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Louis Silvia
Christopher T. Taylor

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Tax Pass-Through in Gasoline and Diesel Fuel: The 2003 Washington State Nickel
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by

Louis Silvia and Christopher T. Taylor[1]

Abstract: This paper considers a previously unexamined increase in excise taxes on
gasoline and diesel fuel that were part of Washington State's Nickel Funding Package of
2003. We fail to reject full pass-through of the amount of the tax increase to retail prices
in both products. We find no significant sensitivity of retail pass-through to station
locations relative to state borders, or to retail competitive conditions as measured by local
station density. The expansion of hypermarkets in Washington State during the period
was a confounding factor that limited precision in estimating tax pass-through effects.

JEL Classifications: L1, L41, L71
Keywords: Tax Incidence, Petroleum industry, Difference in Difference

I. Introduction

This paper considers the pass-through of a previously unexamined increase in excise taxes on gasoline and diesel fuel that were part of Washington State's Nickel Funding Package of 2003. Although there is disagreement on whether pass-through is complete, earlier studies of gasoline taxes have consistently found that consumers bear the bulk of the taxes. Previous studies agree less on why pass-through may be incomplete or may vary from one geographic area to another. Some analysts believe that incomplete pass-through is due to rising marginal costs in production or distribution; others point to less than fully competitive conduct.

Here we examine pass-through in both gasoline and diesel fuel. To our knowledge incidence in diesel has not previously been analyzed. Diesel fuel may have a different level of pass-through given the different supply and demand conditions. To the extent that pass-through is incomplete, we attempt to identify likely causes. Comparing all stations in Washington State to those in Oregon before and after the tax change shows pass-through is less than complete. Further analysis, however, suggests the entry and ongoing expansion of hypermarkets affects this estimate. We, ultimately, conclude that we cannot reject full pass-through of the change in the state excise tax on gasoline and diesel to consumers. Our findings also strongly indicate no tax incidence at wholesale, a result contrary to those of some previous studies.

Section II reviews the literature on tax pass-through in gasoline. Section III offers background on the industry and the 2003 tax change. Section IV outlines our conceptual framework and describes the data. Section V presents our empirical findings. Section VI offers concluding discussion.

II.   Literature on Tax Pass-Through Gasoline Taxes

Tax pass-through is the rate of price increase to consumers per unit of tax imposed. Under perfect competition, the pass-through has an upper bound of one and is determined by the relative elasticities of supply and demand. In models of less than perfect competition, pass-through rates also depend on the curvature of demand and degree of market competitiveness (Weyl and Fabinger, 2013).

Four recent studies examine pass-through of state gasoline taxes. Using monthly, state level data for the 48 mainland states and the District of Columbia between 1989 and 1997, Chouinard and Perloff (2004) estimate a reduced form model with a variety of demand and cost shifters and with state and seasonal fixed effects. They find that consumers bear most of the taxes, but that consumer incidence is smaller in larger states. They attribute incidence differences to varying state-level supply elasticities. In their model, state-level supply elasticities, which reflect wholesalers' abilities to ship gasoline to lower tax states, are inversely related to a state's share of national consumption.[2]   Chouinard and Perloff estimate that a 1 cent per gallon ("cpg") tax increase would raise retail prices by 0.97 cpg in Vermont, the smallest consuming state, but only by 0.75 cpg in California, the largest consuming state.

Barron, Blanchard and Umbeck (2004) examine a seven cpg excise tax reduction in Connecticut in July 2000. Their analysis relies on bi-weekly, station-level, retail prices and weekly, brand level, dealer tank wagon wholesale prices.[3] Using a difference in difference ("DID") approach, they compare pre and post-tax-change gasoline prices in Hartford, CT with

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[2] A nationally measured supply elasticity should be smaller than state-level measures, and Chouinard and Perloff do find that just less than half of federal gasoline taxes are passed on to consumers. They also recognize that other factors, such as distances between states and differing gasoline formulations requirements also affects the ability of wholesalers to shift gasoline from one state to another.

[3] Truck tank wagons pick up gasoline and diesel at product terminals for delivery to retail outlets. Dealer tank wagon prices are wholesale, delivered prices to retail stations. Rack prices, which we use in our analysis, refer to wholesale prices at the product terminals.

prices in other northeast metropolitan locations, assuming seasonal and state fixed effects and six-month pre and post event windows. Barron, Blanchard and Umbeck find a consumer pass-through of about two-thirds.[4] They conclude that rising costs at refineries absorbed most of the remaining the tax decrease. They also find that retailers' revenue per gallon increased by a very small (but statistically insignificant) amount, an effect possibly reflecting rising marginal costs at retail.

Doyle and Samphantharak (2008) use daily, station-specific retail prices to analyze temporary moratoria in Indiana and Illinois of a 5% ad valorem gasoline tax in 2000. They present several specifications beginning with a simple DID comparison with neighboring states, which controls for terminal rack wholesale prices and zip-code level demographic variables are subsequently added. Applying pre and post-tax event windows of seven days, their results indicate that about 70% of the tax reduction was passed on to consumers with 80 to 100% of an increase being passed on. They also observe that pass-through occurred quickly, happening within a week of the tax change.

Doyle and Samphantharak also explore effects of local, brand-level retail concentration on tax pass-through. Some of their findings suggest that greater brand concentration is associated with higher pass-through rates, especially for tax increases. They also find some evidence of smaller pass-through, particularly for reinstatements, at affected retail locations close to the state border and some mixed evidence of price effects across state borders.

The authors also examine the effects of the tax changes on wholesale prices. They argue that the quantity changes associated with tax changes were likely to be so small that the marginal cost of wholesale gasoline should be unaffected by the taxes changes. In their view, any impact

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[4] Barron, Blanchard and Umbeck conclude that total tax did not fall by the full amount of the excise tax reduction because of a small increase in existing ad valorem taxes owing to the increase in wholesale prices after the excise tax change.

on wholesale prices might suggest that wholesale markets may not be competitive. Under this assumption that wholesale supply is (locally) perfectly elastic, they see evidence of less than full pass-through in one of three tax change regressions.

Finally, Alm, Sennoga and Skidmore (2009) analyze a panel of state-level, monthly data for the 50 U.S. states between 1984 and 1999. Estimating a reduced form model with demand and cost shifters and with state and time (monthly) fixed effects, they find a state excise tax pass-through of nearly 100% across all states, with slightly lower pass-through in more rural states. Arguing that retail markets in more urbanized states are likely to be more competitive, the authors attribute the somewhat lower pass-through rate in rural states to weaker retail competition. [5] Across all states, they find that tax changes are fully passed through in the first month of the change though they observe statistically significant second month effects in medium and highly urbanized states.

In sum, recent studies present broadly consistent results about the incidence of state gasoline taxes. Gasoline taxes are mostly borne by consumers. Evidence for over-shifting is limited. Tax pass-through appears to take place quickly. Quick pass-through of tax changes is consistent with Duffy-Deno (1996), EIA (1999), EIA (2003), and Lewis and Noel (2010), all of which find relatively quick pass-through of changes in wholesale gasoline prices to retail prices. Previous studies agree less whether incomplete pass-through is cost or competition related.

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[5] Alm et al. observe that pass-through was greater for medium urbanized states than for highly urbanized states, a finding inconsistent with a view that highly urbanized states should have the highest pass-through, at least if demand were approximately linear. The authors also found some evidence of over shifting for medium urbanized states. Attributing incidence effects to competition differences across states requires assuming that there is no correlation between state urbanization and state-level supply elasiticities.

III.   Industry Background

Washington State's Puget Sound was the home of five refineries in 2003. These refineries typically ran close to capacity during the first half of the 2000s.[6] Washington State and Oregon consumed most of their output, though some Puget Sound gasoline and diesel went to California or was exported, particularly to nearby Canada.

The north to south flow on the Olympic and Kinder Morgan pipelines dominated the bulk distribution infrastructure of western Washington State and western Oregon. Olympic carried gasoline and diesel from the Puget Sound refineries to product terminals to the south, including those serving the relatively populated areas of Seattle, Tacoma and Olympia. Olympic connected to the Kinder Morgan pipeline at Vancouver, WA. The Kinder Morgan line ran south to serve Oregon terminals in Portland, Salem and Eugene. Olympic was generally at capacity south of Tacoma during the 2000s. Ocean barge shipments to Portland from Puget Sound supplemented shipments on Olympic. Shipments from California and foreign refineries into Portland also added to shipments from Puget Sound.[7] Imports from foreign refiners (mostly gasoline) occurred primarily during higher demand summer months.[8]

The logistics of bulk distribution in the more sparsely populated eastern parts of Washington State and Oregon presented a different picture. No pipeline crosses the Cascades. Instead, river barges on the Columbia are the main source of supply. Gasoline and diesel were

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[6] Washington State Attorney General's Office, *2007-08 Gas Price Study*, 2008, available at, http://www.atg.wa.gov/uploadedFiles/Another/Safeguarding_Consumers/Antitrust/Unfair_Trade_Practices/Gas_Prices/41708gasstudy.pdf, at 16-18. Hereafter referred to as the "WA AG Gas Study".
[7] WA AG Gas Study at 14-15.
[8] ICF International, *Review of Pipeline Utility Corridor Capacity and Distribution of Petroleum Fuels, Natural Gas and Biofuels in Southwest Washington,* November 2007, at 16-17, available at http://www.efsec.wa.gov/FILES/Pipeline%20Study/ICF%20Washington%20Final%20Report%20v4%2012-03-07.pdf.

loaded into barges at Portland terminals or directly from ocean-going vessels landed in Portland. Pasco, WA was the primary destination for these barges. Gasoline and diesel barged to Pasco could also be injected into the Chevron pipeline for shipment northeast to Spokane.

Refineries in the Rockies also served eastern Washington and Oregon. The Yellowstone pipeline carried gasoline and diesel to Spokane and east Central Washington State from refineries in Billings, Montana. The first leg of the Chevron pipeline connected Pasco and Spokane terminals to Salt Lake City refineries. Generally, terminals in the east were located at greater distances from refineries (or points of marine landings) compared to terminals in western Washington State and western Oregon.

Washington State had nearly 3,100 gasoline retail outlets in the early 2000s. Less than half of the stations sold retail diesel. Differences in local competition, wages, land values, wholesale prices and transportation costs from terminals and other factors resulted in contemporaneous price differences across retailers. Like gasoline and diesel retailing elsewhere, price differences among stations were often significant even within a small geographic area.[9]

The entry of hypermarkets since the late 1990s is a notable feature of gasoline and diesel retailing in Washington State. Hypermarkets refer to retailers such as Costco, Walmart, Fred Meyer and Safeway that add fuel pumps at their retailing. Hypermarkets outlets sell five to ten times more gasoline than the typical gasoline station, have lower construction and operating costs, and typically offer lower prices. Hypermarkets sold about six percent of retail gasoline sales in the United States by late 2002.[10] Hypermarket entry into Washington State as of 2002

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[9] For an analysis of retail gasoline price differences Washington State between 2000 2007, see the WA AG Gas Study at 41-47. This study found six statistically significant variables explaining retail price differences: population per station, area wages, vehicles per station, property value, tank truck transportation costs, and percent of hypermarkets in the area.

[10] Federal Trade Commission, Bureau of Economics, "The Petroleum Industry: Mergers, Structural Change and Antitrust Enforcement", (2004) at 235-236, available at, http://www.ftc.gov/sites/default/files/documents/reports/petroleum-industry-mergers-structural-change-and-

was well above the national average, accounting for approximately 13.9 percent of gasoline sales

in Washington State. Oregon hypermarket volume at the time was closer to the national average,

accounting for 6.3 percent of statewide gasoline sales.[11]

Washington State's excise taxes on gasoline and diesel had been had been set at 23 cpg

since 1991. This tax in Washington State, both the federal and state tax, is collected at the point

of sale, at retail. The tax had lost value to inflation by 2003 falling to 18.1 cpg in 1991 dollars.[12]

Recognizing a need for new capital investments in the state's transportation system, the

Washington State legislature enacted the Nickel Funding Package in 2003. The Package

consisted of a five cpg excise tax increase on gasoline and on-the-road diesel fuel and increases

in heavy truck weight fees and motor vehicle sales taxes. The Package sought to raise $3.9

billion dollars to pay for 158 highway transportation-related projects over ten years.[13] The tax

increases went into effect on July 1, 2003.

IV.   **Conceptual Framework and Data**

We estimate the tax pass-through with a difference-in-difference identification. We

compare Washington State gasoline and diesel prices before and after the tax change with prices

in nearby states (primarily Oregon). We evaluate tax incidence at wholesale and retail in separate

regressions for each product. The state and federal taxes are collected at the retail level but this

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antitrust-enforcement-report-staff-federal-trade/040813mergersinpetrolberpt.pdf. Hereafter referred to as the "FTC
Petroleum Merger Report."

[11] FTC Petroleum Merger Report, Table 9-9 at 248-249.

[12] Paula Hammond and Chris Gregorie, "Washington State's Gas Tax Saga," presentation at the National Governors
Association Center for Best Practices, June 25, 2008, available at
http://www.wsdot.wa.gov/NR/rdonlyres/5D8C4C3C-86B2-4BE4-B1C2-
9CB1AFE36740/46936/BestPracticesStateSummit.pdf.

[13] Washington State Department of Transportation, "2003 'Nickel' Funding Package, available at
http://www.wsdot.wa.gov/projects/funding/nickel/.

does not preclude possible wholesale effects of the tax. We measure short run demand and

supply sensitivity. This short run would be long enough for non-capital adjustments by

consumers (e.g. changed driving patterns) and sellers (e.g. changed refinery runs, changed

geographic allocation of product, changed retail hours), but not long enough for significant

capital-related adjustments (e.g. more fuel efficient vehicles, refinery reconfigurations, retailer

entry or exit). We use three and six month periods around the tax change to measure pass-

through.

We believe wholesaling in the Pacific Northwest was approximately competitive. This

would imply no change in wholesale prices due to the tax change. No Washington State refiner

was large enough for unilateral market power to be plausible. Significant departures from

marginal cost pricing would require coordination among the state's five refiners. In addition to

the challenges in achieving and maintaining coordination among the five, shipments from

California, from refineries in the Rockies and from foreign refineries would present significant

obstacles to anticompetitive coordination.[14]

We assume that gasoline and diesel retailing is differentiated, spatially and by brand, and

that departures from marginal cost pricing are limited by entry and rival repositioning. We

assume that retailer-level, short run demand elasticities vary according to the extent of localized

competition raising the possibility of differing pass-through rates.[15]

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[14] The FTC's 2006 competitive assessment of U.S refining, including West Coast refining, found no evidence of non-competitive behavior. See Federal Trade Commission, Investigation of Gasoline Price Manipulation and Post-Katrina Gasoline Price Increases, Spring 2006, available at
http://www.ftc.gov/reports/060518PublicGasolinePricesInvestigationReportFinal.pdf. Moreover, the WA AG Office concluded that no illegal conduct regarding gasoline pricing in Washington was found during the period of its study, 2000-2008. See WA AG Gas Study at 2. Our assumption about market power at wholesale is the opposite of Doyle and Samphantharak's. They assume wholesale supply is perfectly elastic and attribute any significant tax event estimate in their wholesale regressions to wholesaler market power. Under our assumption, any significant (and presumably negative) tax effect on wholesale prices would be attributable to inelasticity in wholesale supply.
[15] Research on gasoline demand elasticities has shown that stations with different levels of localized competition have notably different station-specific demand elasticities. For example, Barron, Umbeck and Waddell (2008)

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Our basic estimating equation is:

(1)
$$P_{i,t} = \alpha_{i,t} + B_1 After_t + B_2 After_t * Treatment_i + \sum_{j=1}^{n} B_j Station(rack)_j + \sum_{k=1}^{51} B_k Week_k + \varepsilon_{i,t}$$

Where $P_{i,t}$ is gasoline station (rack) i's price on the day t. α_{it} is the constant. The

dummy $After_t$ takes a value of one in the period after the tax increase. The interaction term

$After_t$*Treatment$_i$ is one for each rack or station in a treatment area in the period after the tax

increase. The interaction variable coefficient, B_2, measures the effect of the tax increase

controlling for the fixed difference in the treatment and control racks or stations before the tax

change and the change in prices in the control areas in the period after the tax increase. The next

two terms, Station(rack) and Week, are station (rack) and week fixed effects. The variable, $\varepsilon_{i,t}$,

is the error term. In other words, we are controlling for common changes in the weekly price of

the product across the treatment and control prices, station (rack) level fixed effects, and then

measuring the price in the treatment group relative to the and control group before and after the

event. We adopt a null hypothesis of full pass-through at retail and zero pass-through at

wholesale (rack).

Petroleum product prices are highly autocorrelated. We use the price for one day per

week (Thursday) to reduce autocorrelation.[16] Retrospectives of petroleum product mergers have

used one of two approaches for dealing with autocorrelation. Hosken, Silvia, and Taylor (2011)

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showed a 1 percent price increase led to a 3 times larger quantity effect for stations with the greatest number of local competitors relative to stations with the least number of nearby competitors. Definitively attributing presumably smaller pass-through to relatively weak local competition requires that retailer cost elasticities are uncorrelated with the degree of local competition however.

[16] We also computed the results for alternative days and this did not qualitatively affect the results.

recognize that OLS remains unbiased and consistent in the presence of autocorrelation and uses

standard errors corrected for heteroscedasticity and autocorrelation in the underlying data.

Taylor and Hosken (2007) take an alternative approach and model the autocorrelation

using the Prais-Winsten correction. This approach should be more efficient. Kreisle (2013)

shows that under some statistical circumstances common to gasoline and diesel price data,

modeling the autocorrelation in this way tends to perform better and comes closer to estimating

the true relationship than using OLS with corrected standard errors. Here we report results using

the Prais-Winsten correction. Results under the alternative approach, OLS with Newey-West

standard errors (which we do not report) are similar however.[17]

 Price data comes from the Oil Price Information Service (OPIS).[18] Rack prices consist

of terminal-average daily price quotes of unbranded gasoline and diesel at terminal locations.[19]

We have 2003 data for twelve rack locations-- seven in Washington State (Anacortes, Moses

Lake, Pasco, Seattle, Spokane, Tacoma and Wilma), two in Oregon (Portland and Eugene) and

one each in Montana (Billings), Utah (Salt Lake City) and Colorado (Denver). We use the

Denver rack data as an additional check on the stability of the control racks.

OPIS retailer price data are derived from corporate fleet card transactions and some credit

card transactions. OPIS records the last transaction price charged at the station on a given day.

While the gasoline and diesel pricing data from OPIS are among the best available, it is not a

random sample of retail stations. Each station may also not report every day. We use station level

fixed effects to control for changes in sample composition.

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[17] We generated our estimates with STATA. Estimations with the Prais-Winsten correction for autocorrelation were implemented using the xtregar command. The xtreg command implemented OLS estimations with corrected standard errors.

[18] All gasoline data refer to conventional specification, regular octane. Octane and fuel specification distinctions are not relevant for on-the-road diesel.

[19] We prefer wholesale unbranded to branded prices because unbranded is typically closer to a transactions price. Distributors who buy at posted rack prices under branded contracts may also receive various discounts, allowances and rebates from branded sellers. Our results, however, do not materially change with branded rack prices.

Table 1 provides descriptive statistics for (unbranded) wholesale prices by terminal location for gasoline and diesel. Annual average rack gasoline prices by location for 2003 varied from a low of 93.9 cpg at Denver to a high of 106.4 cpg at Wilma. Table 1 separately groups the western and eastern terminals in Washington State and Oregon. Unbranded rack prices for both gasoline and diesel were lower in the west than in the east. This fact pattern is consistent with the logistical differences at wholesale supply discussed above, particularly the greater distances of eastern terminals to refineries (or points of marine landings) compared with the western terminals.

Table 2 shows descriptive statistics for gasoline and diesel retail prices for 2003 grouped by area averages for major cities, plus an average for the area outside these cities. Overall, state averages for Oregon and Washington State are also shown. Area average retail prices within the two states differed by as much as 5 cpg. Washington State's retail prices were generally lower than Oregon's, especially for gasoline.

Area averages mask the considerable contemporaneous price variation among retailers within areas. For example, in the week before the tax increase, retail gasoline prices in the Seattle area ranged from 144 cpg to 190 cpg, with a range in diesel of 160 cpg to 180 cpg. Similarly, at that time gasoline prices in Portland at the time ranged between 150 cpg to 180 cpg, with diesel prices ranging between 160 cpg and 180 cpg. Although the differences between the highest and lowest retailer in an area might be 20 cpg or greater, most retailers charged prices much closer to the area average.

V.   **Empirical Results**

Inspection of the raw gasoline retail price data for Washington State overall suggest a

nearly immediate impact of the tax change.[20] Figure 1 shows daily average gasoline prices in

Washington State, less the price in Oregon, controlling for station level fixed effects, in the

month before and after the tax change on July 1, 2003. The average price for July 1 was about 4

cpg more than the previous day, with smaller increases over the next several days.

Consistent with Barron, Blanchard and Umbeck, we estimate the tax pass-through using

six-month pre and post tax change windows. We also provide estimates using three-month

windows. Though the raw data suggests a nearly immediate impact of the tax change upon retail

prices, using shorter comparison periods to estimate pass-through is problematic for two reasons.

First, since we are using one day a week of data to mitigate autocorrelation, shorter windows

would have a very small number of observations. Second, because there is noise in the price

relationships between treatment and control areas, windows of short duration are more likely to

generate spurious results.

Our pass-through analysis begins at wholesale. We find no evidence that the tax change

significantly affected Washington State rack prices as a whole for either gasoline or diesel fuel.

The first two rows of Table 3 show DID estimates in gasoline and diesel for symmetric pre-event

and post-event windows of three and six months, utilizing all Washington State treatment and

non-Washington State controls.[21] Negative point estimates would be expected if the state's

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[20] A comparable graph for retail diesel similarly suggests an immediate price impact upon implementation of the tax, while inspection of the raw gasoline and diesel wholesale data shows no obvious immediate impact.

[21] For this comparison, we used all the racks listed on Table 1 with the exception of Denver. We checked whether geographic reallocation of supply by refiners and other wholesalers in reaction to the tax increase might bias our estimates downward. For example, Oregon wholesale prices might fall if Puget Sound refiners responded to a tax-related reduction in wholesale demand in their home market by redirecting some refinery output to Oregon terminals. Conceivably, there might be a similar depressing effect in Billings and Salt Lake City, as refiners in those

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gasoline or diesel were inelastically supplied at wholesale. However, all gasoline estimates and two of the four diesel estimates are positive, and more importantly none of estimates come close to being significantly different from zero.

Owing to their more remote location from refineries and key logistical supply points, it is possible that eastern Washington State terminals, Pasco, Mosses Lake, Spokane and Wilma, were less elastically supplied than those in the west, Anacortes, Seattle, and Tacoma. If so, wholesale prices in the east could fall relative to those in the west after the tax increase. We find no evidence of such an effect, as the last two rows of Table 3 shows results evaluating whether the tax increase affected the wholesale prices in eastern Washington State relative to those in western Washington State. The list of which racks are include in the east and west groupings are given on Table 1. No parameter estimates are significantly different from zero and a number of the point estimates are very close to zero as well.

These wholesale findings overall suggest that full pass-through to retail might be expected. Table 4 shows estimates for equation (1) for gasoline and diesel based on the full sample of Washington and Oregon retailers for symmetric pre/post windows of three and six months. These estimates, however, indicate that pass-through to consumers was incomplete in gasoline. Diesel estimates are somewhat less precise owing to the smaller sample size compared to gasoline.

As is well known, DID estimation critically assumes a constant price differential between the treatment and control markets, except for change caused by the event. It appears that the entry and expansion of hypermarkets not only affected retail prices in Washington State relative

locations shipped somewhat less into Washington State. Accordingly, we compared wholesale prices in these control areas with wholesale prices in Denver, where marginal supply originates at refineries in the midcontinent and the Texas Panhandle and thus Denver prices were extremely unlikely to be affected by the Washington State tax change. Comparison of pre and post tax differentials for Denver/Portland, Denver/Billings and Denver/Salt Lake City showed no statistically significant change.

to Oregon over the period, but also affected relative retail prices within Washington State.[22] The mere existence of hypermarkets in differing degrees in treatment and control markets would not frustrate identification if their price effects were time-invariant, but this was not the case.

Washington State publishes data on underground fuel tanks. These data show the ongoing hypermarket entry in 2002 and 2003.[23] The leading urban locations of Seattle, Spokane, and Vancouver had most of this hypermarket entry. In particular, more than a third of the state's hypermarkets were in the Seattle Metropolitan Statistical Area (MSA) and more than half were in the Seattle Combined Statistical Area ("CSA").[24]

A comparison of retail gasoline prices in the Seattle CSA to those the rest of the state in 2002 and 2003 illustrates the impact of hypermarket entry.   Figure 2 shows the monthly price difference in gasoline between the Seattle CSA and the rest of Washington, controlling for station level fixed effects.   Seattle CSA prices fell relative to the rest of the state over the period. Seattle gasoline was more expensive by two to six cpg in early 2002 but by the end of the year, gasoline in Seattle was several cents cheaper than gasoline in the rest of the state. The same seasonal pattern occurred in 2003, but the average annual difference between Seattle and the rest of the state is roughly a penny per gallon lower compared to 2002.   Similar comparisons (which we do not report) indicate that Seattle CSA retail gasoline and diesel prices also fell relative to Oregon prices over the period, though the trend in diesel was weaker.

To mitigate the confounding effects from hypermarket entry, we re-estimate equation (1) removing from the sample those parts of Washington State and Oregon with significant

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[22] Contemporaneous newspaper articles report the entry of hypermarkets in Seattle and Washington State and that retail margins were decreasing. See Puget Sound Business Journal
http://www.bizjournals.com/seattle/stories/2003/03/24/story5.html?page=all

[23] Tank data on hypermarket entry in Oregon is less helpful since they do not include the date of entry. The Oregon tank data does show that there are fewer hypermarkets than in Washington and that over one-third of all hypermarkets stations are in the greater Portland area.

[24] The Seattle MSA consists of the city of Seattle, King County, Snohomish County, and Pierce County. The Seattle CSA is the MSA plus Kitsap, Thurston, Skagit, Island, and Mason Counties.

hypermarket activity.[25] In a "hypermarket free" sample, shown in Table 5, point estimates are

higher compared to the full sample. A full, five cpg pass-through to consumers cannot be

rejected for either product for both window lengths. The gasoline results show a point estimate

between 4.75 and 5.00 cents per gallon with a standard deviation of approximately 0.25 cpg.

Retail gasoline prices depend, in part, on local competition. If competitive differences

result in differing retailer-level demand elasticities, we might expect some differences in tax

pass-through across retailers.   We first consider whether pass-through is sensitive to retailers'

locations relative to state borders.   We test whether the difference in prices at Washington State

stations located "close to" important border crossings vary pre and post tax change relative to

stations elsewhere in the state. Close to border stations, presumably, should post smaller price

increases than stations elsewhere in the state. We estimate equation (1) using stations close to the

Washington border as the treatments and the controls are the stations in the rest of the state. We

limit the treatment and control areas to those without significant hypermarket entry, with the

exception of the Idaho border.[26]

We find little evidence of border effects for Washington retailers in either gasoline or

diesel. Table 6 shows the close-to-border results for Canada, Idaho and Oregon; estimates refer

to the difference in pass-through for near border stations compared to other stations in

Washington State (excluding areas impacted by hypermarkets). While point estimates for

gasoline and diesel for the Oregon border are negative, many other estimates have the wrong

sign. In every case, we cannot reject the null of equal pass-through.

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[25] The hypermarket areas in Washington are the Seattle CSA, Spokane, Cowlitz and Clark counties and the Portland MSA in Oregon.
[26] The larger number of observations in the Idaho regressions are due to including Spokane, a hypermarket area. Those Spokane zip codes adjacent to the border are included in the treatment and the rest of the Spokane MSA is included in the control. Without the Spokane treatment stations, there would not have been enough observations to estimate the one month and three month regressions due to the small number of treatment stations

We do find evidence of border effects for Oregon stations in both gasoline and diesel. Similar to the above estimation, we estimated equation (1) with data from Oregon. The treatment stations are near the border and the control stations are in the rest of the state less the hypermarket areas. As reported in Table 7, gasoline and diesel prices increased significantly at Oregon retailers located close to the Washington State border in 6-month window specifications and one of the 3-month window specifications. These effects dissipate, however, when we compare Oregon retailers located somewhat further away from the Washington State border (stations in the next closest zip codes) to all Oregon stations to the south as the next two rows of results show.

Finally, we examine if localized competition at retail matters to pass-through. Using the census of gasoline stations from the Washington State underground tank registry, we identified the number of other stations within one mile of each gasoline station in our sample. We divided the stations into four categories: stations without a competitor within a mile, stations with 1 or 2 competitors within a mile, stations with 3 or 4 competitors within a mile and stations with greater than 4 competitors within a mile. The four categories contained 17.5, 20.1, 26.4 and 36 percent of the observations in order from least to highest number of competitors.

Tables 8 shows the estimated pass-through for the four categories of stations for gasoline and diesel prices for both three and six-month windows. We re-estimate equation (1) using the non-hypermarket areas of Washington and Oregon, but with a different pass-through parameter for each of the four categories of station. The point estimates for the gasoline tax pass-through for each category are all close to 5 cpg, while point estimates for diesel are more variable across station categories in some cases close to or exceeding 7 cpg. However, none of the differences in point estimates across categories are statistically different at usual levels of significance, and in

no case can full pass-through be rejected. Not only is there no difference in the estimated pass-through across the categories, but there also does not seem to be a pattern, i.e. the rank order of pass through is not the same for any of the products or windows.

VI.   Discussion

West Coast refiners were generally operating close to capacity in the early 2000s, and the tax increase occurred right at the peak of summertime demand. Under these circumstances the tax increase might be expected to reduce wholesale prices owing to diminishing returns.

On the other hand, the reduction in quantity demanded due to the tax increase was small and probably unlikely to have much of an impact upon marginal supply costs once geographic reallocation of product is considered. Washington State daily average gasoline consumption was approximately 170 thousand barrels per day ("MBD") in 2003. Full pass-through to consumers of the Nickel Package tax would increase pump prices by about three percent. Assuming a gasoline demand elasticity of -0.2, this price increase would decrease Washington State demand by about 1 MBD. By comparison, total gasoline production in 2003 for the five Puget Sound refineries was approximately 292 MBD, and other refiners also supplied the Pacific Northwest to some extent. Any reduced demand for gasoline and diesel in Washington State could most likely be accommodated by slightly reduced imports into the Pacific Northwest, perhaps in conjunction with slightly increased exports by Puget Sound refiners.

Our main retail result is that we fail to reject full tax pass-through in gasoline and diesel. These findings are consistent with those in most previous studies of gasoline. The similarity of

diesel to gasoline pass-through of is not surprising—the demands for both products are highly

inelastic and the costs of producing and distributing the two products are similar.

Full pass-through is also consistent with our expectation about retail-level short run cost

elasticities within the quantity range relevant to the tax change. Assuming a statewide reduction

in demand of about 1MBD, a significant impact upon marginal costs at the retail level seems

unlikely. A reduction of 1 MBD of gasoline is equivalent to 42,000 gallons per day.

Washington State had about 3,100 gas stations in the early 2000s. Given a daily statewide

reduction of 42,000 gallons, the average gas station would see a reduction in sales of just fewer

than 14 gallons per day, or about less than one vehicle visit per day. Such a small quantity

reduction also seems unlikely to significantly affect costs at the margin of tank-wagon deliveries

from product terminals.

Consequently, any differences in pass-through at the station level in our framework of

differentiated retail competition would be driven by differences in station level demand

elasticities. We examined for near border effects based on the notion that stations close to the

borders would be more constrained in increasing prices than others in the state. We find no

significant differences in pass-through for retailers located close to the Canadian, Idaho and

Oregon borders compared to other Washington retailers.

The absence of a pass-through differential near the Canadian border is not surprising.

Gasoline prices on the Canadian side (the greater Vancouver area) averaged more than 40 cpg

greater than nearby Washington State stations in the first half 2003, while Canadian diesel was

about 25 cpg greater than that available just across the border in Washington State. Canadian

stations were very likely a weak constraint on the pass-through by close to border Washington

stations. Pre-tax price differentials are less persuasive as explanation for an absence of

differential pass-through effects for Washington stations on the Oregon and Idaho borders since the price differences were much smaller that the differences with Canada.[27]

Conceivably the absence of pass-through differentials for Washington border stations might be attributed to the rural nature of these border areas, such as low demand density or limited road connections to neighboring states, factors which would limit the diversion of demand. Yet arbitrage across at least the Washington/Oregon border appeared to robust enough to increase significantly gasoline and diesel prices at Oregon stations adjacent to the Washington border. This effect in Oregon, however, dissipated somewhat further away from the border.[28]

We found no strong evidence that localized competitive conditions matter to pass-through. Full-pass through cannot be rejected for any of the categories of stations or that the estimated pass-through was different by competitive category.

The expansion of hypermarkets in Washington State complicated in identifying pass-through. The hypermarket areas of Washington State comprise over half of the station observations for gasoline and diesel prices. By eliminating the hypermarket area observations, due to the changes in retail competition in those areas, the size of the standard errors on the pass-through estimates increased.[29] Given the changing face of gasoline and diesel retailing, e.g. the increasing importance of convenience stores and the entrance of hypermarkets, any estimation using multiple regions where retailing may have evolved differently is problematic. This suggests that researchers should exercise caution in using sizeable panels of data in this or similar industries.

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[27] While first half 2003 prices for Washington State border stations averaged 7.5 cpg below nearby Oregon border stations, diesel was cheaper on the Oregon side by 0.5 cpg. We have no station-specific price data for Idaho, but we note that first half 2003 gasoline prices at Washington Stations near the Idaho border were about a penny cheaper that state level average Idaho average, while diesel was cheaper in Idaho by about 5 cpg.

[28] Ideally, we would be able to test the ability to arbitrage across borders by examining population and commuting patterns, but this data is not readily available.

[29] This lack of precision was even more noticeable for the diesel estimates that are based on approximately one-quarter of the observations used in the gasoline estimation.

One possibility for mitigating the changing retail situation in Washington, i.e.

hypermarket entry would be to use shorter pre and post event windows. Though the raw data

suggests a nearly immediate impact of the tax change upon retail prices, using windows to

estimate pass-through is problematic for two reasons. First, since we used one day a week of

data to reduce autocorrelation, shorter windows would have a very small number of observations

on each station with which to estimate both the station fixed effects and the effect of the tax

change. Second, because there is noise in the price relationships between treatment and control

areas, windows of short duration are more likely to generate spurious results. For example in our

case, the underlying difference between treatment and control areas, such as the states of

Washington and Oregon, showed week-to-week changes in some instance of greater than one

cent per gallon.[30] This suggests that researchers should exercise caution in using very short pre

and post windows when performing event studies when data have similar properties.

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[30] We calculated the average daily price of gasoline in Washington and Oregon by regressing the price in each state on daily dummy variables and station fixed effects. We then took the weekly average difference of those state level averages. The average week-to-week change in the difference between the state average prices ranged from .07 to 1.1 cents per gallon in the 6 months before the tax change.
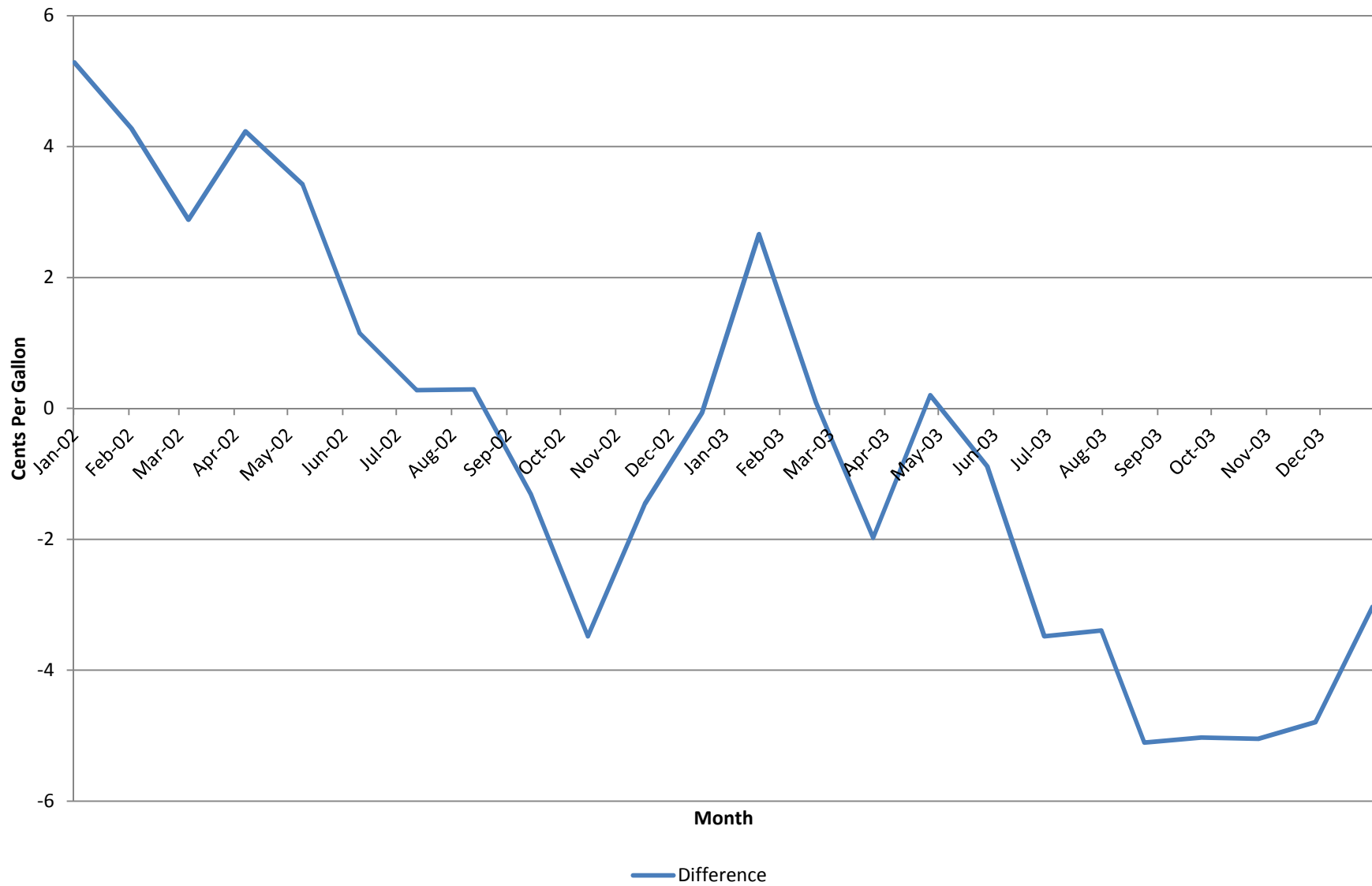
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Figure 1
Difference in Washington and Oregon Daily Average Retail Gasoline Price
June 1 - July 31, 2003
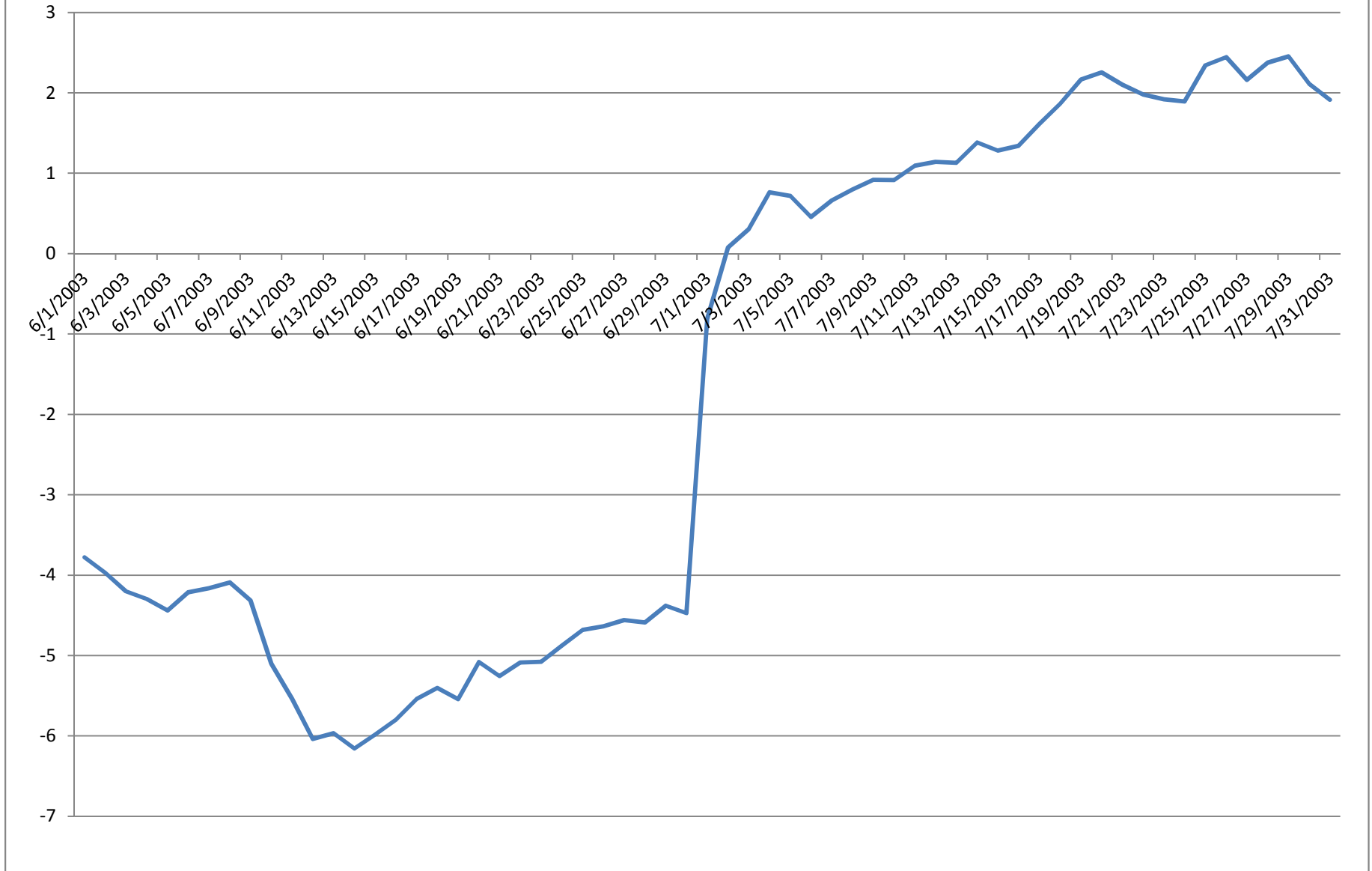
This is the difference, Washington less Oregon, in the average station price by day controlling for station level fixed effects.

Figure 2
Difference in Seattle and Rest of Washington State Monthly Average Retail Gasoline Price
2002-2003

This is the difference, Seattle less the rest of Washington, in the average station price by month controlling for station level fixed effects.

Table 1 - Descriptive Statistics Wholesale (Rack) Prices - 2003

City	Treatment/ Control	State East/West	Gasoline Unbranded Rack			Diesel Unbranded Rack		
			Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Billings	Control	MT	52	104.8	8.7	52	100.1	9.9
Denver	NA	CO	52	93.9	8.5	52	93.2	8.8
Salt Lake City	Control	UT	49	104.0	8.8	52	99.0	10.1
Pasco	Treatment	WA-East	52	103.8	13.3	52	97.2	12.9
Mosses Lake	Treatment	WA-East	52	103.9	12.2	52	99.6	12.1
Spokane	Treatment	WA-East	52	104.2	4.0	52	99.5	12.1
Wilma	Treatment	WA-East	44	106.4	3.0	44	98.2	13.8
Eugene	Control	OR-West	52	100.6	3.1	52	95.0	13.0
Portland	Control	OR-West	49	99.9	1.0	52	93.4	13.1
Anacortes	Treatment	WA-West	52	98.6	-0.1	52	91.1	13.2
Seattle	Treatment	WA-West	52	100.1	14.3	52	92.1	13.3
Tacoma	Treatment	WA-West	52	99.7	14.1	52	92.6	13.0

Table 2 - Descriptive Statistics Retail Prices - 2003

City	State	Obs	Gasoline		Obs	Diesel	
			Mean	Std. Dev.		Mean	Std. Dev.
Portland	OR	9532	171.2	15.7	1573	172.9	14.8
Eugene	OR	4793	170.6	16.0	1654	171.1	14.8
Medford	OR	1383	171.5	14.8	387	166.4	16.1
Salem	OR	1844	166.1	16.0	270	169.0	17.2
Rest of OR	OR	10062	171.7	14.8	3830	171.2	15.1
All of OR	OR	27614	171.0	15.5	7714	171.2	15.2
Vancover	WA	2874	162.6	15.2	568	167.6	12.8
Seattle	WA	16100	169.2	16.3	3535	172.9	15.5
Tacoma	WA	6486	161.6	16.2	1260	170.8	15.4
Everet	WA	6424	166.0	16.1	1353	170.6	15.4
Spokane	WA	5028	163.0	13.0	802	172.2	12.5
Olympia	WA	2233	162.5	15.9	620	166.1	13.1
Bellingham	WA	1807	167.1	16.7	344	167.0	14.9
Pasco	WA	680	166.0	11.1	211	168.7	12.0
Rest of WA	WA	18712	167.1	14.6	5228	168.8	13.5
All of WA	WA	60344	166.2	15.6	13921	170.2	14.5

<p style="text-align:center">TABLE 3 - Wholesale (Rack) Gasoline & Diesel Pass-Through</p>

Sample	Pre/Post	Gasoline	Obs	Diesel	Obs
Table 1 Treatment/Control Racks	3 Month	2.25 (2.45)	269	1.58 (1.50)	275
Table 1 Treatment/Control Racks	6 Month	0.13 (1.63)	547	0.87 (1.25)	553
Table 1 East/West WA Racks	3 Month	0.39 (1.84)	197	-1.62 (1.29)	200
Table 1 East/West WA Racks	6 Month	0.67 (1.20)	397	-0.43 (0.99)	400

Estimates of in Equation (1) H0 : B_2=0, no pass-through

Daily once a week data. Control variables include week and rack fixed effects.
Standard errors in parentheses

<p style="text-align:center">TABLE4 - Station Specific Retail Gasoline & Diesel Pricing</p>

Sample	Pre/Post	Gasoline	Obs	Diesel	Obs
All Stations WA/OR	3 Month	3.27** (0.19)	43,826	4.08** (0.28)	10,807
All Stations WA/OR	6 Month	2.75** (0.14)	85,003	2.54** (0.24)	20,325

Estimates of in Equation (1) H0 : B_2=5, full pass-through

Daily once a week data. Control variables include week and station fixed effects.
Standard errors in parentheses
** Reject Full Pass-Through at 95% confidence level

<p style="text-align:center">TABLE 5 - Station Specific Retail Gasoline & Diesel Pricing - Non-Hypermarket Areas</p>

Sample	Pre/Post	Gasoline	Obs	Diesel	Obs
Non - Hypermarket Areas (WA/OR)	3 Month	4.75 (0.28)	18,707	5.27 (0.38)	5,430
Non - Hypermarket Areas (WA/OR)	6 Month	5.00 (0.21)	36,779	3.49 (0.89)	10,645

Estimates of in Equation (1) H0 : B_2=5, full pass-through

Daily once a week data. Control variables include week and station fixed effects.
Standard errors in parentheses
** Reject Full Pass-Through at 95% confidence level

TABLE 6 - Station Retail Gasoline & Diesel Price-Washington State near Borders

Sample	Pre/Post	Gasoline	Obs	Diesel	Obs
WA Stations Near CND vs Rest of WA Stations	3 Month	1.46 (1.76)	8,693	2.57 (4.81)	2,349
WA Stations Near CND vs Rest of WA Stations	6 Month	0.93 (2.27)	17,387	-3.04 (4.06)	4,615
WA Stations Near ID vs Rest of WA Stations	3 Month	1.09 (1.64)	11,116	-3.73 (5.97)	2,720
WA Stations Near ID vs Rest of WA Stations	6 Month	0.91 (1.24)	22,282	-2.97 (5.44)	5,367
WA Stations Near OR vs Rest of WA Stations	3 Month	-2.31 (2.46)	8,693	-1.96 (2.52)	2,349
WA Stations Near OR vs Rest of WA Stations	6 Month	-0.65 (1.86)	17,387	-0.71 (2.52)	4,615

Estimates of in Equation (1)   H0 : B_2=0, equal pass-through

Daily once a week data. Control variables include week and station fixed effects.
Standard errors in parentheses

TABLE 7 - Station Retail Gasoline & Diesel Price-Oregon near Border

Sample	Pre/Post	Gasoline	Obs	Diesel	Obs
OR Stations Near WA Border vs Rest of OR Stations	3 Month	0.43 (1.03)	13,752	10.86** (3.23)	3,739
OR Stations Near WA Border vs Rest of OR Stations	6 Month	2.91** (0.65)	26,489	3.10** (0.96)	7,198
OR Stations next closet to WA vs Rest of OR Stations	3 Month	1.89 (1.38)	13,277	2.81 (4.46)	3,563
OR Stations next closet to WA vs Rest of OR Stations	6 Month	0.93 (0.89)	25,568	1.28 (3.71)	6,872

Estimates of in Equation (1)   H0 : B_2=0, No change in relative price

Daily once a week data. Control variables include week and station fixed effects.
Standard errors in parentheses
** Reject No change in relative price at 95% confidence level

TABLE 8 - Station Retail Gasoline Pass-Through by Number of Competitors

Sample	Pre/Post	Group	Gasoline	Obs	Diesel	Obs
Non - Hypermarket Areas (WA/OR)	3 month	1	4.84	17,512	7.03	3,820
			(0.49)		(1.32)	
		2	5.01		7.10	
			(0.51)		(1.42)	
		3	5.24		7.37	
			(0.49)		(1.62)	
		4	4.69		5.33	
			(0.47)		(1.30)	
Non - Hypermarket Areas (WA/OR)	6 month	1	5.08	35,662	6.59	7,904
			(0.46)		(1.35)	
		2	4.95		7.17	
			(0.47)		(1.46)	
		3	5.20		7.38	
			(0.46)		(1.68)	
		4	4.82		4.81	
			(0.43)		(1.35)	

Estimates of in Equation (1)   H0 : B_2=5, full pass-through

Daily once a week data. Control variables include week and station fixed effects.
Standard errors in parentheses