Pass-Through Rate of Motor Gasoline Taxes:

Efficiency and Efficacy of Environmental Taxes

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Abstract

I investigate the degree to which taxes on motor gasoline are passed on to consumers by estimating two cointegrating vector autoregression models for each of six states, one that specifies retail prices for motor gasoline that do not include taxes and a second that specifies retail prices for motor gasoline that include taxes. Exclusion tests on models that specify the retail price of motor gasoline without taxes indicate that taxes on motor gasoline are not simply passed on to consumers. The degree to which prices are passed on to consumers is quantified by CVAR models that specify the retail price of motor gasoline including taxes. Direct effects indicate that taxes are fully passed on to wholesale prices in Florida and Massachusetts and passed on to retail prices with a 'mark up' in Florida, Massachusetts and New York. Direct effects are amplified by the indirect effects of taxes on inventories of motor gasoline and refinery utilization rates such that the total effect of taxes on retail motor gasoline prices is greater than a simple pass through in Florida, Massachusetts, New York and Ohio. Conversely, taxes on motor gasoline have little long-run effect on wholesale and retail prices in Washington. These results, which differ from previous results that suggest taxes are passed completely to consumers, are caused in part by assuming that taxes on motor gasoline are exogenous, ignoring upstream sectors of the motor gasoline supply chain, and ignoring changes in the grade and formulation of motor gasoline purchases. If taxes are not simply passed to consumers, the rate of pass through will affects the deadweight loss, welfare transfer, and efficiency of environmental taxes in a way favors cap-and trade solutions relative to taxes.

Introduction

Are taxes that seek to ameliorate environmental externalities effective and/or are they efficient? The answer depends in part on the degree to which taxes are passed on to consumers. In a competitive market, economic theory suggests that the rate at which a Federal tax is passed on to consumers is approximately $\eta/(\eta - \varepsilon)$, in which η is the supply elasticity and ε is the demand elasticity (Chouinard and Perloff, 2004). Demand elasticities for many fuels are thought to be inelastic whereas supply elasticities are relatively elastic (Labandiera *et al.,* 2015). Under these conditions, a competitive market will pass a relatively large fraction of a tax on motor gasoline to consumers. Complete pass-through preserves the efficiency and efficacy of taxes aimed at reducing environmental externalities.

Much of the empirical research on the rate at which markets pass energy taxes to consumers focuses on motor gasoline taxes. To date, these efforts are relatively limited and follow two general approaches. One approach analyze panels that include monthly observations for retail and wholesale motor gasoline prices, crude oil prices, taxes on motor gasoline, and market conditions, such as pollution laws, market power, and proxies for demand (e.g. income, speed limit). Dependent variables include the retail and wholesale prices of motor gasoline. Results focus on the coefficient associated with taxes on motor gasoline. Coefficients that are not statistically different from one indicate that the tax on motor gasoline is passed fully to consumers. Values greater than one indicate that the tax is passed on to consumers with a mark-up whereas coefficients that are less than one indicate that taxes are not passed fully to consumers.

Following this methodology, Chouinard and Perloff (2003) analyze a panel that includes monthly observations for 48 mainland states (and Washington DC) from March 1989 to June

1997. The dependent variables in a system of seemingly unrelated regressions are average wholesale and retail prices for unleaded motor gasoline, including taxes. Fixed effects estimates indicate that a Federal tax falls equally on wholesalers and consumers, whereas state taxes fall almost entirely on consumers. Using a similar panel (50 states, 1984-1999) and a fixed effects estimator, Alm *et al*., (2009) find that gasoline taxes are fully passed to consumers and that the fraction that is passed to consumers in urban states is greater than the fraction that is passed to consumers in rural states. Following a similar approach, Bello and Contin-Pilar (2012) find that regional taxes on motor gasoline are fully passed to consumers in Spain.

A second approach uses changes in motor gasoline taxes as natural experiments in which prices are compared before and after a tax increase or decrease. This approach allows authors to analyze daily observations that are obtained from receipts from sales of motor gasoline from individual gas stations. Doyle and Samphantharak (2008) analyze the effects of a temporary suspension of the gas tax in Indiana (and its subsequent re-instatement) by comparing the price of regular unleaded gasoline to the same price in the neighboring states of Illinois and Kentucky. Results indicate that about 70 percent of the reduction in motor gasoline prices is passed to consumers whereas 80 – 100 percent of the tax reinstatement is passed to consumers. Focusing on a five-cent increase in taxes on motor gasoline in Washington during 2003 and comparing the resultant changes to those in Oregon, Silvia and Taylor (2014) find that the pass through to Washington drivers is less than complete but argue that much of this reduction is caused by the on-going expansion of hypermarkets, which are retailers such as Costco, Walmart, Fred Meyer and Safeway that add fuel pumps. Furthermore, they find that taxes on motor gasoline prices have little effect on wholesale prices.

Here, I use a time series approach to analyze the degree to which taxes on motor gasoline in six states are passed to wholesale and retail prices for motor gasoline. This approach uses a cointegrated vector autoregression (CVAR) model, which has several strengths relative to previous analyses. First, the CVAR model allows me to test the unstated assumption that taxes on motor gasoline (and other aspects of the upstream supply chain) are exogenous. This avoids simultaneous equation bias that would occur if prices for motor gasoline affect variables specified on the right-hand side by previous analyses. Second, the CVAR model is consistent with the presence of a stochastic trend in the time series and explicitly separates short- and long-run effects. This allows me to avoid *ad hoc* lags structures and spurious regressions (Hendy and Juselius, 2000). Third, I test for an indirect effect of taxes by including upstream sectors of the oil supply chain (inventories and refinery utilization rates). This allows me to avoid omitted variable bias that is caused when the effect of upstream factors are ignored (e.g. Kaufmann and Laskowski, 2005). Finally, I focus on a specific grade and formulation of gasoline. Concentrating on the price for a specific type of gasoline avoids the possibility that higher taxes induce substitution away from premium and mid-grades gasolines, which would could bias estimates for the effect of a tax on the average price for motor gasoline. Nonetheless, this change comes with a cost; I cannot use daily data derived from credit card sales and spatial variations in price within the state.

Useable observations for motor gasoline prices (with and without taxes) are available for six states; Florida, Massachusetts, Minnesota, New York, Ohio, and Washington. For CVAR models that specify the retail price of motor gasoline without taxes, I reject restrictions that eliminate taxes on motor gasoline taxes from cointegration space. This suggests that in the long-run, taxes on motor gasoline prices are not passed to consumers on a one-for-one basis. This result is reinforced by statistical estimates of CVAR models that specify the retail price of motor gasoline with taxes. For these models, cointegrating relations reject the hypothesis that taxes on motor gasoline are passed to retail consumers on a one-for one basis in Florida, Massachusetts, New York and Ohio. In these states, long-run retail prices rise more than taxes. Furthermore, this rise is amplified in Florida and Massachusetts by indirect effects, in which taxes on motor gasoline affect upstream sectors in ways that increase retail prices. Together, these results suggest that the efficacy and efficiency of a tax on motor gasoline in particular, and environmental externalities in general are more complex than currently envisioned by proponents.

These results and the methods used to obtain them are described in five sections. The next section describes the data and statistical methodology that are used to analyze the relation among motor gasoline prices, taxes on motor gasoline, and upstream sectors in the oil market. Section 3 describes the econometric results for the two CVAR models that are estimated for each of six states. These results are interpreted relative to questions about the degree to which motor gasoline taxes are passed to wholesale and retail prices in the fourth section. The fifth section describes what these results imply for the efficacy and economic efficiency of environmental taxes writ large.

II Methodology

Data

I compile monthly observations for the price of motor gasoline, taxes on motor gasoline, prices of crude oil, refinery utilization rates, and inventories of motor gasoline. The price of motor gasoline for resale are used to measure wholesale prices (https://www.eia.gov/dnav/pet/pet_pri_refmg_dcu_SMA_m.htm). One measure of the retail price for motor gasoline is the sale price of motor gasoline through retail outlets excluding taxes (https://www.eia.gov/dnav/pet/pet_pri_allmg_d_SOH_PTC_dpgal_m.htm). These data are available for all fifty states, but observations stop in February 2011. Retail prices for motor gasoline including taxes are available through the present, but these data start in 2000 (https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_nus_w.htm). Furthermore, observations are available for only nine states. Of these, state taxes on motor gasoline do not change after 2000 in Texas and Colorado (Federal taxes are constant during this period) therefore, these states are excluded from the sample. California is excluded from the sample because state taxes on motor gasoline are levied both as a percentage of price and a flat rate. As such the sample include observations for six states; Florida, Massachusetts, Minnesota, New York, Ohio, and Washington.

For each state, I collect prices on the largest selling form a regular gasoline, either conventional or all formulations (Table A-1, Supplemental Material). The latter is chosen based on the availability of data and the form that makes up the largest part of sales. Focusing on a single grade and form of gasoline is critical because there can be significant changes in the types of gasoline purchased over the sample period. Furthermore, these changes may be affected by taxes on motor gasoline. Higher taxes may encourage consumers to switch from premium and/or midgrade to regular gasoline, which would lower the average price of gasoline. Changes in the average price due to changes in the types of gasoline purchased would obfuscate the effects of motor gasoline taxes on motor gasoline prices. Consistent with this hypothesis, CVAR models that specify the average price of all grades of motor gasoline prices (e.g. regular, midgrade, and premium) generate results that are different than those reported in section V. The effect of changes in the types of motor gasoline purchased over time is ignored by previous efforts that use panel techniques.

Rather than focus on exogenous (supposedly) changes in demand (e.g. income, speed limits, etc.) over time, I compile observations on upstream sectors of the oil market that may be related to the price of motor gasoline; inventories of motor gasoline (*Stock*), refinery utilization rates (*Refine*), and the price of crude oil (*PCrude*). I use monthly observations on refinery inventories of motor gasoline by type for each Petroleum Administration Defense District (PADD) because state level data are not available (https://www.eia.gov/dnav/pet/pet_stoc_ref_dc_r10_mbbl_m.htm). Refinery utilization rates are available by PADD (https://www.eia.gov/dnav/pet/pet_pnp_unc_dcu_nus_m.htm). Finally, the price of crude oil is measured by the average price paid by refiners (https://www.eia.gov/dnav/pet/pet_pri_rac2_dcu_nus_m.htm).

Monthly data for the Federal and state tax on motor gasoline are available by state from the Federal Highway Administration (https://www.fhwa.dot.gov/policyinformation/motorfuelhwy_trustfund.cfm). These data are expressed in cents per gallon. Because the Federal tax does not change over the sample period, I sum Federal and state taxes (*Tax*). State taxes represent the charge that is levied as a dollar amount per volume of motor fuel (Figure 1).

Previous research indicates that the point at which taxes on diesel fuel are collected affects the rate at which the tax is passed to consumers (Kupczuk *et* al., 2016). Unfortunately, there is no consistent set of data to indicate the point in the supply chain at which taxes are collected. Data on the point of collection for motor gasoline taxes are available through 2008 from Highway Taxes and Fees: How They Are Collected and Distributed," published by the Federal Highway

Administration(https://www.fhwa.dot.gov/policyinformation/motorfuel/hwytaxes/2008/mf101.cfm). During this period, there is no change in the point of taxation in any of the six states analyzed. Data are available for 2012 from the FTA Motor Fuel Tax Uniformity CommitteeE-Commerce Subcommittee Survey and 2016 from the Federation of Tax Administrators (https://www.taxadmin.org/assets/docs/MotorFuel/201609%20Motor%20Fuel%20Tax%20Information%20by%20State%20Book.pdf), but the categories used to describe the point of taxation differ from those used during the 2000-2008 Table A-2). As such, it is not possible to determine whether the point of classification changes. But if such changes affect the rate that taxes on motor gasoline are passed to consumers, such changes would disrupt long-run cointegrating relations. As described in the next sections, results suggest that the CVAR models contain one or more cointegrating relations that include prices for and taxes on motor gasoline. This implies that either there is no change in the point of taxation in individual states or such changes have no detectable effect on the long-run relation between prices for and taxes on motor gasoline.

To make price directly comparable, observations for the price of crude oil, motor gasoline, and taxes on motor gasoline are converted to US dollars per gallon and deflated by monthly values of the U.S. city average for all items (CUUR0000SA0) that is obtained from the Bureau of Labor. To eliminate the effects of inverting matrices with elements that differ greatly in size (due to different units of measure), the time series for inventories of motor gasoline and refinery utilization rates are standardized as follows:

$$x_t = \frac{(y_t - \bar{y})}{\sqrt{Var(y)}} \qquad (1)$$

in which y_t is the value (in original units), $\bar{y}$ is the average value over the sample period, and $Var(y)$ is the variance over the sample period.

Statistical Methodology

Short- and long-run relations among motor gasoline prices, taxes on motor gasoline, and usptream sectors of the motor gasoline supply chain are estimated using a cointegrating vector autoregression (CVAR) model. A CVAR has several advantages relative to the methodologies described in the previous section. The CVAR analyzes relations among non-stationary time series. This avoids spurious regressions, which may or may not be present in results generated by panel techniques that ignore the time series properties of the data. The CVAR can be used to test whether variables are endogenous and/or weakly exogenous, which avoids *a priori* assumptions about whether wholesale motor gasoline prices, retail motor gasoline prices, taxes on motor gasoline, and upstream components of the oil market are independent or dependent variables. The CVAR separates short- and long-run effects, which alleviates the need for lag structures that are used by previous approaches. Finally, the CVAR can identify more than one cointegrating relation, which allows taxes to affect more than a single variable. For a more complete description of the CVAR, see Juselius (2006).

The general form of the CVAR model is given by:

$$\Delta x_t = A_0\, \Delta w_t + A_1\, \Delta w_{t-1} + \Phi_1\, \Delta x_{t-1} + \Pi(x_{t-1} w_{t-1})' + k_0 + \Theta M + \varepsilon_t \qquad (2)$$

in which x_t is a vector of (p) endogenous variables whose behavior is being modeled, w_t is a vector of exogenous variables, k_0 is a vector of constant terms, M is a vector that eleven monthly dummy variables (Jan-Nov), $A_0, A_1, \Phi_1, \Theta,$ and Π are matrices of regression coefficients, Δ is the first difference operator ($\Delta x_t = x_t - x_{t-1}$), and ε is $Niid(0, \Omega)$.

When the time series are nonstationary, the long-run matrix Π from equation (2) can be formulated as:

$$\Pi = \alpha\beta' \qquad (3)$$

in which α is a $p{\times}r$ matrix of adjustment coefficients (also known as *loadings*), β' is an $r{\times}p$

matrix of cointegration coefficients that define stationary deviations from long-run equilibrium relationships, and r is the number of long-run cointegrating relations. As such the element of β that is associated with taxes on motor gasoline represents its direct long-run effect on prices for motor gasoline.

The number of cointegrating relations present is given by the rank (r) of the Π matrix. The cointegration rank r is determined by solving an eigenvalue problem in which the eigenvectors estimates of β and $\alpha = f(\beta)$ can be found for a given β. The eigenvectors β are determined by an orthogonality condition and are ordered according to their degree of stationarity (Juselius, 2006).

Several diagnostic tools are available to determine the rank of Π; the most common is the likelihood based trace test (Johansen, 1996), which tests the null hypothesis of (p-r) unit roots against the alternative hypothesis of $(p - r + 1)$ unit roots. The test procedure is based on a sequence of tests, starting from $r = 0$ (no stationary relations among the endogenous and/or exogenous variables), $r = 1$ (p-1 stochastic trends, one stationary cointegration relation) and ending with $(r = p)$ (all cointegration relations are stationary). The test is based on the null hypothesis of a unit root, therefore it often has low power to reject a unit root when the true root is close to the unit circle.

Once the rank of the CVAR model is determined, I test restrictions that make all elements of α that load the cointegrating relations into the equation for a given variable to zero. Rejecting this restriction indicates the variable responds to disequilibrium in one or more of the long-run cointegrating relations; the variable is endogenous and is placed in the x vector. Failure to reject the restrictions indicates that the variable does not repsond to disequilibrium, is weakly exgenous, and is placed in the w vector. Sorting variables between endogenous and weakly exogenous classification simplifies the effort to impose identifying restrictions (Greenslade *et al*., 1997). Imposing restictions $\beta = 0$ on all elements of β that are assoicated with a specifc variable test whether that variable can be exlcuded from cointegration space. Failure to reject this restriction implies that the excluded variable has no long-run relation with any of the endogenous variables in the x vector.

For each of six states the CVAR model is estimated with two sets of data. One set uses the price of motor gasoline without taxes. For this model, I test restrictions that taxes on motor gasoline can be excluded from cointegration space. If taxes on motor gasoline prices are passed to consumers on a one-for-one basis, threre will be no long-run relation between taxes and the price of motor gasoline without taxes. Rejecting this null hypothesis will indicate that taxes on motor gasoline are not passed to wholesale or retail prices on a one-for-one basis.

The second CVAR model (for each of six states) specifies the price of motor gasoline that includes taxes. These data are used to indentify an overidentified model. The direct effect of taxes on motor gasoline prices is given by the coefficient in a cointegrating relation that (1) is associated with taxes on motor gasoline prices, (2) incudes the wholesale and/or retail price of motor gasoline, and (3) either of these prices 'equilibrium adjust' to disequilibrium in this cointegrating relation.

To estimate the total long-run effects of a change in taxes on motor gasoline, the overidentified models are used to used to simulate two experiments. The first set is designed to assess the ability of the weakly exogenous variables to account for the short- and long-run movements in the wholesale and retail price of motor gasoline. The second set of experiments is designed to assess the total (direct and indirect) long-run effects of a one cent increase in the tax on motor gasoline prices. To do so, the weakly exogenous variables are held at their sample mean ($\bar{x}$) and the model is simulated to equilibrium. The tax on motor gasoline is increased by a one cent ($\bar{x} + 0.01$) and the model is allowed to come to a new equilibrium. The price difference between the two equilibrium values represents the long-run effect of the one cent tax increase on wholesale or retail price for motor gasoline.

II Results

For models that specify the retail price of motor gasoline without taxes the test statistic rejects the null hypothesis that it is stationary for all time series (Table 1). These models contain one or more cointegrating relations (Table A-3, Supplemental Material). For all states other than Ohio, tests reject the null hypothesis that the wholesale and retail (excluding taxes) price for motor gasoline is weakly exogenous (i.e. prices respond to disequilibrium in the long-run cointgerating relations). Tests reject the null hypothesis that the tax on motor gasoline prices can be excluded from cointgeration space for only one state, Florida. In all other states, tests reject the hypothesis that taxes on motor gasoline can be excluded from long-run cointegrating relations among variables.

For models that specify the price of motor gasoline including taxes, tests reject the null hypothesis that the time series are stationary, except refinery utilization rates in Minnesota (Table 2). These nonstationary variables share the same stochastic trends, as indicated by the presence of either three or four cointegrating relations (Table A-4). For all states, tests reject the null hypothesis that the wholesale and retail price of motor gasoline is weakly exogenous. In all states, tests fail to reject the null hypothesis that the price of crude oil is weakly exogenous. For all states other than New York, tests reject the null hypothesis that inventories of motor gasoline and/refinery utilization rates are weakly exogenous. Tests fail to reject the null hypothesis that taxes on motor gasoline are weakly exogenous in all states, except for Minnesota.

In all six states, the retail price of motor gasoline (including taxes) adjusts towards a long-run equilibrium value that is implied by a cointegrating relation that includes the price of motor gasoline including taxes (Table 3). As such, these cointegrating relations can be interpreted as a long-run equation for retail prices of motor gasoline. Four of these cointegrating relations include taxes on motor gasoline, which implies a long-run relation between taxes on and retail prices for motor gasoline. For states other than New York and Minnesota, the wholesale price of motor gasoline adjusts towards a long-run equilibrium value that is implied by a cointegrating relation that includes the wholesale price of motor gasoline. These cointergating relations include taxes on motor gasoline in two states, Florida and Massachusetts, which implies a long-run relation between taxes on and wholesale prices for motor gasoline.

Consistent with these results, the CVAR model that specifies the retail price for motor gasoline including taxes is able to simulate wholesale and retail prices for motor gasoline based on the observed values for variables that are weakly exogenous (Figure 2 & 3). As such, the model should be able to accurately represent the total effect of a change in taxes on the wholesale and retail price for motor gasoline.

Discussion

Are taxes on motor gasoline fully passed to consumers?

Statistical estimates of CVAR models that specify the retail price for motor gasoline without taxes generally are inconsistent with the hypothesis that taxes on motor gasoline are fully passed to consumers. As described previously, tests generally reject the null hypothesis that taxes on motor gasoline prices can be excluded from cointegration space. Rejecting this null hypothesis suggests that for every state analyzed here (except Florida), taxes on motor gasoline are part of a long-run relation that also includes the wholesale and retail price of motor gasoline (excluding taxes). If taxes on motor gasoline are passed to consumers on a one-for-one basis, taxes would have no long-run effect on retail (or wholesale) prices that do not include taxes. Instead, the need to include taxes in the long-run relation implies that in the long-run, taxes on motor gasoline are related to the retail price of motor gasoline without taxes and/or the wholesale price.

The need to include taxes suggests two possible long-run effects. If taxes are not fully passed on to consumers, a tax on motor gasoline prices would reduce the pre-tax price of motor gasoline, which will create a negative long-run relation between taxes on motor gasoline and the retail price of motor gasoline without taxes. Conversely, the pre-tax price of motor gasoline will be positively related to taxes on motor gasoline if taxes increase the price of motor gasoline by more than the tax. The sign and magnitude of the effect of taxes is quantified by models that specify the price of motor gasoline that include prices.

Before describing those results, the interpretation of models that specify motor gasoline prices without taxes requires a *caveat*. For only New York and Ohio do test statistics reject the null hypothesis that the wholesale or retail price of motor gasoline is weakly exogenous (Table 1). Rejecting this null hypothesis implies wholesale or retail prices adjust to disequilibrium in the long-run relation among taxes and wholesale and retail prices for motor gasoline. In all other five states, the failure to reject the null hypothesis that wholesale and retail prices of motor gasoline are weakly exogenous implies that these prices are unaffected by disequilibrium in cointegrating relations. Nonetheless, the inability to exclude taxes on motor gasoline, wholesale prices for motor gasoline, and retail prices for motor gasoline (without taxes) from cointergation space implies that the retail price of motor gasoline that excludes taxes shares a stochastic trend with wholesale prices and taxes on motor gasoline. This long-run relation implies that taxes on motor gasoline are not passed to retail (or wholesale) prices on a one-for-one basis.

The sign and magnitude for the effect of motor gasoline taxes on prices for motor gasoline

Statistical estimates of models that specify retail prices (including taxes) indicate that taxes on motor gasoline are not simply passed through to consumers; in some states, taxes are marked up whereas in other states, taxes are not passed fully to consumers. The total effect of taxes on wholesale and retail prices is determined by both direct and indirect effects. Direct effects are represented by the element of the cointegrating vector that is associated with taxes in cointegrating relations that include the price of gasoline and load into the equation for the price of motor gasoline. These criteria are satisfied by cointegrating relations for wholesale prices in the CVAR models for Florida and Massachusetts. In both Florida ($\hat{\beta} = -1.096$, t = 0.60, p > 0.54) and Massachusetts ($\hat{\beta} = -0.987$, t = 0.08, p > 0.93), I fail to reject restrictions that imposes a value of -1.0[1] on the coefficient that is associated with taxes on motor gasoline. The failure to reject the null hypothesis indicates that taxes on motor gasoline are fully passed to wholesale prices in Florida and Massachusetts. In the other four states, taxes on motor gasoline do not have a direct effect on the wholesale price of motor gasoline.

The CVAR models for Florida, Massachusetts, Minnesota, and New York, contain a cointegrating relation that represents the long-run relation between the retail price of motor gasoline (including taxes) and taxes on motor gasoline. To assess the rate at which taxes on motor gasoline are passed directly to retail prices, I whether the coefficient associated taxes equals -1.0. This restriction is rejected strongly in the model for Florida ($\hat{\beta} = -1.789$, t = 13.7,

[1] A value of -1.0 implies taxes are passed to prices on a one-for-one basis

$p < 0.00001$), Massachusetts ($\hat{\beta} = -1.408$, t = 5.25, $p < 0.00001$), Minnesota ($\hat{\beta} = -2.032$, t = 3.22, $p < 0.002$), and New York ($\hat{\beta} = -2.257$, t = 5.82, $p < 0.00001$). Point estimates for the coefficient associated with taxes that are greater than one in absolute terms imply that taxes are marked up 41 to 126 percent as they are passed on to retail price for motor gasoline. Taxes have no direct effect on retail prices for motor gasoline in Ohio and Washington.

The direct effect of taxes on retail prices in Minnesota is clouded by the third cointegrating relation (CR #3), which indicates that there is a second long-run relation that includes taxes on motor gasoline and wholesale and retail prices. But disequilibrium in this cointegrating relation moves both the retail price of motor gasoline and the tax on motor gasoline towards long-run values implied by this cointegrating relation. In the long-run, taxes on motor gasoline are positively related to wholesale prices and negatively related to retail prices. This suggests that policy makers raise taxes when retail prices for motor gasoline are below its long-run equilibrium. Consistent with this interpretation, taxes rise during the oil price collapse that is associated with the 2008 financial crisis (Figure 1). Because of this bi-directional adjustment, it does not make sense to assume that taxes are exogenous and evaluate the rate at which taxes are passed on to retail prices.

The direct effect is not the only way in which taxes on motor gasoline may affect wholesale and retail prices for motor gasoline. Indirect effects may occur if taxes affect upstream sectors of the oil supply chain and if these effects are passed on down the supply chain to wholesale and/or retail prices for motor gasoline. In the CVAR model for Florida, CR #3 indicates that inventories of motor gasoline are positively related to taxes. And CR#1 indicates that inventories are positively related to retail prices of motor gasoline. Under these conditions, taxes on motor gasoline prices in Florida affect upstream sectors, and these effects are passed down the supply chain to wholesale and retail prices for motor gasoline.

The indirect effects of taxes on motor gasoline prices is quantified by simulations in which all endogenous variables adjust to a one cent increase in taxes. Specifically, the indirect effect given by the difference between the total and direct effect (Figure 4). In Florida and Massachusetts, where there is a direct relation between taxes and wholesale prices, the indirect effects of taxes on wholesale prices tend to be relatively small. Conversely, the indirect effects of taxes on wholesale prices tend to be large in New York and Ohio, where the CVAR model cannot identify a direct effect of taxes.

In Florida and Massachusetts, the direct effects of motor gasoline taxes on the retail price of motor gasoline are amplified by indirect effects. In Florida, taxes directly affect inventories and wholesale prices, and together these indirect effects raise the total effect of taxes by another 1.7 cents per gallon. In Massachusetts, the indirect effect is about 1.0 cents per gallon and is associated with the direct effect of taxes on inventories and refinery utilization rates.

Direct and indirect effects raise the wholesale price for motor gasoline in Florida, Massachusetts, New York, and Ohio. This effect contradicts previous results which suggest that taxes do not affect wholesale prices. In the same states, a one cent increase in taxes increases the retail price of motor gasoline by more than one cent. In Washington, taxes on motor gasoline taxes have a negligible effect on wholesale and retail prices. Together, these results are inconsistent with the hypothesis that taxes on motor gasoline are simply passed to consumers.

Furthermore, differences among states in the rate at which taxes on motor gasoline are passed on to retail prices is not consistent with the effect of state-level differences in elasticities that are described by Chouinard and Perloff (2004). According to their derivation, the rate of pass through to consumers should vary inversely with a state's share of gasoline sales. The results described here indicate that there is no statistically significant relation between a state's share of US motor gasoline consumption in 2015 and the total effect of a one cent increase in motor gasoline taxes on the retail price of motor gasoline.

Conclusion and Policy Implications

Results that taxes on motor gasoline are not passed on to consumers as suggested by economic theory have two important implications; why do they differ from previous empirical results and what are the policy implications of these differences. Differences with previous results may be caused by in part by *a priori* assumptions. First, the two panel analyses estimate the effect of motor gasoline taxes on motor gasoline prices using the fixed effect methodology. Although this methodology allows the effects of unobservable variables to vary across states or over time, the fixed effects estimator assumes that the regression coefficient associated with taxes on motor gasoline (and the other independent variables) is the same across states. In other words, the rate of pass through is the same across all states. This assumption is not tested, even though statistical methods to do so are available (see Hsiao, 1986). As such, results that suggest a 100 percent rate of pass through may be an average of rates that vary greatly among states.

To test the effect of the estimation procedure on the results, I assemble the monthly observations for the six states into a panel and use a fixed effects estimator to estimate the relation between retail prices and taxes on motor gasoline, wholesale prices, crude oil prices, inventories, and refinery utilization rates (Table 4). The point estimate for the coefficient associated with taxes is less than one (0.66) and is not statistical different from 1.0 if the standard errors are estimated using a procedure that is robust to arbitrary correlation within groups (t =

1.09, $p > 0.27$). Similarly, conclusions are reached based on the sum of point estimates for the regression coefficient associated with the contemporaneous and lagged effect of taxes on retail prices for motor gasoline. Together, these results suggest that assembling state data into a panel and estimating their relation using a fixed effects estimator may be partially responsible for previous results that suggest that taxes on motor gasoline are passed on to retail prices.

If the absolute and relative rates at which taxes are passed on to consumers cannot be described accurately by the assumption of a competitive market and supply/demand elasticities, this failure makes it difficult to evaluate the degree to which environmental taxes will achieve environmental goals. Specifically, rates of pass through that do not equal to 100 percent affect the efficacy and efficiency of environmental taxes and adds another layer of uncertainty that may reduce efficacy and efficiency of environmental taxes relative to quotas and/or tradeable permits.

The degree to which an environmental tax that is designed to achieve the optimal level of abatement (marginal costs of abatement equal the marginal cost of environmental impacts) depends on the rate at which taxes are passed on to final consumers. If taxes are ‘marked up’ (as suggested by thus analysis), the additional price increase will reduce emissions relative to the optimum. Under these conditions, too much abatement will occur. Conversely, too little abatement will occur if the tax is not fully passed on to consumers, as in the case of Washington.

Furthermore, the rate of pass through affects welfare by transferring surplus between producers and consumers. Pass through rates greater than 100 percent transfer some consumer surplus to producers. Conversely, passing less than 100 percent of a tax to consumers will transfer surplus from producers to consumers.

The effects of the rate of pass through on the level of abatements, deadweight losses, and welfare transfers exacerbates the uncertainty that is associated with environmental taxes relative to cap and trade systems. A cap and trade system generates a relatively certain level of abatement because the number of permits is known. But the effect of this known level of abatement on prices is uncertain because of uncertainties about supply and demand elasticities. The effect of environmental taxes on prices is relatively certain if they are passed completely to consumers. But this certainty is reduced if the rate of pass through is uncertain, as indicated here. Under these conditions, both the price effects and the level of abatement generated by environmental taxes are uncertain. Together, these uncertainties suggest that tradeable permits may be a more effective and efficient method for internalizing environmental externalities.

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Figure Captions

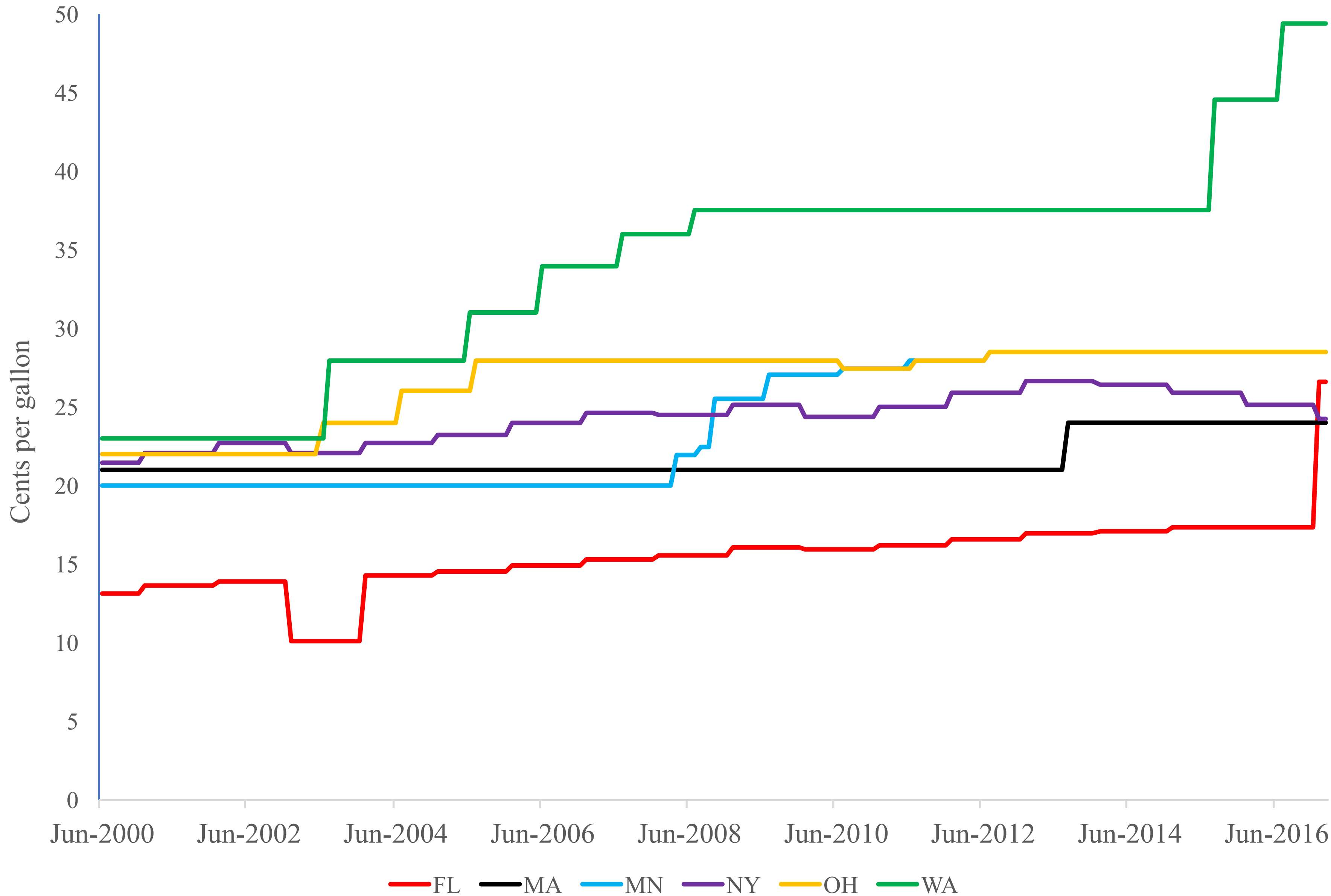
Figure 1 State taxes on motor gasoline. The evolution of taxes on motor gasoline in Florida (orange), Massachusetts (black), Minnesota (blue), New York (purple), Ohio (orange), and Washington (green).

Figure 2 Wholesale prices for motor gasoline Predicted versus observed wholesale prices for motor gasoline in Florida (blue), Massachusetts (red), Minnesota (black), New York (orange), Ohio (green), and Washington (blue).

Figure 3 Retail prices for motor gasoline Predicted versus observed retail prices for motor gasoline in Florida (blue), Massachusetts (red), Minnesota (black), New York (orange), Ohio (green), and Washington (blue).

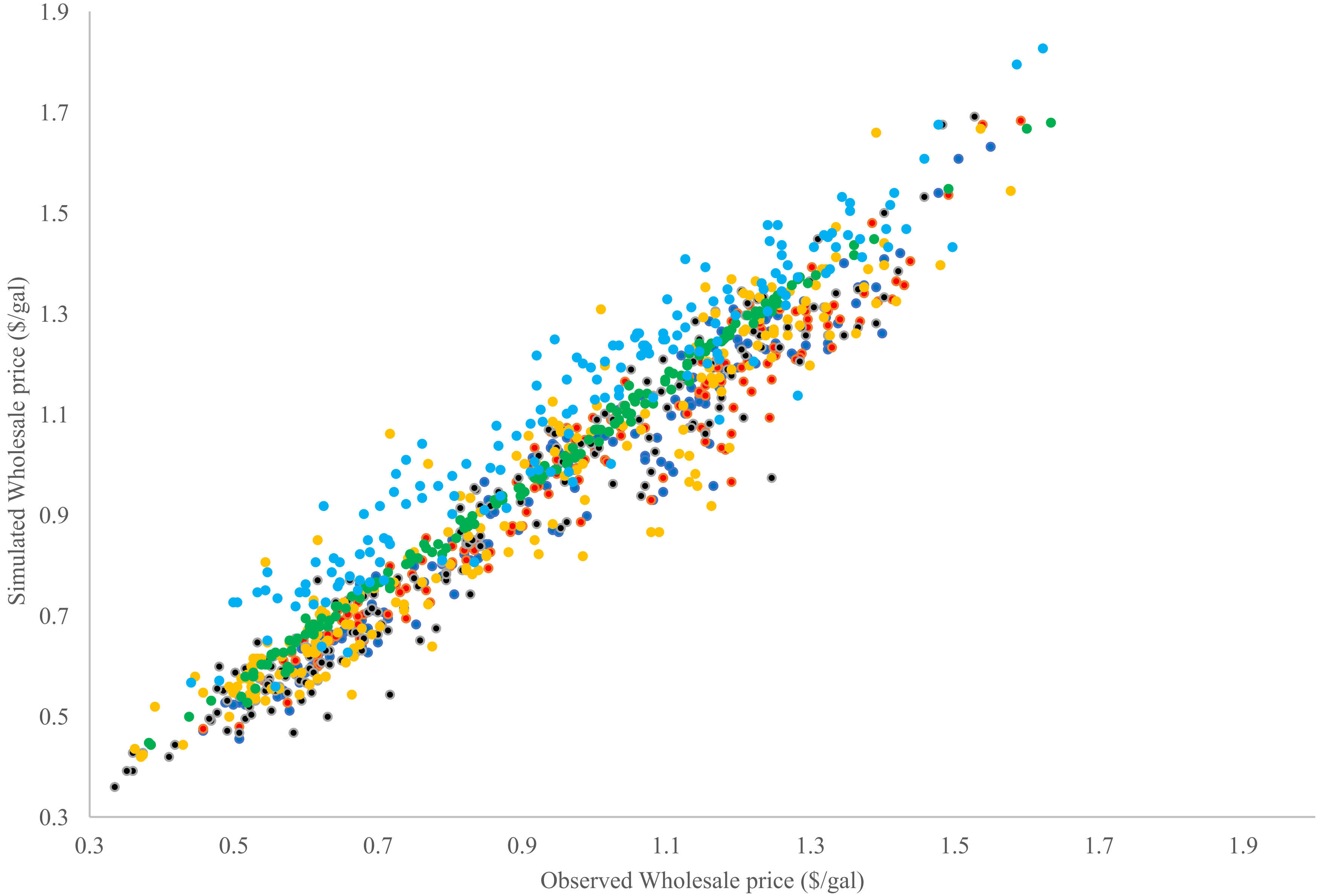
Figure 4 Direct and total pass through The direct (stripped) and total (solid) long-run effect of a $0.01 increase in taxes on motor gasoline on wholesale (black) and retail (red) prices for motor gasoline.

Figure 1



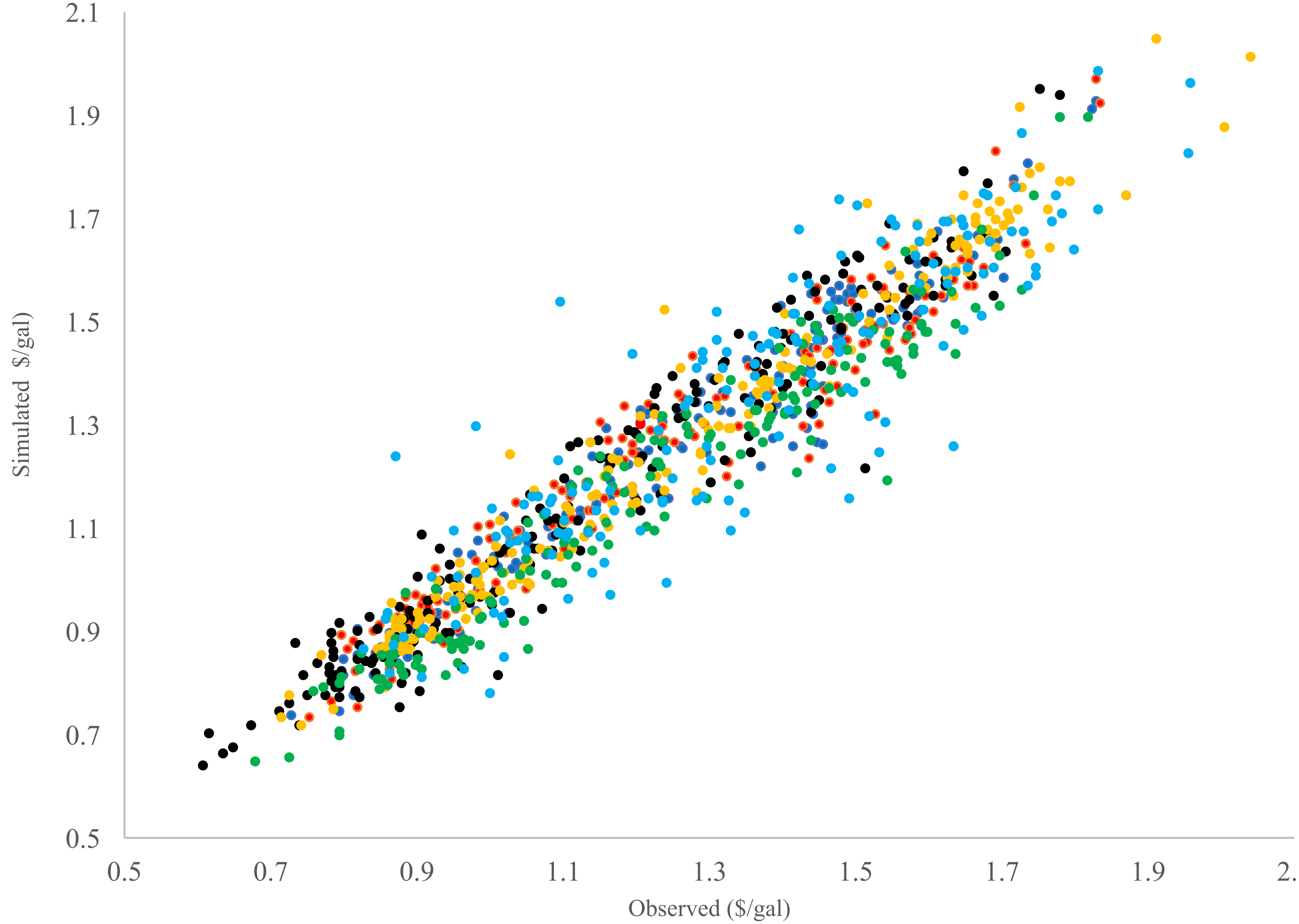
50
45
40
35
30
25
20
15
10
5
0
Cents per gallon
Jun-2000
Jun-2002
Jun-2004
Jun-2006
Jun-2008
Jun-2010
Jun-2012
Jun-2014
Jun-2016
FL
MA
MN
NY
OH
WA

Figure 2



Simulated Wholesale price ($/gal)
1.9
1.7
1.5
1.3
1.1
0.9
0.7
0.5
0.3
0.3
0.5
0.7
0.9
1.1
1.3
1.5
1.7
1.9
Observed Wholesale price ($/gal)

Figure 3



2.1
1.9
1.7
1.5
1.3
1.1
0.9
0.7
0.5
Simulated $/gal)
0.5
0.7
0.9
1.1
1.3
1.5
1.7
1.9
2.1
Observed ($/gal)

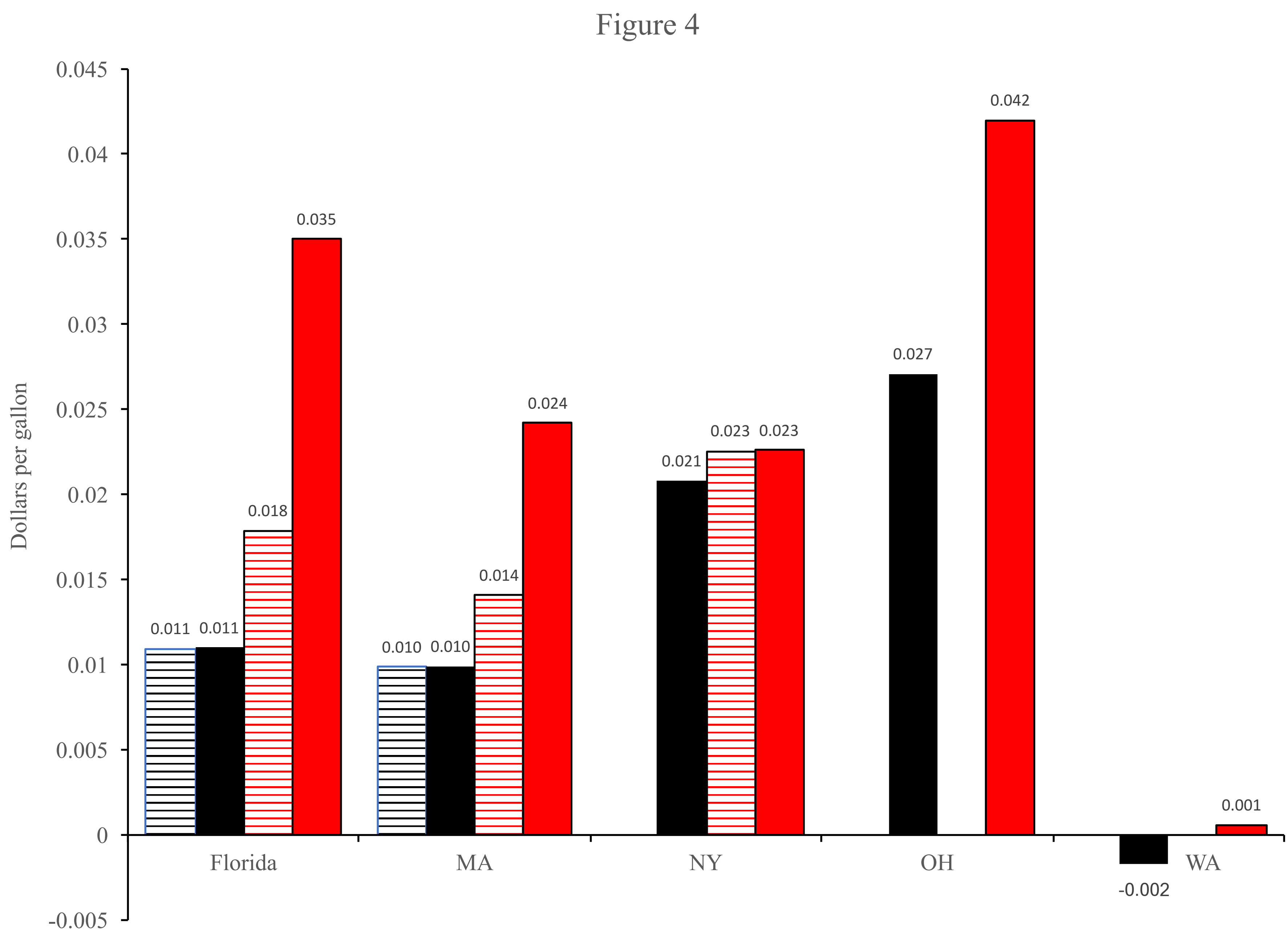


Figure 4
Dollars per gallon
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
-0.005
0.011
0.011
0.018
0.035
0.010
0.010
0.014
0.024
0.021
0.023
0.023
0.027
0.042
-0.002
0.001
Florida
MA
NY
OH
WA

Table 1 Tests of models that specify the price of motor gasoline prices that do not include taxes.

	Retail	*Wholesale*	*PCrude*	*Refinery*	*Tax*	*Stock*
Florida						
Exclusion	$\chi^2(1) = 23.2$	$\chi^2(1) = 23.6$	$\chi^2(1) = 5.4$	$\chi^2(1) = 7.2$	$\chi^2(1) = 1.1$	$\chi^2(1) = 0.3$
Stationarity	$\chi^2(1) = 41.6$	$\chi^2(1) = 42.$	$\chi^2(1) = 41.6$	$\chi^2(1) = 41.0$	$\chi^2(1) = 41.1$	$\chi^2(1) = 44.7$
Exogenous	$\chi^2(1) = 3.0$	$\chi^2(1) = 0.2$	$\chi^2(1) = 0.9$	$\chi^2(1) = 0.4$	$\chi^2(1) = 2.1$	$\chi^2(1) = 0.0$
Massachusetts						
Exclusion	$\chi^2(3) = 19.1$	$\chi^2(3) = 13.8$	$\chi^2(3) = 5.3$	$\chi^2(3) = 5.6$	$\chi^2(3) = 14.0$	$\chi^2(3) = 4.9$
Stationarity	$\chi^2(3) = 16.9$	$\chi^2(3) = 16.7$	$\chi^2(3) = 17.2$	$\chi^2(3) = 5.4$	$\chi^2(3) = 18.3$	$\chi^2(3) = 18.4$
Exogenous	$\chi^2(3) = 8.0$	$\chi^2(3) = 3.2$	$\chi^2(3) = 0.2$	$\chi^2(3) = 4.3$	$\chi^2(3) = 13.0$	$\chi^2(3) = 2.0$
Minnesota						
Exclusion	$\chi^2(2) = 22.3$	$\chi^2(2) = 30.3$	$\chi^2(2) = 17.6$	$\chi^2(2) = 5.4$	$\chi^2(2) = 24.7$	$\chi^2(2) = 3.2$
Stationarity	$\chi^2(2) = 20.1$	$\chi^2(2) = 19.9$	$\chi^2(2) = 16.5$	$\chi^2(2) = 7.8$	$\chi^2(2) = 25.1$	$\chi^2(2) = 18.3$
Exogenous	$\chi^2(2) = 4.1$	$\chi^2(2) = 4.9$	$\chi^2(2) = 0.3$	$\chi^2(2) = 2.2$	$\chi^2(2) = 4.1$	$\chi^2(2) = 0.3$
New York						
Exclusion	$\chi^2(1) = 20.4$	$\chi^2(1) = 20.4$	$\chi^2(1) = 1.9$	$\chi^2(1) = 5.6$	$\chi^2(1) = 3.9$	$\chi^2(1) = 0.1$
Stationarity	$\chi^2(1) = 38.7$	$\chi^2(1) = 38.6$	$\chi^2(1) = 38.7$	$\chi^2(1) = 36.8$	$\chi^2(1) = 40.3$	$\chi^2(1) = 40.6$
Exogenous	$\chi^2(1) = 5.0$	$\chi^2(1) = 0.2$	$\chi^2(1) = 1.1$	$\chi^2(1) = 0.2$	$\chi^2(1) = 0.1$	$\chi^2(1) = 0.2$
Ohio						
Exclusion	$\chi^2(3) = 34.0$	$\chi^2(3) = 36.1$	$\chi^2(3) = 33.8$	$\chi^2(3) = 15.0$	$\chi^2(3) = 16.6$	$\chi^2(3) = 9.2$
Stationarity	$\chi^2(3) = 25.3$	$\chi^2(3) = 25.3$	$\chi^2(3) = 24.9$	$\chi^2(3) = 13.3$	$\chi^2(3) = 23.6$	$\chi^2(3) = 24.9$
Exogenous	$\chi^2(3) = 17.8$	$\chi^2(3) = 18.0$	$\chi^2(3) = 0.7$	$\chi^2(3) = 13.6$	$\chi^2(3) = 2.8$	$\chi^2(3) = 6.4$
Washington						
Exclusion	$\chi^2(1) = 0.8$	$\chi^2(1) = 0.1$	$\chi^2(1) = 7.4$	$\chi^2(1) = 0.0$	$\chi^2(1) = 8.8$	$\chi^2(1) = 5.9$
Stationarity	$\chi^2(1) = 29.0$	$\chi^2(1) = 28.9$	$\chi^2(1) = 29.2$	$\chi^2(1) = 27.4$	$\chi^2(1) = 30.8$	$\chi^2(1) = 22.5$
Exogenous	$\chi^2(1) = 2.1$	$\chi^2(1) = 2.4$	$\chi^2(1) = 1.0$	$\chi^2(1) = 1.2$	$\chi^2(1) = 4.2$	$\chi^2(1) = 5.3$

Table 2 Tests of models that specify the price of motor gasoline prices that include taxes.

	Retail	*Wholesale*	*PCrude*	*Refinery*	*Tax*	*Stock*
Florida						
Exclusion	$\chi^2(3) = 53.0$	$\chi^2(3) = 49.4$	$\chi^2(3) = 15.9$	$\chi^2(3) = 10.4$	$\chi^2(3) = 10.0$	$\chi^2(3) = 18.3$
Stationarity	$\chi^2(3) = 9.94$	$\chi^2(3) = 18.4$	$\chi^2(3) = 10.4$	$\chi^2(3) = 9.8$	$\chi^2(3) = 13.9$	$\chi^2(3) = 15.7$
Exogenous	$\chi^2(3) = 18.4$	$\chi^2(3) = 10.4$	$\chi^2(3) = 1.7$	$\chi^2(3) = 1.0$	$\chi^2(3) = 3.0$	$\chi^2(3) = 7.5$
Massachusetts						
Exclusion	$\chi^2(4) = 33.4$	$\chi^2(4) = 33.4$	$\chi^2(4) = 26.7$	$\chi^2(4) = 24.4$	$\chi^2(4) = 20.3$	$\chi^2(4) = 33.2$
Stationarity	$\chi^2(4) = 14.9$	$\chi^2(4) = 15.4$	$\chi^2(4) = 15.8$	$\chi^2(4) = 17.4$	$\chi^2(4) = 16.3$	$\chi^2(4) = 14.9$
Exogenous	$\chi^2(4) = 17.9$	$\chi^2(4) = 14.6$	$\chi^2(4) = 6.0$	$\chi^2(4) = 10.8$	$\chi^2(4) = 6.1$	$\chi^2(4) = 45.7$
Minnesota						
Exclusion	$\chi^2(3) = 48.6$	$\chi^2(3) = 48.2$	$\chi^2(3) = 37.0$	$\chi^2(3) = 34.0$	$\chi^2(3) = 27.9$	$\chi^2(3) = 26.1$
Stationarity	$\chi^2(3) = 28.6$	$\chi^2(3) = 28.5$	$\chi^2(3) = 29.3$	$\chi^2(3) = 0.8$	$\chi^2(3) = 29.7$	$\chi^2(3) = 27.9$
Exogenous	$\chi^2(3) = 16.2$	$\chi^2(3) = 9.7$	$\chi^2(3) = 1.6$	$\chi^2(3) = 33.4$	$\chi^2(3) = 11.5$	$\chi^2(3) = 5.6$
New York						
Exclusion	$\chi^2(3) = 33.3$	$\chi^2(3) = 31.9$	$\chi^2(3) = 12.0$	$\chi^2(3) = 11.6$	$\chi^2(3) = 5.1$	$\chi^2(3) = 3.9$
Stationarity	$\chi^2(3) = 25.1$	$\chi^2(3) = 24.8$	$\chi^2(3) = 24.0$	$\chi^2(3) = 12.7$	$\chi^2(3) = 27.3$	$\chi^2(3) = 26.5$
Exogenous	$\chi^2(3) = 12.4$	$\chi^2(3) = 10.0$	$\chi^2(3) = 6.8$	$\chi^2(3) = 6.8$	$\chi^2(3) = 1.0$	$\chi^2(3) = 2.2$
Ohio						
Exclusion	$\chi^2(3) = 18.2$	$\chi^2(3) = 18.2$	$\chi^2(3) = 24.2$	$\chi^2(3) = 26.1$	$\chi^2(3) = 10.9$	$\chi^2(3) = 10.4$
Stationarity	$\chi^2(3) = 27.5$	$\chi^2(3) = 26.5$	$\chi^2(3) = 30.2$	$\chi^2(3) =10.4$	$\chi^2(3) = 20.1$	$\chi^2(3) = 21.1$
Exogenous	$\chi^2(3) = 19.9$	$\chi^2(3) =18.3$	$\chi^2(3) = 1.3$	$\chi^2(3) = 25.1$	$\chi^2(3) = 6.2$	$\chi^2(3) = 16.9$
Washington						
Exclusion	$\chi^2(3) = 30.2$	$\chi^2(3) = 33.8$	$\chi^2(3) = 25.0$	$\chi^2(3) = 24.9$	$\chi^2(3) = 1.7$	$\chi^2(3) = 40.9$
Stationarity	$\chi^2(3) = 16.5$	$\chi^2(3) = 17.1$	$\chi^2(3) = 17.5$	$\chi^2(3) = 10.1$	$\chi^2(3) = 25.8$	$\chi^2(3) = 18.9$
Exogenous	$\chi^2(3) = 16.8$	$\chi^2(3) = 16.8$	$\chi^2(3) = 1.6$	$\chi^2(3) = 21.8$	$\chi^2(3) = 7.4$	$\chi^2(3) = 19.7$

Table 3 Tests of models that specify the price of motor gasoline prices that do not include taxes.

	Retail	*Wholesale*	*PCrude*	*Refinery*	*Tax*	*Stock*	*Constant*
Florida $\chi^2(3) = 0.308\ p > 0.93$							
CR #1	*1.000*	-1.02	--	**-0.009**	**-1.789**	-0.007	--
CR #2	--	*1.000*	**-1.000**	--	**-1.096**	--	--
CR #3	-11.463	11.965	--	--	**-63.333**	*1.000*	14.053
Massachusetts $\chi^2(4) = 2.40\ p > 0.66$							
CR #1	25.153	25.153	--	--	**-57.279**	*1.000*	18.414
CR #2	*1.000*	-1.022	--	--	**-1.408**	--	-0.178
CR #3	--	*1.000*	**-1.000**	--	**-0.987**	--	--
CR #4	--	--	**--**	*1.000*	**-56.845**		11.237
Minnesota $\chi^2(3) = 1.77\ p > 0.62$							
CR #1	1.000	-1.019	--	--	-1.341	**0.011**	--
CR #2	*1.000*	--	**-1.029**	-0.069	-2.033	--	--
CR #3	*0.694*	-0.694	--	0.039	*1.000*	--	-0.390
New York $\chi^2(4) = 1.01\ p > 0.89$							
CR #1	*1.000*	--	**-1.110**	**--**	**-2.257**	**0.025**	--
CR #2	1.000	-1.086	**--**	**-0.009**	**--**	**--**	**-0.282**
Ohio $\chi^2(4) = 2.08\ p > 0.72$							
CR #1	--	-1.000	**1.000**	-0.032	**-0.686**	--	--
CR #2	--	-24.75	**-24.750**	*1.000*	--	0.297	3.312
CR #3	*1.000*	-1.551	**0.533**	--	--	-0.10	-0.201
Washington $\chi^2(4) = 3.36\ p > 0.50$							
CR #1	*1.000*	-0.984	--	--	--	-0.076	-0.311
CR #2	-0.350	*1.000*	**-0.601**	-0.034	--	--	--
CR #3	--	--	--	*1.000*	--	*-1.905*	-0.964

Table 4 Results generated by treating the data for individual states as a panel

Variable	Cotemporaneous	With Lags
Whole	0.959 (0.0137) [0.011]	0.957 (0.0137) [0.012]
Tax	0.661 (0.112) [0.312]	2.437 (0.486) [0.398]
Tax_{t-1}		-1.812 (0.483) [0.599]
PCrude	0.063 (0.063) [0.015]	0.058 (0.0144) [0.014]
Stock	-5.05e-06 (7.65e-07) [1.74e-06]	-4.779e-6 (7.65E-07) [1.75e-07]
Refinery	4.32E-04 (1.07e-03) [1.56e-03]	3.377e-03 (1.08e-03) [1.50e-05]

Values in parenthesis are standard errors calculated in the usual method. Values in brackets are standard errors coefficient standard errors that are robust to arbitrary correlation within groups.

Supplemental Material

Table A-1 The types of gasoline and inventories used in the state models

Florida

Price EMM_EPMRU_PTE_SFL_DPG Florida Regular Conventional Retail Gasoline Prices (Dollars per Gallon).

Inventory MG4RS_R10_1 East Coast (PADD 1) Conventional Motor Gasoline Stocks at Refineries (Thousand Barrels)

Massachusetts

Price EMM_EPMR_PTE_SMA_DPG Massachusetts Regular All Formulations Retail Gasoline Prices (Dollars per Gallon)

Inventory MG4RS_R10_1 East Coast (PADD 1) Conventional Motor Gasoline Stocks at Refineries (Thousand Barrels)

Minnesota

Price MM_EPMR_PTE_SMN_DPG Minnesota Regular All Formulations Retail Gasoline Prices (Dollars per Gallon)

Inventory MGFRSP21 Midwest (PADD 2) Finished Motor Gasoline Stocks at Refineries (Thousand Barrels)

New York

Price EMM_EPMRU_PTE_SNY_DPG New York Regular Conventional Retail Gasoline Prices (Dollars per Gallon)

Inventory MG4RS_R10_1 East Coast (PADD 1) Conventional Motor Gasoline Stocks at Refineries (Thousand Barrels)

Ohio (Redo due to stocks)

Price EMM_EPMR_PTE_SOH_DPG Ohio Regular All Formulations Retail Gasoline Prices (Dollars per Gallon)

Inventory MGFRSP21 Midwest (PADD 2) Finished Motor Gasoline Stocks at Refineries (Thousand Barrels)

Washington

Price EMM_EPMR_PTE_SWA_DPG Washington Regular All Formulations Retail Gasoline Prices (Dollars per Gallon)

Inventory MGFRSP51 West Coast (PADD 5) Finished Motor Gasoline Stocks at Refineries (Thousand Barrels)

Table A-2 Point at which taxes are imposed on motor gasoline by state

2001

https://www.fhwa.dot.gov/ohim/hwytaxes/2001/pt1.htm

FL Imported, terminal wholesalers, suppliers, blenders
MA Licensed distributors and importers
MN Licensed distributors
NY Registered distributors on first import or production
OH Wholesalers and distributors of motor vehicle fuel
WA Supplier (terminal rack) or importer

2008

https://www.fhwa.dot.gov/policyinformation/motorfuel/hwytaxes/2008/mf101.cfm

FL Imported, terminal wholesalers, suppliers, blenders
MA Licensed distributors and importers
MN Licensed distributors
NY Registered distributors on first import or production
OH Wholesalers and distributors of motor vehicle fuel
WA Supplier (terminal rack) or importer, or blender

2012

2012 https://www.taxadmin.org/assets/docs/MotorFuel/other-data/2012_pointstax.pdf
FL Exchange Receiver at Rack
MA Distributor
MN First Receiver Below the Rack
NY Importation into State/First Receipt into Storage
OH Distributor
WA Position Holder at Rack

2016

State https://www.taxadmin.org/assets/docs/MotorFuel/2016-09%20Motor%20Fuel%20Tax%20Information%20by%20State%20Book.pdf

FL Position holder or exchange receiver at the rack
MA Wholesale: Licensed Distributors and Importers
MN 1st Licensed Distributor after the rack.
NY first import into or production in the State
OH Receipt less credits
WA Tax at the Rack

Table A-3 Trace statistics results for models that specify retail prices of motor gasoline that do not include taxes

p-r	r	Crit Val	FL	MA	MN	NY	OH	WA
6	0	103.7	107.0*	133.4**	132.8**	111.9*	160.9**	101.1+
5	1	76.8	62.0	82.4*	78.0*	70.4	104.0**	65.3
4	2	53.9	39.9	50.9	48.3	47.9	62.5*	37.9
3	3	35.1	20.0	31.5	24.4	28.5	29.8	19.0
2	4	20.2	7.7	16.3	9.1	11.3	10.3	10.2
1	5	9.1	0.4	3.2	2.1	1.2	13.5	2.8

Test statistics reject at the null hypothesis at the **1%, *5%, +10% level.

Table A-4 Trace statistics results for models that specify retail prices of motor gasoline including taxes

p-r	r	Crit Val	FL	MA	MN	NY	OH	WA
6	0	103.7	164.6**	163.4**	164.4**	144.1**	149.7**	148.3**
5	1	76.8	92.9**	110.3**	108.4**	90.5**	102.4**	92.5**
4	2	53.9	57.6*	69.1**	58.9**	58.2*	59.8*	55.7*
3	3	35.1	33.4+	37.3*	17.9	28.4	25.8	27.2
2	4	20.2	14.0	13.5	7.6	7.3	9.6	14.0
1	5	9.1	3.3	6.1	1.4	1.4	1.9	3.6

Test statistics reject at the null hypothesis at the **1%, *5%, +10% level.