally, I run a set of linear regressions using observations from the last one week or two weeks immediately preceding each of the three implementation dates (March 18, April 1, and June 1), with the first-differenced daily gasoline price as a dependent variable, a dummy variable for the state implementing a suspension on the respective date (or states, if the date is March 18) as the sole regressor, and excluding any states that have already suspended their tax by that date. The results, shown in Appendix Table A1, indicate no statistically significant difference between the daily price changes in tax holiday states compared to the rest of the sample.

These findings lend support to the empirical setup described below.

3.3 Empirical Specification

My empirical analysis quantifies the degree to which gasoline taxes are passed through to consumers by exploiting the variation in gasoline taxes and prices across locations and over time. Formally, I estimate a linear model in which retail price of gasoline is specified as a function of a number of covariates, controlling for unobserved effects:

$$p_{it} = \alpha\tau_{it} + \boldsymbol{X}_{it}'\boldsymbol{\Lambda} + \mu_i + \delta_t + \epsilon_{it}. \qquad (6)$$

In the above model, i indexes city and t indexes calendar date. The outcome variable p_{it} is price of regular gasoline at the pump (i.e., inclusive of all taxes), and the key covariate is gasoline tax τ_{it}. In addition, $\boldsymbol{X}_{it}$ is a vector of time-varying local characteristics. The model in (6) also includes city fixed effects μ_i that capture all time-invariant local cost shifters, as well as the demographic and political characteristics, discussed earlier, which either change very slowly or are fixed within the 5-month window. Similarly, δ_t represents time fixed effects, which account for changes in federal policies, macroeconomic conditions, broader supply chain operations, global oil market forces, and other seasonal factors that may impact gasoline demand and supply. Finally, ϵ_{it} is an idiosyncratic error term.

The coefficient of interest in this model α measures the average daily effect of a change in gasoline tax on the price paid at the pump, i.e., average pass-through at the retail level. This coefficient is identified through deviations in the price and tax variables from their city and daily means.

4. Results

4.1 Average Pass-Through

Using my sample of 108 cities, I estimate the average pass-through of gasoline taxes over the 5-month study period. I employ a number of alternative specifications of the empirical model described in (6). All specifications include city fixed effects but differ in the way time-varying factors are captured. In the first specification, δ_t consists of month and day-of-the-month fixed effects. Control variables include WTI crude oil price and capacity utilization. In the second specification, I control for time fixed effects more rigorously through month-by-day dummies which completely subsume all location-invariant factors. Finally, Specification III adds minimum neighboring state tax, unemployment, and gasoline inventories as controls for market demand- and supply-side factors.

The results are presented in Table 3. All three specifications yield statistically significant estimates of α. The estimate in Specification I indicates that a one cent-per-gallon increase in tax would lead to an increase in the retail price of gasoline by 0.88 cpg, i.e., a pass-through rate of 88%. An F-test fails to reject the equality of this estimate and one (p-value = 0.2), as shown in Table 3, suggesting a full pass-through. The other two specifications have slightly lower point estimates that are statistically distinguishable from one. In particular, Specification III, which is my preferred empirical specification, implies a pass-through rate of 0.79 that is quite precisely estimated. This result indicates that, on average, retail gasoline consumers in my sample experienced less than full pass-through during the 5-month period.

I conduct a number of robustness checks of the above result. The output is presented in Table 4. First, I test the sensitivity of the average pass-through estimate to a different set of time-varying controls. Specification III, described above, is my baseline. In the first robustness check (R1), I test the sensitivity of the baseline result to the inclusion of separate linear time trends for the group of tax holiday states versus all remaining states. Besley and Burgess (2004) utilize this approach to test for possible correlation between region-specific policy change and other underlying trends. As shown in the second column of Table 4, the inclusion of group time trends does not impact my average pass-through estimate, thus providing support for the identification strategy used in this analysis. Next, in robustness check R2 I add state-level characteristics: monthly GSP per capita and share of GSP by industry. In spite of the higher level of aggregation and lower frequency of change, these covariates are a useful complement to unemployment as a measure of local economic conditions. The pass-through estimate under this specification remains very similar in magnitude to the baseline result and is statistically different from one. As an alternative check (R3), I augment the baseline specification with state-month fixed effects to control more flexibly for regional time-varying factors. Although these additional fixed effects absorb some of the identifying variation in the data, the average pass-through rate, shown in the fourth column of Table 4, is still estimated very precisely and remains close to the baseline result.

I also test the sensitivity of my result to variations in the data sample. First, I restrict the sample to cities located within a 50-mile-wide corridor along the boundaries of tax holiday states. On the one hand, geographic proximity is likely to ensure that tax holiday and non-tax holiday cities on both sides of the borders are relatively similar. On the other hand, since state boundaries were drawn many years ago, the location of these cities is plausibly orthogonal to the imposition of a tax suspension policy. As shown in the fifth column of Table 4, although sample size has been cut in half, the pass-through estimate remains almost identical to my baseline result. Lastly, there may be a concern that, since tax suspension policies were announced weeks in advance, consumer and retailer behavior could have been impacted, particularly during the days leading up to the tax change. Furthermore, once taxes were reduced, producers may have been slow to adjust their pricing due to accumulated inventories that were purchased under the higher tax rate. While Figure 2 does not indicate any explicit unexpected price patterns in tax holiday states around the dates of policy imposition (i.e., no price increase immediately before the tax suspension and an almost immediate drop once the policy is in place), I am nonetheless cautious and test the robustness of my findings to dropping all tax holiday state observations within a week before and after the policy is implemented or removed. The resultant pass-through estimate, displayed in the last column of

Table 4, is 0.82, which remains reasonably close to my baseline result and is still statistically different from one.[16]

4.2 Heterogeneity of Pass-Through

While I estimate a less-than-full average pass-through rate, this average value could mask potential heterogeneity in the degree to which taxes are passed through to consumers in different locations. To explore this possibility, I re-run my baseline specification, this time interacting the tax covariate with dummy variables for the four tax holiday states. I then plot the four coefficient estimates, along with a 90%, 95%, and 99% confidence interval for each state, in Figure 3.

Figure 3 reveals a number of interesting findings. First, all estimates are significant at the 5% level or more, indicating that at least a portion of the tax change was reflected in retail gasoline prices. Second, there appears to be heterogeneity in pass-through across the four states. Connecticut and New York feature lower pass-through rates than Georgia and Maryland, with the difference between the two groups of states being statistically significant. Third, Georgia is the only state in which tax changes were completely passed onto the consumers – the pass-through estimate of 0.96 is not statistically distinguishable from one. In the remaining three states, the pass-through point estimates are between 0.39 and 0.87 and the upper bounds of all confidence intervals remain below one.

I consider some potential contributing factors behind the above heterogeneity across states. In particular, I examine the possibility that the varying degree of pass-through may be associated with regional variation in gasoline supply elasticity. Recall that one clear implication of the theoretical model in Section 2, summarized by Proposition 1, was that differences in supply elasticity would translate into differences in pass-through rates. Marion and Muehlegger (2011) discuss a number of possible constraints to gasoline supply, such as environmental regulations, refinery capacity constraints, and inventory shortages. All else equal, the presence of such constraints is likely to make supply more inelastic. In what follows, I utilize my data to explore the effect of each of these potential supply constraints on pass-through.

4.2.1 Gasoline Content Regulations

The 1990 amendment of the Clean Air Act mandated the use of reformulated gasoline (RFG) in a number of EPA-designated ozone non-attainment areas. RFG is a special blend of gasoline that burns more "cleanly" resulting in the emission of less smog-forming and toxic pollutants compared to conventional gasoline. Currently, the RFG requirements cover – either partially or fully – 16 states and the District of Columbia. In my sample, 35 of the 108 cities have an active RFG mandate. From the four tax holiday states, Georgia is the only state with no RFG

[16] In addition, to address the potential autocorrelation in daily gasoline prices, I adopt the approach of Silvia and Taylor (2016) and re-estimate my baseline model using a sub-sample with data from one specific day each week. As shown in Appendix Table A2, my results remain unchanged, regardless of the weekday used.

requirements. On the other hand, all Connecticut cities are subject to the regulation, while Maryland and New York are partially covered: half of the 8 cities in Maryland and 15% of the 13 cities in New York in the sample fall under the RFG mandate.

The presence of gasoline content regulations in a given area complicates the supply chain, as it necessitates that refineries determine in advance what blends to produce, while both transportation and storage need to account for a larger number of potentially incompatible fuels that have to be kept separate from each other (Marion and Muehlegger, 2011). Consequently, RFG regulations are likely to reduce flexibility of supply, leading to lower pass-through compared to areas that are not subject to the requirement.

To test this, I separate the sample into two groups: non-RFG and RFG cities. I then re-estimate my baseline model in each of the two sub-samples. The results are displayed in the first two columns of Table 5 and are consistent with the above discussion. In particular, the average pass-through rate in the non-RFG sub-sample is of higher value and is only distinguishable from one at the 10% significance level. On the other hand, the sub-sample with active RFG regulations features a lower pass-through point estimate of 0.74 that is different from both one and 0.9 with 99% confidence.

These findings are consistent with the spatial heterogeneity in pass-through rates discussed above. Specifically, Georgia as the only tax holiday state with no gasoline content regulations features the highest pass-through rate. On the other hand, Connecticut cities, which are fully covered by the RFG mandate, experience the lowest pass-through in the sample.

4.2.2 Refinery Capacity Constraints

Next, I explore the possible role of refinery capacity constraints. If oil refineries are able to adjust their production relatively flexibly, gasoline supply can also respond more readily to changes in price. However, when refineries are at or near full capacity, there is less scope to change production in the short run, i.e., supply is more inelastic.

Recall that refinery capacity utilization data are only available for the entire East Coast region and do not vary by location in my sample. Nonetheless, two important points should be noted. First, the implementation of tax holiday policies varies by time, as some states suspend or reinstate their tax later than others. Second, a quick look at the weekly refinery capacity utilization in Figure 4 also reveals temporal variation in that data, with utilization levels starting at about 87% in February and rising considerably in the second half of the study period until they reach 95% in late June. This is consistent with general evidence that refineries run close to full capacity in the summer – the season of peak driving – and below full capacity during earlier months of the year. In 2022, this was exacerbated by the closures of several oil refineries during the COVID-19 pandemic (EIA, 2022), as well as the ban on oil imports from Russia, which suggests that peak capacity utilization was likely reached sooner than usual.

To explore the potential impact of refinery capacity constraints, I again split up my sample into two. One sub-sample includes observations from days with capacity utilization between 85%

and 90%, while the other sub-sample includes all days with capacity utilization above 90%. The results from my baseline model, re-estimated in each sub-sample, are presented in the middle two columns of Table 5 and indicate a stark contrast in the pass-through rate depending on the level of capacity utilization. In particular, during times of "low" utilization (i.e., 85-90%), I estimate a full pass-through. On the other hand, when capacity utilization is "high" (i.e., above 90%), the estimated pass-through is 0.74 and is statistically distinguishable from one.[17] This pattern is consistent with supply being constrained during periods of the high utilization, thus leading to a lower pass-through value at those times.

This finding could explain why states, such as New York, which instituted a tax holiday relatively late during the study period also exhibit a relatively lower pass-through compared to states where the policy is present since March or April. It also implies that overall pass-through in the sample would have likely remained low through the rest of the summer, as refineries continued operating at near full capacity.

4.2.3 Storage Constraints

Gasoline is typically stored at wholesale terminals before being delivered to retail stations. As explained in Borenstein et al. (2004) and Marion and Muehlegger (2011), in the absence of constraints in the perfectly competitive storage market, inventories at wholesale terminals would serve to dampen gasoline price volatility. Thus, with ample storage inventories, any change in taxes will be fully passed onto the consumers. However, when inventories are low, supply can no longer flexibly respond to changes in price, which would imply a lower pass-through rate.

Recall that I have weekly gasoline inventory data for three regions: New England (6 states), Central Atlantic (4 states and District of Columbia), and Lower Atlantic (5 states). Figure 5 displays the weekly inventories in each region during the 5-month study period. Among the four tax holiday states, Connecticut is located in New England, Maryland and New York are part of the Central Atlantic region, and Georgia is in the Lower Atlantic. As a proxy for storage constraints, I consider periods when inventories are in the bottom 25% of the distribution in each region, indicated by a dashed line in Figure 5. Note that the tax suspension in Maryland (March 18-April 17) did not occur during a period of low inventories. For the remaining three states, potential storage constraints were faced at least part of the time while their tax holiday was in place: 31% of the time in Georgia, 43% in Connecticut, and 60% in New York.

To examine the possible role of storage constraints, I once again stratify my sample into two sub-samples. The first sub-sample contains all observations from time periods during which gasoline inventories were above the 25% mark. The other sub-sample consists of all remaining observations with potential storage constraints. The results from re-estimating my baseline model in each sub-sample are shown in the last two columns of Table 5. Consistent with the above discussion, I find a higher average pass-through rate during times of no storage constraints: the estimate is just barely distinguishable from one, with a *p*-value of 0.1. On the other hand, the "low

[17] This is consistent with the results in Marion and Muehlegger (2011).

inventories" sub-sample yields a pass-through estimate that is lower in magnitude and statistically different from both one and 0.9.

This positive association between gasoline inventory levels and pass-through rates appears consistent with the lower degree of pass-through in Connecticut and New York compared to the other tax holiday states. It could also serve as a possible rationale behind the relatively high pass-through estimate in Maryland, in spite of that state's high prevalence of RFG regulations.

4.3 Welfare Implications

The incomplete pass-through of tax changes in Connecticut, Maryland, and New York can have important welfare implications in those markets. As discussed earlier, tax holiday measures target providing relief for gasoline consumers, or, more formally, they seek to increase consumer surplus. However, the theoretical model in Section 2 showed that the gains in consumer surplus from a gasoline tax decrease are proportional to the pass-through rate in the market. In what follows, I present a simple back-of-the-envelope calculation of the amount by which consumer surplus gains in Connecticut, Maryland, and New York are reduced due to their lower pass-through rates.

My approach is straightforward. First, I calculate the increase in consumer surplus in each state assuming a full pass-through. Then, I re-do the calculations, this time using the state-specific pass-through rate estimates from Section 4.2. The difference between these two results captures the foregone consumer surplus gains due to incomplete pass-through of the tax. Figure 6 depicts these losses under two general cases: (i) when demand is inelastic and (ii) when demand is relatively more elastic. All else equal, starting from the same initial consumption quantity and implementing the same tax reduction, the foregone consumer gains would be greater under the more elastic demand, as shown in Figure 6. Thus, calculations obtained under the assumption of inelastic demand provide a lower bound on the possible consumer losses due to less than full pass-through.

Following this, I adopt the simplifying assumption that state-level gasoline consumption remains unchanged during the period of interest. Note that, under a perfectly inelastic demand, equation (5) reduces to

$$\Delta CS = -\rho Q(\tau_1 - \tau_0), \tag{7}$$

where Q denotes the (fixed) quantity of gasoline consumption at the time of the tax change. I use this formula in my calculations. I obtain data from EIA on monthly state-level regular gasoline sales in Connecticut, Maryland, and New York during March 2021. Table 6 presents the results. Calculated monthly consumer losses due to incomplete pass-through of the tax range from \$6.1 million in Maryland to \$27.1 million in New York. As noted above, these numbers represent a lower bound for the amount by which pass-through rates erode consumer gains from the tax holiday in each state.

What if policymakers failed to recognize the differences across states and instead "naively" used the average pass-through rate estimate of 79% in their evaluation analyses? To explore the bias from ignoring pass-through heterogeneity in this setting, I re-do my calculations, this time replacing $\rho = 1$ with $\rho = 0.794$, and then again find the difference between the resultant value and the one obtained with the state-specific pass-through rate. The results, shown in the last column of Table 6, indicate that biased evaluations would overstate the impact of the tax holidays in Connecticut and New York by about \$9-14 million per month and understate the outcome of Maryland's tax suspension policy by \$3.5 million. Once again, these values would be larger (in absolute magnitude) under elastic gasoline demand.

While subject to the caveat of failing to account for adjustments in fuel consumption, my back-of-the-envelope calculations are nonetheless a useful illustration of the potentially significant implications of pass-through heterogeneity with regards to the welfare effects and perceived efficacy of the state tax holiday policies.

5. Conclusion

In the spring of 2022, in order to combat the rapid increase in fuel prices, a number of states decided to temporarily suspend either a portion or all of their taxes on retail gasoline. The staggered implementation of these "tax holidays" provides a useful quasi-experimental setting that I utilize to estimate the pass-through of tax changes onto prices paid at the pump. Using daily data from a sample of 108 cities in 15 East Coast states and the District of Columbia during the period February 1-June 30, 2022, I find an average pass-through rate of gasoline taxes of 79%. This estimate is statistically different from 100%, which implies that, at least in some of the tax holiday states, the benefits from tax suspension were not fully passed onto the consumers.

My subsequent analysis reveals that only one out of the four tax holiday states (Georgia) experienced a full pass-through rate, while estimated pass-through in the remaining states ranges from 39% to 87%. I explore a number of possible supply-side factors that may have contributed to this heterogeneity and find that locations with gasoline content regulations tend to exhibit reduced pass-through rates. I also find that pass-through rates are lower during periods of constraints in refinery capacity utilization and wholesale storage. These results are consistent with the pattern of estimated pass-through values across the tax holiday states. Back-of-the-envelope calculations suggest potentially significant state-level welfare impacts of the tax pass-through heterogeneity.

These findings have important policy implications, given that a primary goal of the tax suspension measures is to ease the financial burden on consumers. A pass-through rate of less than 100% implies that consumers failed to capture at least a portion of the benefits from the tax reduction. The results from my heterogeneity analysis further highlight the importance of accounting for local and regional supply factors in the decision of whether and when to institute a tax holiday. With oil prices reaching record high levels for the first time in more than a decade and ongoing debates about gasoline tax holidays in multiple states and at the federal level, it will be vital to continue exploring the potential dampening effect of supply- and demand-side constraints on the pass-through in retail gasoline markets.

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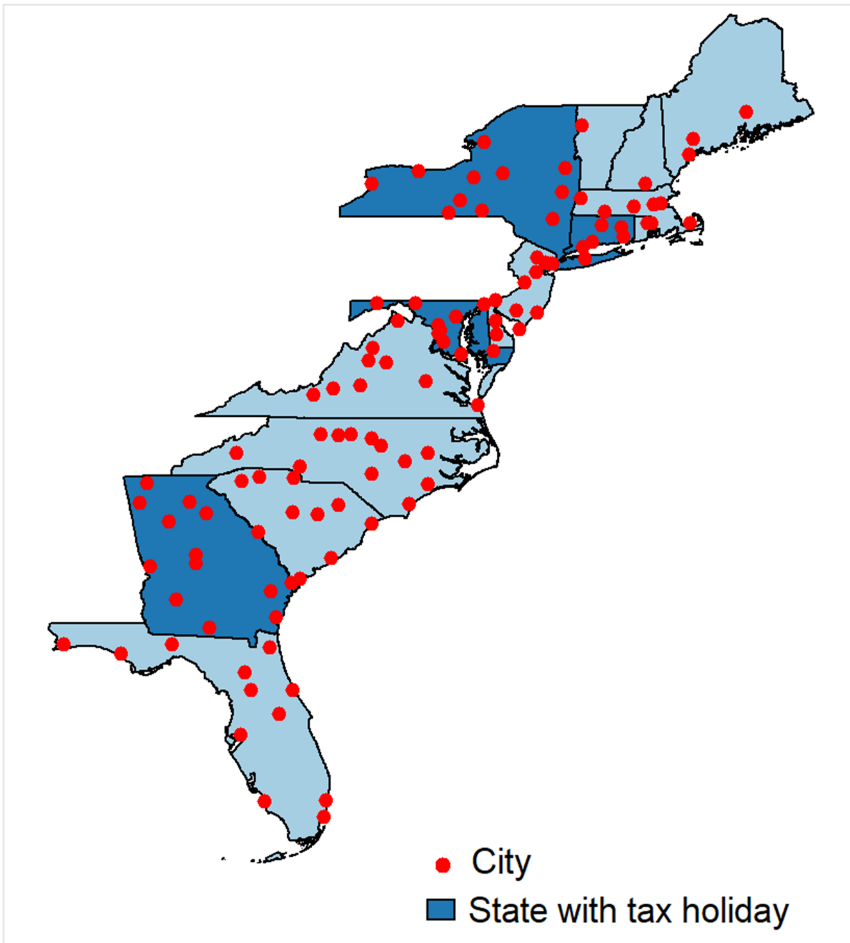

Figure 1: Map of the Study Area

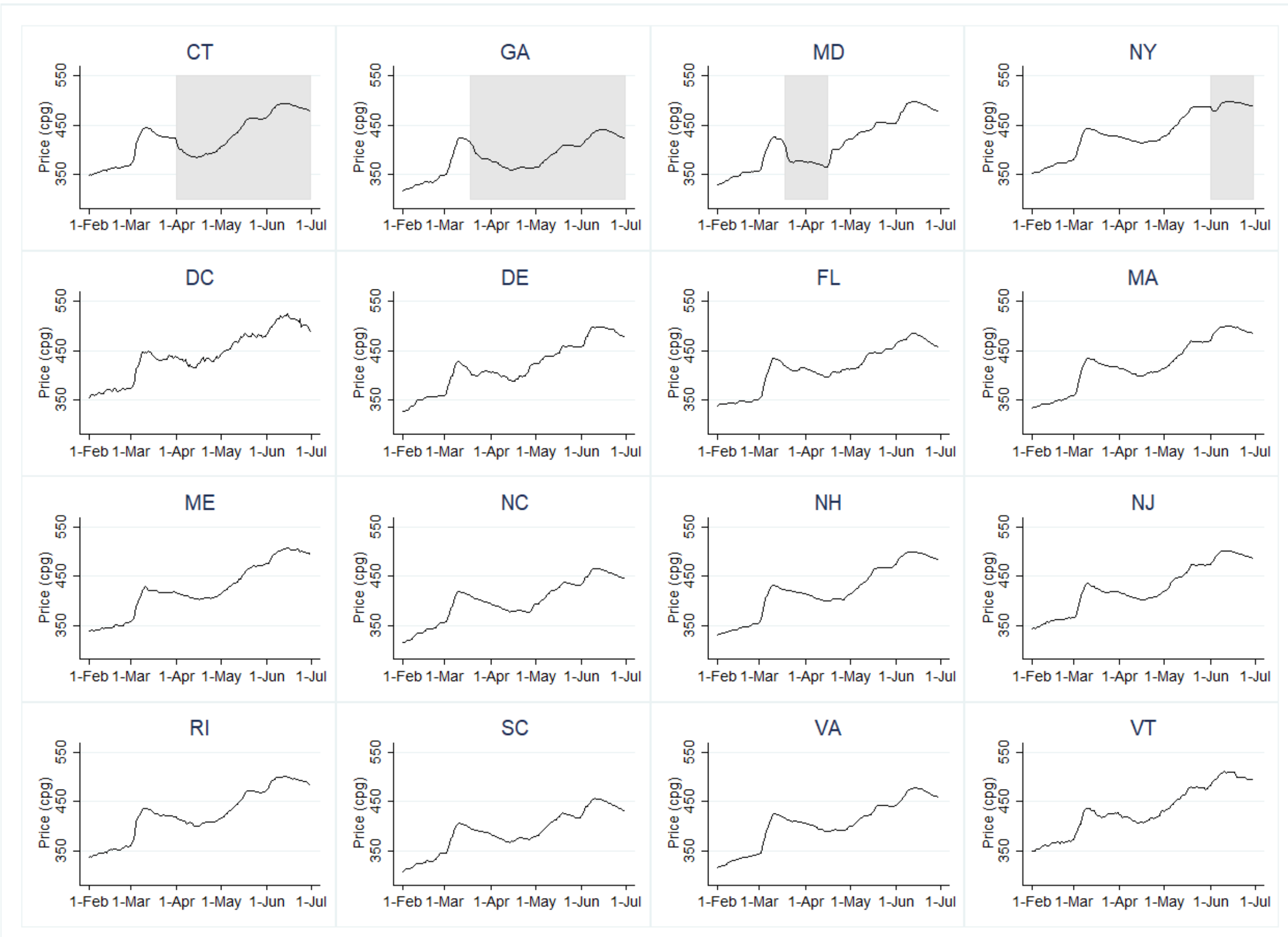

Figure 2: Average Daily Retail Gasoline Prices by State

<u>Notes:</u> Gray bands for Connecticut, Georgia, Maryland, and New York indicate time period during which a tax holiday is in place.

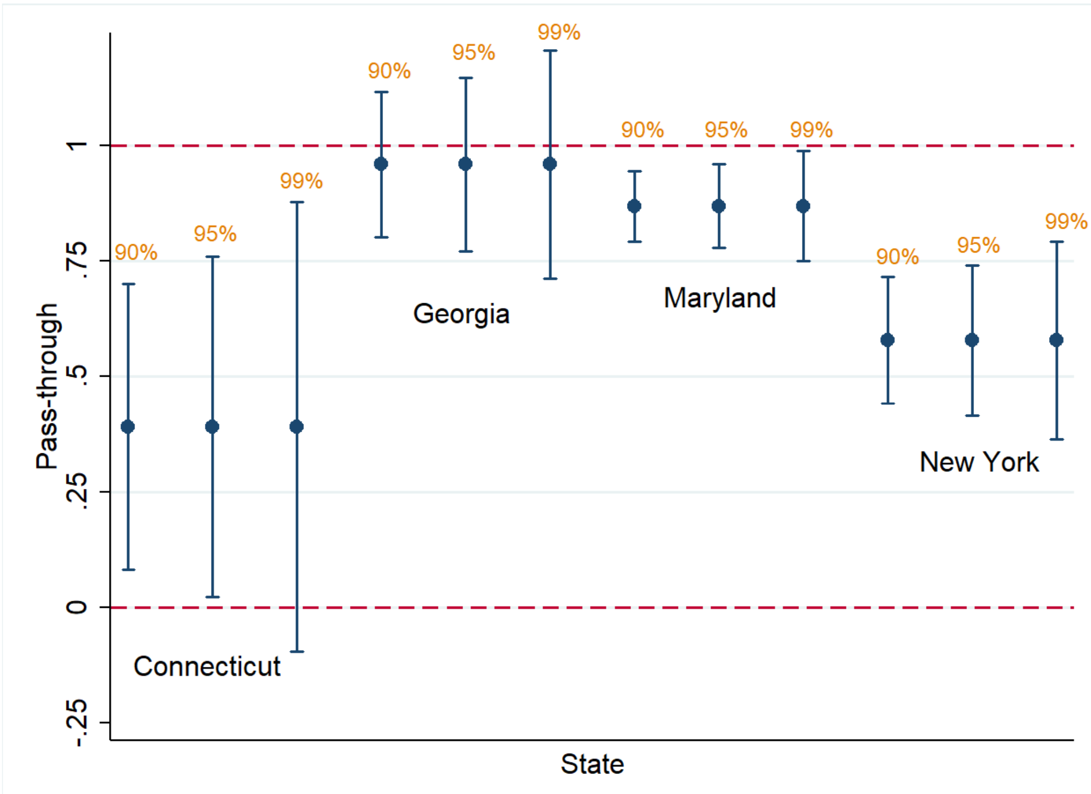

Figure 3: Pass-Through by State

<u>Notes:</u> 90%, 95%, and 99% confidence intervals are constructed from estimates of a regression of retail gasoline price on tax interacted with dummies for Connecticut, Georgia, Maryland, and New York. Regression also controls for minimum neighbor tax, unemployment, gasoline inventories, city fixed effects and month × date fixed effects, with two-way clustered standard errors by state and month.

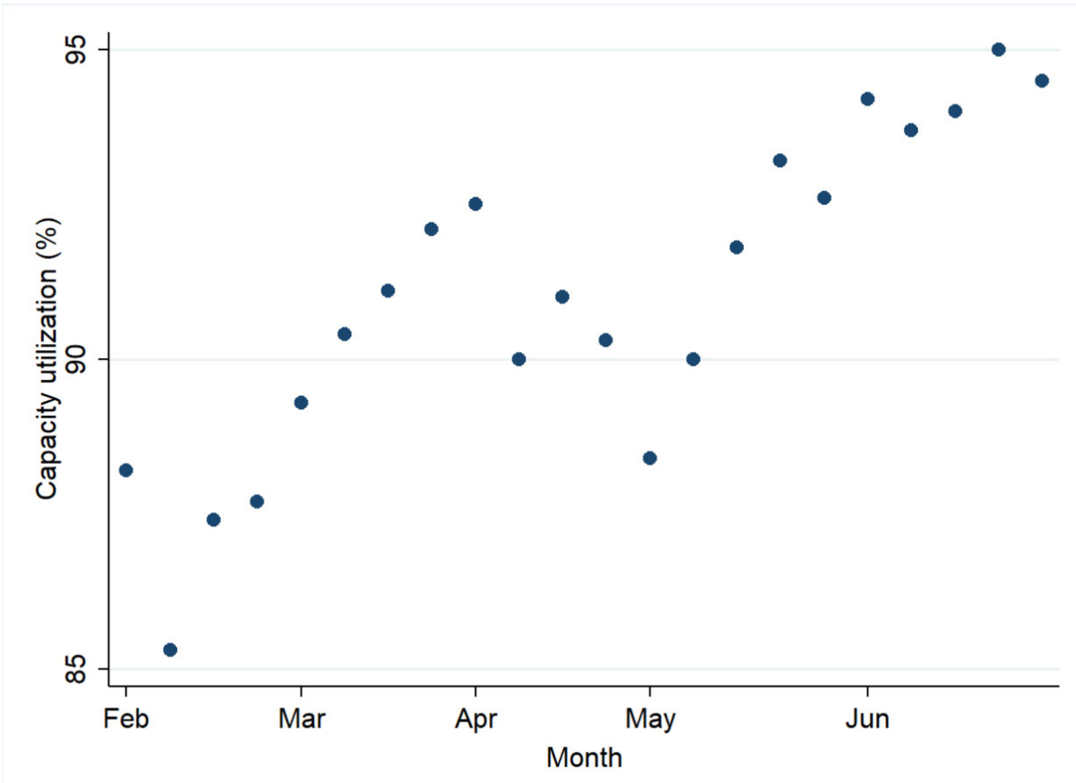

Figure 4: Weekly Refinery Capacity Utilization

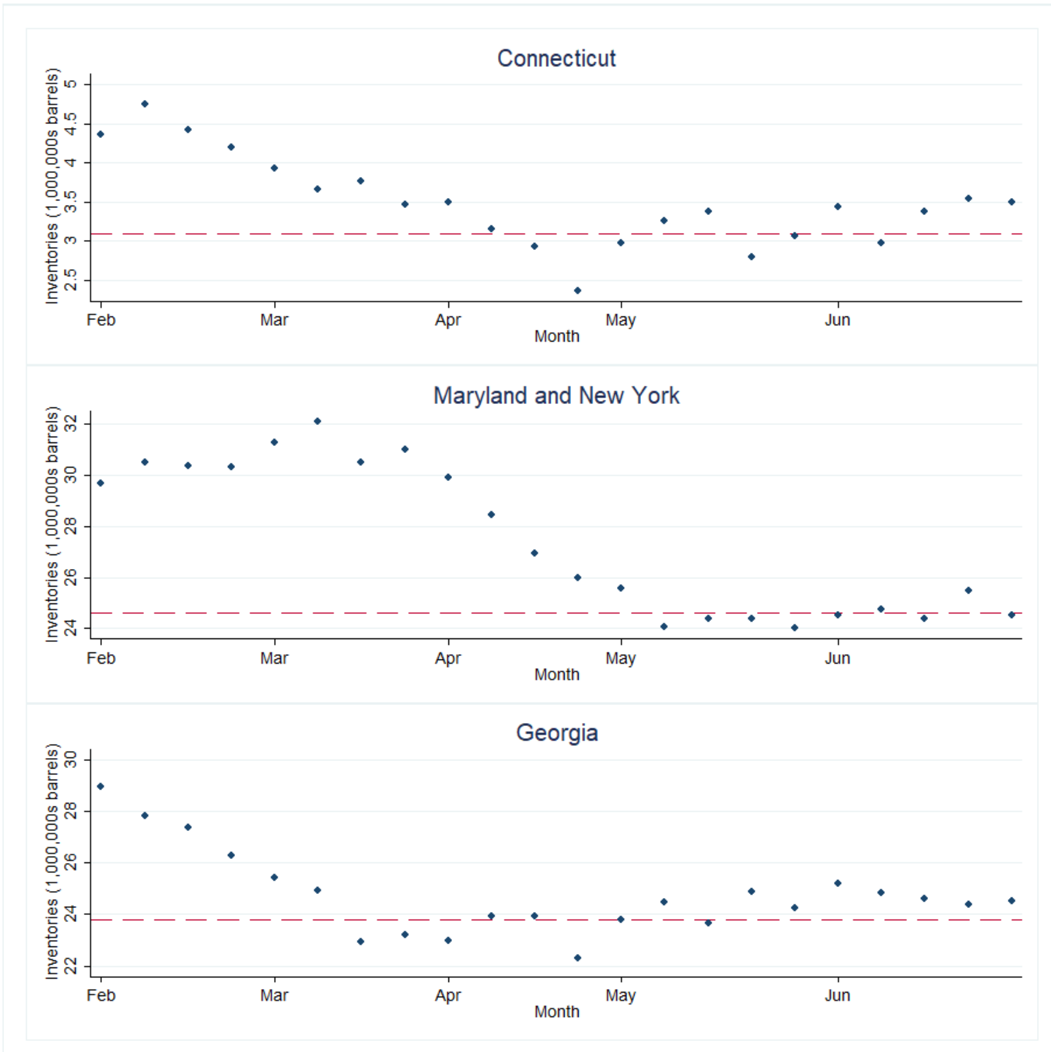

Figure 5: Weekly Gasoline Inventories in Tax Holiday States

Notes: Red dashed line indicates threshold for bottom 25% of distribution of inventory levels within the respective region.

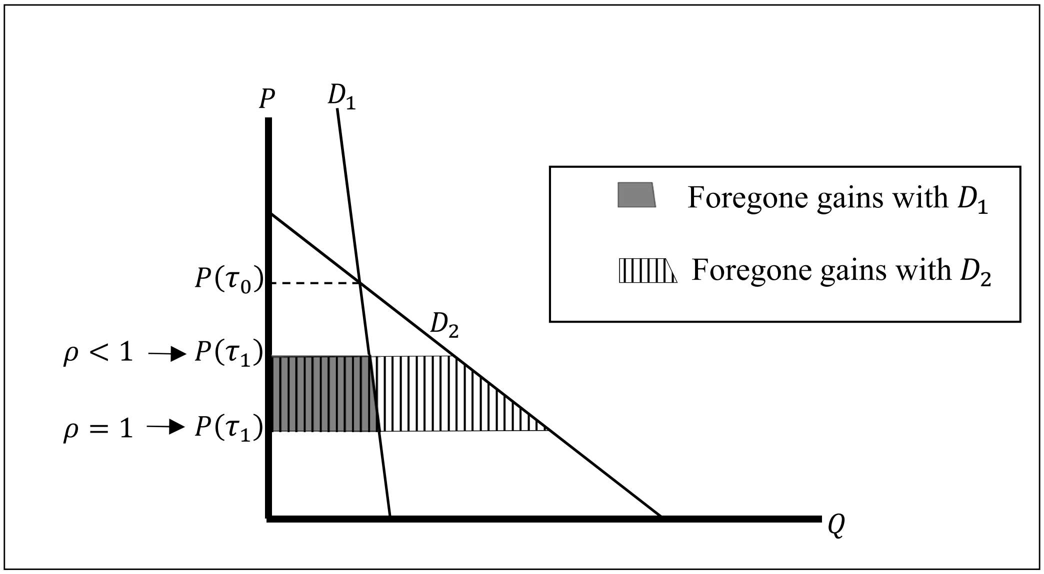

Figure 6: Effect of a Tax Decrease from τ_0 to τ_1 on Consumer Surplus

<u>Notes:</u> D_1 and D_2 represent two demand curves with different price elasticity and the same consumption quantity under price $P(\tau_0)$.

Table 1: Summary Statistics by Group

Variable	No holiday	Holiday	Difference	*p*-value
Reformulated gasoline requirement (=1)	0.35	0.27	0.08	0.41
Unemployment rate (%)	3.5	3.7	-0.2	0.19
Minimum neighboring state tax (cpg)	16.65	19.60	-2.95	0.50
Population (1,000,000s)	5.8	10.3	-4.5	0.26
Percent adults with BA or higher	37.8	37.7	0.1	0.98
Median household income ($1,000s)	70.53	74.81	-4.28	0.55
Democrat governor	0.50	0.50	0	1.00
Democrat fraction of state senate	0.59	0.60	-0.01	0.93
Democrat fraction of state house	0.55	0.62	-0.07	0.48
GSP per capita (1,000s 2012 dollars)	66.1	64.8	1.3	0.95
Percent share GSP - manufacturing	7.3	6.5	0.8	0.66
Percent share GSP - mining	0.12	0.10	0.02	0.71
Percent share GSP - transportation	1.4	1.7	-0.3	0.46
Gasoline inventories (1,000s barrels)	16.5	20.7	-4.2	0.54

Notes: Unit of observation for reformulated gasoline requirement and unemployment rate is city. For all remaining covariates, unit of observation is state. First two columns report the mean of each variable for "No holiday" group (11 states and District of Columbia) and "Holiday" group (4 states). Column "Difference" shows the difference between group means. Last column reports *p*-value from a *t*-test of the group means.

Table 2: Time-Varying Predictors of Gasoline Tax Change

Variable	Specification	
	I	II
Unemployment	1.911	0.052
	(2.194)	(0.120)
GSP per capita	-5.062	0.155
	(11.612)	(0.604)
% GSP share - manufacturing	-4.943	0.455
	(16.720)	(0.834)
% GSP share - mining	491.881	-21.847
	(377.624)	(20.241)
% GSP share - transportation	-28.104	0.021
	(112.040)	(6.053)
Gasoline inventories	-1.002	0.023
	(0.692)	(0.036)
Month fixed effects	yes	yes
p-value for joint significance test	0.63	0.61
Observations	432	432

Notes: Unit of observation is city-month. All variables are first-differenced. Dependent variable in Specification I is gasoline tax (in cpg). Dependent variable in Specification II is a dummy variable for change in gasoline tax. *p*-value reported from an F-test of joint significance of the six covariates. Two-way clustered standard errors by state and month are shown in parentheses. $p < 0.1$ (*), $p < 0.05$ (**), $p < 0.01$ (***).

Table 3: Average Pass-Through Rate

Variable	Specification		
	I	II	III
Tax	0.881***	0.825***	0.794***
	(0.095)	(0.091)	(0.068)
WTI crude oil price	yes	no	no
Capacity utilization	yes	no	no
Local controls	no	no	yes
City fixed effects	yes	yes	yes
Month fixed effects	yes	no	no
Day-of-month fixed effects	yes	no	no
Month × date fixed effects	no	yes	yes
Pass-through = 1 (*p*-value)	0.21	0.06	0.00
Pass-through = 0.9 (*p*-value)	0.84	0.41	0.13
Pass-through = 0.8 (*p*-value)	0.40	0.79	0.93
Observations	16,200	16,200	16,200

Notes: Unit of observation is city-day. Dependent variable is retail gasoline price (in cpg), inclusive of tax. Local controls include minimum neighbor tax, unemployment, and gasoline inventories. Two-way clustered standard errors by state and month are shown in parentheses. $p < 0.1$ (*), $p < 0.05$ (**), $p < 0.01$ (***).

Table 4: Robustness Checks

Variable	Specification					
	Baseline	R1	R2	R3	R4	R5
Tax	0.794***	0.794***	0.759***	0.753***	0.776***	0.820***
	(0.068)	(0.068)	(0.052)	(0.084)	(0.069)	(0.087)
Local controls	yes	yes	yes	yes	yes	yes
State covariates	no	no	yes	no	no	no
City fixed effects	yes	yes	yes	yes	yes	yes
Month × date fixed effects	yes	yes	yes	yes	yes	yes
Group time trends	no	yes	no	no	no	no
State × month fixed effects	no	no	no	yes	no	no
Sample	full	full	full	full	border cities	exclude +/-1 week
Pass-through = 1 (*p*-value)	0.00	0.00	0.00	0.00	0.00	0.04
Pass-through = 0.9 (*p*-value)	0.13	0.12	0.01	0.08	0.08	0.36
Pass-through = 0.8 (*p*-value)	0.93	0.58	0.43	0.58	0.73	0.82
Observations	16,200	16,200	16,200	16,200	5,700	15,480

Notes: Unit of observation is city-day. Dependent variable is retail gasoline price (in cpg), inclusive of tax. Local controls include minimum neighbor tax, unemployment, and gasoline inventories. State covariates include real GSP per capita and percentage of real GSP by manufacturing, mining, and transportation industry. Specification R4 includes only cities within a 50-mile corridor around the boundary of a tax holiday state. Specification R5 drops observations in tax holiday states within one week of tax change date. Two-way clustered standard errors by state and month are shown in parentheses. $p < 0.1$ (*), $p < 0.05$ (**), $p < 0.01$ (***).

Table 5: Heterogeneity Analysis

Variable	RGF regulations		Refinery constraints		Storage constraints	
	No RGF mandate	RFG mandate	Low utilization	High utilization	High inventories	Low inventories
Tax	0.826***	0.738***	1.013***	0.740***	0.863***	0.718***
	(0.087)	(0.043)	(0.080)	(0.064)	(0.082)	(0.083)
Local controls	yes	yes	yes	yes	yes	yes
City fixed effects	yes	yes	yes	yes	yes	yes
Month × date fixed effects	yes	yes	yes	yes	yes	yes
Pass-through = 1 (*p*-value)	0.06	0.00	0.87	0.00	0.10	0.00
Pass-through = 0.9 (*p*-value)	0.40	0.00	0.17	0.02	0.65	0.03
Pass-through = 0.8 (*p*-value)	0.77	0.16	0.01	0.35	0.44	0.32
Observations	10,950	5,250	5,724	10,476	11,697	4,503

Notes: Unit of observation is city-day. Dependent variable is retail gasoline price (in cpg), inclusive of tax. Local controls include minimum neighbor tax, unemployment, and gasoline inventories. "RFG regulations" splits the sample between cities with no mandate for reformulated gasoline (RFG) and cities with RFG mandate. "Refinery constraints" splits the sample between observations with refinery capacity utilization at or below 90% ("low") and observations with utilization above 90% ("high"). "Storage constraints" splits up the sample between observations with gasoline inventories above the bottom quartile of the region's distribution ("high") and observations with inventories in the bottom quartile ("low"). Two-way clustered standard errors by state and month are shown in parentheses. $p < 0.1$ (*), $p < 0.05$ (**), $p < 0.01$ (***).

Table 6: Monthly Consumer Surplus Impacts

State	Consumer surplus gain (actual ρ)	Consumer surplus gain ($\rho = 1$)	Consumer surplus gain ($\rho = 0.794$)	Loss	Bias
Connecticut	\$8,746,181	\$22,368,750	\$17,760,788	\$13,622,569	\$9,014,606
Maryland	\$40,520,223	\$46,628,565	\$37,023,081	\$6,108,342	-\$3,497,142
New York	\$37,167,054	\$64,302,862	\$51,056,473	\$27,135,808	\$13,889,418

Notes: Consumer surplus gain calculated by multiplying pass-through rate × monthly gasoline consumption × tax change. "Loss" calculated as the difference between surplus gain values in the second and first column. "Bias" calculated as the difference between surplus gain in third and first column.

APPENDIX

Table A1: Gasoline Price Change Prior to Tax Holiday Implementation

Period	State		
	Georgia and Maryland	Connecticut	New York
1 week	0.188	-0.034	0.032
	(0.136)	(0.235)	(0.180)
2 weeks	0.322	-0.035	0.243
	(0.408)	(0.097)	(0.162)

Notes: Unit of observation is city-day. Each estimate is obtained from a linear regression with dependent variable the first-differenced retail gasoline price (in cpg), inclusive of tax. Independent variable is a dummy variable for the state(s) listed on top of each column. Row "1 week" uses observations during 1 week prior to implementation date. Row "2 weeks" uses observations from 2 weeks preceding implementation. Regressions in column "Connecticut" exclude observations from Georgia and Maryland. Regressions in column "New York" exclude observations from Georgia, Maryland, and Connecticut. Standard errors, clustered by state, are shown in parentheses. $p < 0.1$ (*), $p < 0.05$ (**), $p < 0.01$ (***).

Table A2: Average Pass-Through Estimate Using One Day per Week

Variable	Specification						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Tax	0.803***	0.829***	0.792***	0.813***	0.795***	0.768***	0.777***
	(0.074)	(0.074)	(0.081)	(0.076)	(0.082)	(0.081)	(0.075)
Local controls	yes	yes	yes	yes	yes	yes	yes
City fixed effects	yes	yes	yes	yes	yes	yes	yes
Month x date fixed effects	yes	yes	yes	yes	yes	yes	yes
Weekday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Pass-through = 1 (*p*-value)	0.00	0.02	0.01	0.02	0.02	0.01	0.00
Pass-through = 0.9 (*p*-value)	0.19	0.34	0.18	0.26	0.21	0.11	0.11
Pass-through = 0.8 (*p*-value)	0.97	0.70	0.92	0.87	0.95	0.69	0.76
Observations	2,376	2,376	2,268	2,268	2,160	2,376	2,376

Notes: Unit of observation is city-day. Dependent variable is retail gasoline price (in cpg), inclusive of tax. Local controls include minimum neighbor tax, unemployment, and gasoline inventories. Each specification drops data from all days of the week except for the day listed in row "Weekday." Two-way clustered standard errors by state and month are shown in parentheses. $p < 0.1$ (*), $p < 0.05$ (**), $p < 0.01$ (***).