What's in a Name? The Incidence of Gasoline Excise Taxes versus Gasoline Carbon Levies

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Abstract

Legislators often attach specific names to individual taxes to help explain their purpose, increase transparency, and ease public backlash over tax increases. It may be politically beneficial, but does the simple act of naming a tax and attaching it to a specific set of benefits have an actual effect in the marketplace? Do consumers respond differently to tax-induced price increases depending on what that tax is? In this article, a natural experiment is used to evaluate tax incidence after the introduction of two gasoline taxes in Alberta - 1) an increase in the generic excise tax and 2) an environmentally-targeted "carbon levy". While similar on the cost side, the taxes were very different in name and transparency on the benefit side. Results show that benefit-side transparency can matter – responses were lower and incidence higher for the more transparent carbon levy than with the less transparent excise tax.

JEL Classification Codes: L11, L15, L81, L91, M38, Q31

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1 Introduction

Legislators around the world have a long history of attaching names to individual taxes with specific purposes, such as Canada's "Fair Share Health Care Levy" or China's "Environmental Protection Tax". The simple act of naming a tax and transparently conveying its purpose can make the tax more palatable to taxpayers, provided the purpose is deemed worthy. This stands in contrast to general tax increases which, while servicing many of the same types of programs and public services, are a bit of a black box and can be met with more opposition. When George H.W. Bush famously promised "Read my lips, no new taxes" in the 1988 presidential campaign, but then later signed a

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budget bill that included general tax increases, public reaction was swift and negative - irrespective of what the social programs the new taxes would ultimately be used for. That broken promise played an important role in Bush's failed re-election bid four years later.

One type of tax with a specific name and transparent purpose attached to it, and one that has received a great deal of recent attention, is the so-called "carbon tax" or "carbon levy". Carbon levies, commonly imposed on sales of gasoline and other products derived from fossil fuels, are designed to reduce carbon emissions while simultaneously funding research and development of more environmentally friendly sources of renewable energy. As of the time of writing, the United States is one of the few industrialized countries without a carbon levy, but fifteen U.S. states in the West and Northeast were actively considering one. In January 2019, dozens of prominent economists published a letter in the Wall Street Journal urgently calling for the introduction of a federal carbon levy.[1] A small but growing literature has emerged to evaluate the effects of carbon levies on carbon emissions, and in most cases, carbon levies are found to be effective at reducing carbon emissions (e.g. Rivers and Schaufele (2015)). Effects can work through short run substitution away from more expensive fossil fuels and through long run substitution towards more cost-effective alternative energy sources whose development has been funded by the levy.

In this study, we look at a different aspect of carbon levies. We are not interested in estimating the effects of a carbon levy per se, but rather in estimating the effects of *calling it* a carbon levy and transparently conveying its potential benefits to consumers. We want to know if consumers will respond differently to a tax when that tax is given a specific name and attached to a transparent set of benefits that (many) consumers value, in contrast to a generic tax increase of a similar size, which funds general revenues and does not provide as transparent a set of benefits. Specifically, we examine how transparency on the benefits side affects the incidence of a tax.

Our prior is that transparency of benefits should not matter to the taxpayer in terms of market activities since, from a financial perspective, a dollar is worth a dollar. But it is well known that consumers often act in a more inelastic way and pay a premium for products that embody perceived benefits to society during production, e.g. more environmentally friendly, union made, humane, or animal-friendly. To the extent that consumers are more accepting of a carbon levy whose

[1] Wall Street Journal (2019). "Economists' Statement on Carbon Dividends". January 16, 2019.

stated purpose is more agreeable to them and whose expected benefits are more transparently communicated, those consumers may respond in a less negative, and more inelastic way.

The idea has been discussed and debated in policy circles, but establishing a link between the transparency of benefits of a tax and the incidence of the tax has been difficult due to an identification problem. Basically, a tax generally either has a meaningful name that conveys a transparent purpose and an expected set of benefits, or it does not. The challenge is to find a comparable benchmark tax, one that is roughly equal in size and equal in transparency on the cost side, but different in transparency on the benefit side. In practice, the researcher may need to compare the named tax with a tax on a different product, or in a different state, or in a distant time period, or on products purchased by different kinds of consumers.

Fortunately, and largely unique to the literature, we solve this identification problem by exploiting a fortuitous natural experiment in the retail gasoline industry in the province of Alberta, Canada. The provincial government there implemented two new taxes on the sale of gasoline, one in April 2015 and another in January 2017, twenty-one months apart, of roughly equal sizes and equal transparency on the cost side, but with very different names and very different degrees of transparency on the benefits side.

The first, imposed in April 2015, was a simple increase in the usual excise tax on gasoline of 4.0 cents per liter (or approximately 11.4 U.S. cents per gallon). The increase was significant (on gasoline prices of about a dollar per liter) and was used to supplement general provincial revenues which in turn contributed to a variety of general government services, such as administration, health care, education, infrastructure and regulation. While the tax would ultimately fund important services, there was no special name or specific purpose attached to the tax, and the link between it and the direct benefits that it was expected to provide was less transparent to consumers.

In contrast, the second tax, imposed in January 2017, came with a special name, a transparent purpose, and a clearly-stated set of expected benefits. The so-called "carbon levy" was implemented as a tax to help the environment, reduce greenhouse gas emissions, invest in renewable energy projects and energy efficiency programs, and promote other environment conservation projects (Government of Alberta, 2018). The tax was similar to the excise tax increase on the cost side, at 4.49 cents per liter (or approximately 12.8 U.S. cents per gallon), and like the excise tax increase, was transparent in terms of its existence. But unlike the excise tax increase, the carbon levy offered transparency on the benefits side as well, with readily available information on which environmental programs would be supported and in what dollar amounts. While the carbon levy was by no means only positively received, as it is still a tax, the added benefit-side transparency enabled a vibrant public discussion about the value of the benefits it would provide.

The two Alberta taxes – similar in cost-side transparency but different in benefit-side transparency – presents a unique opportunity to examine the relationship between benefit-side transparency and consumer incidence, holding all else equal. Using panel data on wholesale and retail gasoline prices, along with tax information, for both regular and premium grade gasoline for Western Canadian cities over a five year period, we estimate the consumer incidence of the two taxes, or as it is commonly called in the gasoline literature, the degree of tax passthrough. Cities in the province of Alberta serve the treatment group, first receiving the excise tax treatment in April 2015 and then the carbon levy treatment in January 2017. As it turns out, these were also the only two tax increases on gasoline anywhere in Western Canada over our sample period, meaning that other cities in Western Canada can serve as an additional layer of control for what would have happened to gasoline prices but for the two taxes. Other cities in Western Canada are an almost ideal control because they are supplied from the same deposits of crude oil, and are served by the same pipelines and refineries.

There are several important questions. We first examine the extent of passthrough of tax changes into gasoline prices overall and whether they are "complete" or "incomplete". Passthrough on the excise tax is complete if retail prices in Alberta cities increase by 4.0 cents per liter after April 1, 2015 (when the excise tax increased from 9 to 13 cents per liter), relative to the control cities. Passthrough on the carbon levy is complete if retail prices in Alberta cities increased an additional 4.49 cents per liter after January 1, 2017 (when the carbon levy was introduced). Passthrough of a tax change is incomplete if the corresponding price change is less than the tax change itself. The question of whether passthrough is complete or incomplete has been a long-standing question in the gasoline literature (e.g. Marion & Muehlegger (2011), Silvia and Taylor (2014)) and we contribute to that literature here.

Second, we test whether the degree of passthrough, or incidence, of a tax depends on the naming and transparency of benefits of the tax. To the extent that consumers are more accepting of a carbon levy with a transparent set of benefits (viewing the price increase net of social benefit to be smaller), relative to an equivalently-sized excise tax increase without the same benefit-side transparency, we would expect the degree of passthrough to be higher on the carbon levy and the incidence of the carbon levy to fall more heavily on consumers. If not, the degree of passthrough should be relatively more uniform across the two taxes. This is a testable proposition.

This question of whether consumers respond, not just to gasoline price increases generally, but differently to different sources of gasoline price increases, has received little attention in the gasoline literature. Two notable exceptions, and two studies closely related to this one, are Chouinard and Perloff (2014), which examine differential consumer responses to changes in federal versus state taxes, and Li et al. (2014), which examine differential consumer responses to excise taxes versus tax-exclusive cost changes. Both find that cost components in gasoline do matter. Our study contributes to this small but important behavioral literature.

To preview results, we find meaningful differences in passthrough and incidence between the carbon levy on one hand and a general excise tax increase on the other. The degree of passthrough is higher and largely complete for the carbon levy in relatively short order, whereas it is smaller and less than complete for the general excise tax increase. The results suggest that consumers more accepting of a tax with a specific name and a transparent set of benefits will respond less negatively to the tax. The policy implication is straightforward - better connecting the taxes that are paid to the benefits they are expected to provide can make those taxes more palatable to consumers and reduce negative reactions.

One novel feature of our study is that we estimate effects not only for regular grade gasoline but for premium grade gasoline as well. Few gasoline-related studies include premium grade gasoline in their analysis, but in framing their conclusions about "gasoline" generally, implicitly assume that results on regular grade gasoline carry over to higher octane grades as well. Our study shows that this assumption can be premature. We find some interesting differences in relative incidence across the two grades of gasoline, with important distributional implications.

The remainder of this paper proceeds as follows. Section 2 provides background information and review of relevant literature, Section 3 discusses the data and our empirical strategy. Section

4 presents the results, and Section 5 provides some concluding remarks.

2 Literature and Background

Economists study the incidence of tax – the distribution of the tax burden between buyers and sellers – to better understand the welfare implications of tax policy reforms. Standard textbook theory on tax incidence suggests that the price elasticities of demand and supply together determine the degree of tax passed through to consumers and producers.

A simple model posits that demand is given by $D(p(\tau))$ and supply is given by $S(p(\tau) - \tau)$, where p is the tax-inclusive price and τ is the specific (per unit) tax. Note that demand in this model responds only to the post-tax price and supply responds only to the pre-tax price. Simple algebra shows that the increase in the tax-inclusive price paid by the consumer per unit of tax is given by

$$\frac{dp}{d\tau} = \frac{\partial S/\partial p}{(\partial S/\partial p - \partial D/\partial p)} = \frac{\eta}{\eta - \varepsilon}$$

where η is the aggregate elasticity of supply and ε is the aggregate elasticity of demand. The change in the tax-exclusive price is given by

$$\frac{d(p-\tau)}{d\tau} = \frac{\partial S/\partial p}{(\partial S/\partial p - \partial D/\partial p)} - 1 = \frac{\partial D/\partial p}{(\partial S/\partial p - \partial D/\partial p)} = \frac{\varepsilon}{\eta - \varepsilon}$$

The terms $dp/d\tau$ and $d(p - \tau)/d\tau$ represent the incidence of the tax to consumers and producers, respectively. Incidence to consumers is greater with more elastic supply and more inelastic demand, and full consumer burden corresponds to either perfectly elastic supply or perfectly inelastic demand. Incidence to producers is greater with more inelastic supply and more elastic demand, with full burden corresponding to perfectly inelastic supply or perfectly elastic demand.[2]

It is well known that demand elasticities for retail gasoline are generally low and that supply elasticities are high (Brons et al. (2008); Hughes et al. (2008); Levin et al. (2017); Lin and Prince

[2] The standard theory shows that incidence depends only on elasticities and not on who is actually required to collect and remit the tax to the government, i.e. the statutory incidence of the tax. One concern might be that if agents are behavioral and different agents are responsible for remitting the two different taxes, then different statutory incidence could affect results. However, this is not the case. Both taxes must be remitted by the same firm, known as a Full Direct Emitter, which is the first firm to put finished gasoline into the supply chain, i.e. a refiner or a direct importer. Statutory incidence then cannot underlie any differential passthrough results.

(2013); Noel and Roach, (2016)). One thus expects the burden of gasoline tax increases to fall disproportionately on consumers, and this is generally the finding. However, there is less consensus on whether consumer incidence of gasoline taxes is complete or incomplete.

One group of studies finds it to be incomplete. Barron et al. (2004) examine a reduction in the excise gasoline tax in Connecticut after a large price spike in 2000 and find that only about two-thirds of the tax reduction was ultimately passed through to consumers. Doyle and Samphantharak (2008) examine the temporary moratorium on the 5% gasoline tax in Illinois and Indiana in the summer of 2000 and show that only 70% of the tax suspension and 80–100% of tax reinstatement were passed through to retail prices. Silvia and Taylor (2014) find incomplete passthrough of a five–cent excise gasoline tax increase in Washington state.

Another group of studies finds it to be complete. Alm et al. (2009) and Marion & Muehlegger (2011) examine passthrough of U.S. state gasoline excise taxes over the 1980s and 1990s and find them to be complete. Bello and Contin- Pilart (2012) and Stolper (2016) find complete passthrough of regional gasoline taxes in Spain as well.

Few studies test for differences in passthrough rates depending on the source of the cost increase, which is our goal here. Two notable exceptions and the two most closely related to the current effort are Chouniard and Perloff (2004) and Li et al. (2014). Chouinard and Perloff (2004) examine differences in passthrough rates for U.S. federal taxes and individual state taxes and find that the federal gasoline tax fell equally on consumers and wholesalers but state taxes fell almost entirely on consumers. Li et al. (2014) search for differences in passthrough in response to changes in general excise taxes on one hand and changes in tax-exclusive wholesale prices on the other. They find that consumers respond more to changes in excise taxes than to changes in tax-exclusive prices, and argue that it is because of the more permanent nature of excise tax increases in contrast to the more transitory nature of crude and wholesale price changes.[3] We build on this research and examine differences in incidence, not across tax-based and non-tax-based sources of cost increases, or across federal and state excise taxes, but across two different state-level gasoline taxes that have different names and different degrees of transparency on the benefit side.

[3] Many studies test for differences in passthrough rates based on the direction of a cost increase, rather than the source of the cost increase, including Bacon (1991), Borenstein et al. (1997), Bachmeier and Griffin (2003). Verlinda (2008) Deltas (2008), Noel (2009), Lewis (2011), Lewis and Noel (2011), and others.

For consumers to respond differently, it is necessary to know what those sources are. There is evidence, outside of gasoline markets, that the salience of a tax (i.e. transparency that it exists) can affect incidence and passthrough. Chetty et al. (2009), for example, find that consumers reduce grocery consumption significantly more when a tax increase is included in posted prices than if applied later at the register. This is less of an issue in the case of gasoline, since taxes are well-known, posted at the pump, and only tax-inclusive prices are displayed on large storefront signboards, making gasoline taxes among the transparent in any consumer market.

While arguably equally transparent to consumers on the cost side, there is a substantial difference in the transparency of the two taxes on the benefits side. A Google search for articles on the two taxes highlights the issue. A search for "Alberta carbon levy 2017" turns up hundreds upon hundreds of news articles discussing and debating every aspect of the Alberta carbon levy, its potential benefits, and how it is different from and more defensible than an excise tax. While there was no shortage of opposition (it is a tax after all), there was also significant support, and articles listed the specific dollar amounts that would go to various renewable energy products, public transit projects, energy efficiency projects, coal plant decommissioning, and so on. Independent publisher Narwhal Magazine wrote that it would be a "fundamental misunderstanding of the policy to suggest that this is equivalent to a sales tax" and goes on to list numerous differences, notably that its benefits are clear and transparent and that "none of it will go into Alberta's general revenue pool" where it would ultimately vanish into general expenses.[4]

In contrast, the excise tax increase had little discussion of potential benefits. A Google search for "Alberta excise tax increase 2015" turns up a handful of articles that matter-of-factly report the excise tax increase and its costs. The Canadian Press (comparable to Reuters or AP in the U.S.) stated only that "The gasoline tax jumps four cents a liter on Friday. The government notes Alberta's gas tax has not been raised since 1991 and remains the lowest in the country".[5] Online comments tend to be uniformly negative, and there was little discussion of possible benefits the tax increase would bring. The other articles we found that mention the 2015 Alberta excise tax increase were similarly terse.

[4] Narwhal Magazine. "Five Handy Facts about Alberta's New Carbon Tax". January 2017.

[5] Canadian Press. "Taxes and fees: Top 7 highlights of Alberta Budget 2015." March 26, 2015.

This suggests a potential for behavioral differences in consumer responses to the excise tax on one hand and the carbon levy on the other. The excise tax has a transparent cost to consumers (4.0 cents per liter) but with proceeds absorbed into general revenues, does not have as transparent a set of benefits attached to it. In contrast, the carbon levy not only has a transparent cost (4.49 cents per liter) but also a transparent set of potential benefits attached to it. If the potential benefits of the carbon levy make it more acceptable to a meaningful proportion of consumers, we should see that reflected in a differential response between the two, with a lower demand response on the carbon levy. Lower demand response implies more inelastic demand, and ultimately higher passthrough rates, which we can measure in our data.[6]

Finally, our paper is related to the growing literature on the effects of carbon levies more generally. The neighboring province of British Columbia (B.C.) was among the first jurisdictions in North America to adopt a carbon levy, beginning in 2008, and several studies have examined its effects. Rivers and Schaufele (2015) show that it reduced demand and CO_2 emissions by a non-negligible amount, and Elgie and McClay (2013) find a similar decrease. Beck et al. (2015) analyze the social welfare implications of the B.C. carbon tax and conclude that the tax was a progressive tax.[7] Davis and Kilian (2011) predict relative small effects of a carbon tax if implemented in the U.S., arguing that a 10-cent higher tax would decrease demand by only 1.43% and reduce transportation CO_2 emissions by only 0.48%.

3 Data and Methodology

To our knowledge, ours is the first study to contrast two state-level gasoline taxes that were similar in magnitude, but vastly different in name and transparency of benefits, all in a natural experiment setting. Our natural experiment focuses on the province of Alberta, in the western part of Canada. On April 1, 2015, the Alberta government increased its usual and generic excise tax by four cents per liter, from 9 cents per liter to 13 cents per liter. Then on January 1, 2017, it created a new per-

[6] The idea that consumers would be willing to continue to consume a more expensive "bad" (i.e. polluting gasoline) because at the same time it supports a greater "good" (i.e. programs that work toward a cleaner environment) has parallels with the moral licensing literature (e.g. Harding and Rapson (2019) and references therein).

[7] This differs from most studies of gasoline taxes that find them to be regressive (e.g. Sammartino, (1990), Chernick and Reschovsky (1997)).

liter tax under the pseudonym of a "carbon levy", equal to an additional 4.49 cents per liter. As it turns out, these two tax increases were the only two in all of Western and Central Canada, at both the provincial and federal level, between 2013 and 2017. This lends itself well to a straightforward difference-in-differences analysis in which major cities in Alberta serve as the treatment group and major cities in nearby provinces serve as the control group. We compare the degree of passthrough of the two tax increases, or their incidence, holding unobserved time-invariant factors fixed and unobserved city-invariant factors fixed as well.

The treatment group consists of four impacted cities in Alberta (Calgary, Edmonton, Lethbridge, and Red Deer) and the control group consists of nine unimpacted cities in the three other provinces of Western Canada – the provinces of British Columbia, Saskatchewan and Manitoba. There are four control cities in British Columbia (Vancouver, Victoria, Kamloops and Kelowna), three in Saskatchewan (Regina, Saskatoon, Prince Albert) and two in Manitoba (Winnipeg, Brandon). The treatment and control groups are relatively well balanced geographically with four cities in Alberta and either four or five control cities on either side of it (British Columbia being to the west and Saskatchewan and Manitoba being to the east). They are also relatively well balanced in terms of size, with the population of the four treatment cities ranking second, third, ninth and tenth out of the total thirteen cities in the sample. All cities in the sample - whether treatment or control - face similar supply shocks and conditions throughout the period, since they are all connected to a common supply source (via pipeline from major oil crude reserves and refineries in Western Canada). To the extent there are city-specific shocks to wholesale costs that are unrelated to any tax change, we control for these with city-specific wholesale prices.

We employ wholesale and retail price information, along with excise, carbon levy, and ad valorem tax information, from Kent Marketing Ltd. between January 2013 and December 2017. The data consists of weekly average retail prices and the corresponding average weekly wholesale prices ("rack prices"), for each city, for regular grade gasoline and premium grade gasoline.[8] It includes comprehensive information on excise taxes, sales taxes, and other applicable taxes on gasoline at the federal, provincial, and local level, along with changes in those taxes over time. The only tax

[8] If a rack price for a given city is not published, we use the rack price for the closest city with a published rack price within the province.

changes in our sample cities during our sample period was in Alberta. Summary statistics are reported in Table 1 and time series plots of retail and wholesale prices are presented in Figures 1 and 2 for regular grade and premium grade gasoline respectively.

We perform a series of analyses to examine incidence and passthrough. First, we establish that gasoline prices and its cost components are cointegrated. Then we estimate the overall degree of tax passthrough, i.e. consumer incidence, of each tax, and compare them. Given that standard OLS does not account for the superconsistency of estimates in the cointegrating equation, we employ the dynamic ordinary least squares (DOLS) specification of Stock and Watson (1993) which does. The DOLS specification adds lagged and lead rack price first differences to the cointegrating equation, and accounts for any remaining serial correlation through Newey-West standard errors. The basic estimating equation is given by:

$$\begin{aligned} PRICE_{gct} = {} & \beta^p_{0g} + \beta^p_{1g} TAX_t + \beta^p_{2g} LEVY_t + \beta^p_{3g} ALBERTA_c + \beta^p_{4g} RACK_{gct} \\ & + \rho^p_{TAX,g} TAX_t \times ALBERTA_c + \rho^p_{LEVY,g} LEVY_t \times ALBERTA_c \\ & + \sum_{s=-S}^{S} \gamma^p_{sg} \Delta RACK_{gct} + X_{gct} B \\ & + \sum_{c=2}^{13} \phi^p_{cg} + \sum_{d=2}^{12} \xi^p_{dgt} + \sum_{y=2014}^{2016} \zeta^p_{ygt} + \varepsilon^p_{gct} \end{aligned} \tag{1}$$

where $PRICE_{gct}$ is the retail price of gasoline grade g in city c at time t. The two grades are regular grade gasoline and premium grade gasoline. The variable TAX_t is equal to 4.0 cents per liter after April 1, 2015 when the additional excise tax went in effect, and $LEVY_t$ is equal to 4.49 cents per liter after January 1, 2017 when the carbon levy went in effect. The dichotomous variable $ALBERTA_c$ is equal to one for each of the four treatment cities in the province of Alberta. The variable $RACK_{gct}$ is the posted wholesale price of gasoline grade g in city c at time t and controls for wholesale price changes, and $\Delta RACK_{gct} = RACK_{gct} - RACK_{gc,t-1}$ with S being the lag/lead length.[9] The row vector X contains additional covariates, included and discussed along with the relevant specifications, and the column vector B contains corresponding coefficients. The ϕ^p_{cg}, ξ^p_{dgt}

[9] The lag/lead length S is determined by the testing down method. We use $S = 3$, though our coefficients of interest are very similar for longer or shorter lag/lead lengths.

and ζ^p_{ygt} are sets of city fixed effects, month fixed effects, and year fixed effects respectively. Note that in specifications where the ϕ^p_{cg} are included, the $ALBERTA_c$ indicator function is omitted since $ALBERTA_c$ is nothing more than a collection of time-invariant city fixed effects. The omitted month fixed effect is January, and there are two omitted year fixed effects – the usual omitted year fixed effect is 2013 and the second omitted year fixed effect is 2017, since this is accounted for by the $LEVY_t$ main variable, given that the carbon tax went into effect on January 1 of that year. The p superscripts denote coefficients in the price equation. The ε^p_{gct} are normally distributed error terms, potentially containing within-market correlation. In all specifications, we calculate and report robust Newey-West standard errors.

In addition to the price equation, we estimate a corresponding retail margin equation. The margin equation uses $MARGIN_{gct} = PRICE_{gct} - RACK_{gct}$ on the left hand side, instead of price, m superscripts instead of p superscripts on the coefficients, and β^m_{4g} is restricted to be equal to one.

The main variables of interest are the interaction terms $TAX_t \times ALBERTA_c$, and $LEVY_t \times ALBERTA_c$. Their coefficients show the overall degree of passthrough of each tax into retail prices (and margins), as a percentage from zero (0%) to one (100%). To simplify the text, we reference the former interaction by its coefficient $\rho^i_{TAX,g}$ and the latter interaction by its coefficient $\rho^i_{LEVY,g}$. Passthrough is complete if retail prices in the treatment cities increase by 4.0 cents per liter shortly after April 1, 2015 and an additional 4.49 cents per liter shortly after January 1, 2017, that is, if $\rho^p_{TAX,g} = \rho^p_{LEVY,g} = 1$. It is incomplete otherwise. We perform the analysis both for regular grade gasoline and premium grade gasoline.

In addition to testing whether passthrough is complete or incomplete, we are interested in testing for differences in the rates of passthrough across the two taxes. While our prior is that a one cent per liter increase in an excise tax should be equivalent to a one cent increase in a carbon levy (and equivalent to a one cent tax increase under any other name), if consumers respond to these differently-named and differently-purposed taxes in different ways, passthrough will also differ.

We conclude the analysis by performing a number of robustness checks. These include models involving expanded control groups and additional control variables, models of real versus nominal prices, models including and excluding ad valorem taxes on gasoline, and Vector Autoregressive

Error Correction Models (VAR–ECM), highlighting the short run dynamics as well. We provide details of each specification as we introduce them.

In our baseline specifications, we use nominal prices and prices that are exclusive of ad valorem taxes. Our results are very similar when using real prices instead of nominal prices, given the short time period involved (twenty-one months between taxes) and low rates of inflation. They are also similar when using ad-valorem-inclusive taxes instead of ad-valorem-exclusive taxes, given the relatively small ad valorem tax in Alberta. We use the discussion surrounding ad valorem taxes to emphasize the importance of being clear about ad valorem taxes, which has not always been the case in the literature. In short, the tax-on-tax nature of gasoline ad valorem taxes means that changes in passthrough rates do not correspond proportionally to changes in firm margins, as is sometimes presumed. This can lead to biases in margin studies and can be especially problematic in Europe where ad valorem rates are high and ad-valorem-inclusive and ad-valorem-exclusive passthrough can greatly differ.

We begin our empirical analysis with a series of preliminary diagnostics. We first perform a series of Augmented Dickey–Fuller (ADF) unit root tests on retail prices, rack prices, and margins, separately for each city and for each grade of gasoline and for each of the three distinct periods in our study – January 1, 2013 to March 31, 2015 (before the two tax changes went into effect), April 1, 2015 to December 31, 2016 (after the additional excise tax went into effect but before the carbon levy went into effect) and January 1, 2017 to December 31, 2017 (after both tax changes went into effect). There are 78 individual unit root tests in total (two grades x three periods x thirteen cities) for each type of price series (retail, rack, and margins). If unit roots are present and the price series is non-stationary, regressions of these variables can lead to spurious results unless the variables are themselves cointegrated. Not surprisingly, we cannot reject the null hypothesis of a unit root in either the retail price series or in the rack price series individually in many cases (we reject the null 21 times out of 78 for the retail price series and 22 times out of 78 for the rack price series). However, when taking the difference between retail prices and rack prices and performing unit root tests on price–cost margins, we reject the null hypothesis of a unit root at the 5% level in every case.[10] Phillips–Perron (PP) unit root tests also agree – we reject the null hypothesis of a unit root

[10] We reject the null 70 out of 78 times at the 1% level.

in margins at the 5% level in each city and period for each grade – a total of 78 null rejections in 78 tests.[11] Together, the ADF and PP tests show that margins are stationary. Since margins are simply retail minus rack prices, retail and rack prices are thus cointegrated with a cointegrating coefficient close to one.

To confirm the cointegrating relationship, we also perform Engle-Granger cointegration tests on retail and rack prices, for each city, grade, and time period (for a total of 78 tests). Engle-Granger tests agree with the margin unit root tests – we reject the null hypothesis of no cointegration in each case at better than the 1% level in each case.[12] Johansen trace statistic cointegration tests also agree, rejecting the null hypothesis at the 5% level or better in each case. We conclude that retail and rack prices are cointegrated. Since our regressions all contain either retail and rack prices in combination, or the difference in retail and rack prices, i.e. margins, or a series of first differences of retail prices and rack prices, spurious results from trending or random walk variables in our price and margin regressions is not a concern.

To further demonstrate the point, we test for the existence of different pre-existing trends in either prices or margins across our treatment and control cities, both before the implementation of the first tax increase (prior to April 1, 2015), and between the implementation of the first and second tax increase (April 1, 2015 to December 31, 2016). If there are differential pre-existing trends across the treatment and control cities that are expected to continue into the treatment period, that can generate a spurious result, since the result may simply reflect the continued convergence or divergence of the trends. In all four cases (2 grades x 2 pre-existing trend periods), we find no evidence of differential pre-existing trends, with highly insignificant coefficients on the trend-treatment interaction term and a median p-value of 0.56. We conclude that our data is well-behaved and proceed.

[11] We reject the null 74 out of 78 times at the 1% level.

[12] The Engle–Granger test is based on Augmented Dickey–Fuller tests using the residuals of the cointegrating regression (of retail prices on rack prices) rather than on prices themselves, and using further adjusted critical values as derived by Phillips and Ouliaris (1990).

4 Results

We have three interesting findings. First, we find that the rate of passthrough on the two taxes is generally high. On average across the two taxes and our various specifications, approximately 90% of the tax increases on regular grade gasoline are passed through to consumers, and thus borne by them. The finding is consistent with the low aggregate elasticities of demand for gasoline estimated in the literature (e.g. Hughes et al. (2008)), and is near the center of the range of tax passthrough estimates in the gasoline tax literature.

Second, and central to our analysis, we find a meaningful difference between the passthrough of the additional excise tax on one hand and the carbon levy on the other, for regular grade gasoline. In the case of the carbon levy, we find complete passthrough, indistinguishable from 100% even with tight standard errors, with point estimates on $\rho^p_{LEVY,REG}$ very close to one. We never reject complete passthrough in any specification. In contrast, we find incomplete passthrough for the additional excise tax, generally in the neighborhood of 75%, with point estimates on $\rho^p_{TAX,REG}$ between 0.7 to 0.8 in most specifications. We reject complete passthrough in every instance. The difference in passthrough is economically meaningful and consistent with our hypothesis that consumers may respond to the environmentally-marketed carbon levy differently than the equivalent generic excise tax increase. The responses are less elastic and more muted, and translate into higher passthrough.

Third, we find an interesting difference when we perform the same comparison for premium grade gasoline instead of regular grade gasoline. It is well known that premium grade gasoline tends to be purchased by wealthier consumers and that these consumers tend to be more inelastic. This should suggest more complete passthrough under either tax. Consistent with this, we find essentially complete passthrough for premium grade prices for both kinds of taxes. Instead of 75% passthrough for regular grade gasoline, we typically 90% to 100% passthrough on the excise tax increase for premium grade gasoline, across specifications. Passthrough on the carbon levy continues to be topped out at 100%. The result is that consumers of premium grade gasoline bear the highest consumer incidence from the two taxes collectively with noticeably less heterogeneity in passthrough across them. It shows that the naming and transparency of benefits of the tax has the greatest effect on consumers of regular grade gasoline, with little effect for consumers of premium grade gasoline, who are already almost perfectly inelastic to price increases.

The empirical specifications are presented in Table 2. The first two specifications estimate tax passthrough into regular and premium grade gasoline prices, respectively, and the second two estimate tax passthrough into regular and premium grade margins.

Specification (1) is the base difference-in-differences specification for regular grade gasoline prices, with Albertan cities as the treatment group and other Western Canadian cities outside of Alberta as the control group. There are two treatment periods (TAX equal to 4.0 cpl after April 1, 2015 and $LEVY$ equal to 4.49 cpl after January 1, 2017). We include a control for contemporaneous rack prices, while rack lags and leads and the various dichotomous control variables are not shown to preserve space.

We find that passthrough of the two taxes was high and that the incidence of the taxes was substantially higher on consumers than firms. The coefficient ρ_{TAX}, denoting the interaction of TAX and $ALBERTA$, is 0.732, and shows that the passthrough rate of the excise tax on regular grade gasoline prices in Albertan cities was approximately 73%. or equivalently 2.93 cents per liter on the 4.0 cent per liter tax increase. The coefficient ρ_{LEVY} ,denoting the interaction of $LEVY$ and $ALBERTA$, is 1.027, showing that the passthrough rate of the carbon levy was approximately 103%, or equivalently 4.61 cents per liter on the 4.49 cent per liter levy. Taken together, the average passthrough rate across the two taxes was 88%, statistically significantly higher than higher than 50%, or even 75%, on an overall basis. It shows that consumers bear the greatest burden of the tax.

Not only are passthrough rates high, they are meaningfully different. The difference in passthrough rates is approximately 29.5 percentage points, statistically significant at the 5% level, with the carbon levy having the higher of the two passthrough rates. This column labelled "Difference" reports the difference and its associated standard error. It represents an economically meaningful difference in the two passthrough rates reflecting differences in the benefit-side transparency of the two otherwise similar taxes.

On the debate about whether passthrough of costs into gasoline prices is complete or incomplete, interestingly, we are finding an example of each. The coefficient on the excise tax is statistically significantly less than one, and rejects the null hypothesis that passthrough of the excise tax into regular grade gasoline prices is complete. In contrast, the coefficient on the carbon levy is not significantly different from one, even with tight standard errors, and fails to reject the null hypothesis that passthrough of the carbon levy into regular grade gasoline prices is complete.

Specification (2) considers premium grade gasoline prices instead of regular grade gasoline prices and shows an interesting difference. We find high passthrough for both taxes generally, but this time passthrough on the excise tax is noticeably higher and more consistent with that of the carbon levy. The coefficient ρ_{TAX} is 0.947, corresponding to 95% passthrough on the 4.0 cent per liter excise tax increase, compared with 75% for regular grade gasoline previously. The coefficient ρ_{LEVY}, in contrast, is essentially the same as before, at 1.017, and corresponds to an essentially 100% passthrough on the 4.49 cent per liter carbon levy. The difference in ρ_{TAX} across the two grade-based specifications is statistically significant, while the difference in ρ_{LEVY} is not. The results are consistent with our expectations that premium grade gasoline consumers tend to be more inelastic and passthrough tends to be more complete for this grade regardless of the naming of the tax.

Specifications (3) and (4) repeat the analysis using regular grade and premium grade margins instead of regular grade and premium grade prices, on the left hand side. Results are similar. For regular grade gasoline, passthrough of the additional excise tax into margins is 0.714 cents per liter, or about 71%, and passthrough of the carbon levy into margins is 1.004 cents per liter, or almost exactly 100%. For premium grade gasoline, passthrough of the additional excise tax now rises to 0.949 cents per liter, or 95%, and passthrough of the carbon levy is 1.019 cents per liter, essentially 100% again. The pattern of significance is the same as in the price regressions.

The results show that the degree of passthrough into prices and margins are high generally and that the burden of the tax is largely borne by consumers. The results (for regular grade gasoline and ignoring the difference in taxes) are similar to Alm et al. (2009), Marion and Muehlegger (2011) and Bello and Contin-Pilart (2012), which find a high degree of tax passthrough, and less similar to Barron et al. (2004), which finds a lower degree of tax passthrough. The results on premium grade gasoline are new.

Also new is the estimated difference in passthrough based on the benefit-side transparency of the tax. The point estimates, for regular grade gasoline, show economically meaningfully higher passthrough on the carbon levy, a tax that is more transparently connected to a set of benefits, than on the additional excise tax, whose ultimate disposition, although undoubtedly important, is less transparently connected.

It is instructive to relate our findings back to those of Li et al. (2014), who compared consumer responses to tax changes, vis-a-vis tax-exclusive cost changes. Li et al. argue that taxes have greater saliency and are longer lasting than tax-exclusive cost changes which, all else equal, lead to a larger (negative) consumer response. The idea is that when consumers hear about a tax and expect the tax is to stay, they make larger adjustments away from gasoline. This implies more elastic demand, a lower passthrough rate, and lower consumer incidence for taxes that are more salient and long lasting.

Our analysis differs from theirs in an important way, however. In their research examining tax-based and non-tax-based price increases, any one cent cost increase, be it from crude oil price changes or taxes, is considered equally negative to consumers in each period. Theirs is simply a question of whether consumers recognize that a given cost increase is from a tax increase because that would be longer lasting and thus more negative.

But in our context, the two sources of price increases we are comparing are both tax-based price increases. As taxes, both are equally salient in the sense that consumers generally know they both exist, and both are expected to long lasting at the time of their passing, as taxes generally tend to be.[13] So we inherently control for the differences that Li et al. are exploring. Instead, we are examining a different distinction. We loosen the assumption that the two taxes are viewed equally negatively by all consumers, and consider differences in the transparency of benefits. We find that more transparent benefits reduce the perceived magnitude of the price increase net of its social value, leading to a more inelastic response, and higher passthrough.

We next perform a series of robustness checks to test the stability of our estimates. First, we stretch our control group to reach outside Western Canada and include cities in the next closest Canadian province to the east, Ontario. The advantage of including this additional province is that it doubles the size of our control group, from nine cities to nineteen cities. The disadvantage

[13] In 2019, a national carbon levy program went into effect that applies to any province without its own carbon levy program already.

is that Ontario may not be as comparable to Alberta as the other provinces in Western Canada. Ontario is geographically further removed from Western Canada and, more notably, is not supplied out of Western Canada but from U.S. and overseas sources. While we still control for differential cost changes using local rack prices, arguably the more distant province will be less comparable in terms of demand shocks.[14] With this caveat in mind, we add the cities of Toronto, Ottawa, Hamilton, London, Kingston, Thunder Bay, Sault Ste. Marie, Sudbury, Timmins and North Bay to the expanded control group.[15]

We report results in Table 3. The four specifications in the table correspond to the four specifications of Table 2, but with the larger control group. We find noisier but similar results and all our conclusions carry through. In Specification (1), using regular grade gasoline prices, the coefficient ρ_{TAX} is equal to 0.775, corresponding to 78% passthrough on the excise tax. The coefficient ρ_{LEVY} is 0.982, corresponding to 98% pass-though. The former is significantly different than one, and rejects the null hypothesis that passthrough is complete. The latter is not significantly different from one, even with tight standard errors, and does not reject the null hypothesis that passthrough is complete. The two coefficients are also statistically significantly different from one another, as was the case previously, with a difference of 0.207.

Specification (2) performs the analysis for premium grade gasoline instead, and again finds that ρ_{TAX} and ρ_{LEVY} are not statistically significantly different from one another in the premium case, with a difference of just 0.038. The point estimates are slightly smaller than with the more narrowly-defined control group, but still show close to complete passthrough.

Specifications (3) and (4) replace prices with margins on the left hand side, and produce a similar pattern of coefficients and significance. In the case of regular grade gasoline, the difference in the ρ_{TAX} and ρ_{LEVY} coefficients is 0.175, statistically significantly different from zero. In the case of premium grade gasoline, the difference is much smaller, at 0.031, and not statistically significantly different from zero. Even with the expanded and less ideal control group, our main results continue to hold.

[14] There are five more provinces in Canada even further east, but each is subject to various forms of gasoline price regulation, and we exclude them.

[15] For reference, most cities in Ontario are north of Ohio or New York State, whereas cities in Alberta are north of Montana and Idaho.

Next, we perform a number of robustness checks and report the results in Tables 4A and 4B. Table 4A is for regular grade gasoline and Table 4B is for premium grade gasoline. Each row in each table corresponds to a separate specification, which is described by the note at the beginning of that row. We report six main results of interest for each specification in each table – the coefficients ρ_{TAX} and p_{LEVY} and the difference between the two, first when prices are used as the left hand side variable, and then again when margins are used as the left hand side variable. All specifications use the Western Canada control group and all include city, year, and month indicator variables, except as noted, as well as local rack prices and additional controls as noted.

We begin with regular grade gasoline in Table 4A. In the first specification ("CPI Adjusted Prices"), we replace nominal prices with real prices, using 2015Q1 as the base quarter. Since the sample period is short and inflation is low, we expect this to have little impact, and we find this to be the case. In the price regression, we find that ρ_{TAX} is equal to 0.814, corresponding to 81% passthrough, statistically significantly less than one (i.e. incomplete passthrough). We find that p_{LEVY} is equal to 1.065, corresponding to 106% passthrough, and not statistically significantly different than one (complete passthrough). The difference in the coefficients is 0.251, statistically significantly different than zero. The corresponding estimates in the margin regressions are 0.795 and 1.045, for a statistically significant difference of 0.250. In summary, whether using nominal or real prices, all of our conclusions carry through.

In the second specification ("Month-of-Sample Indicators"), we use a set of month-of-sample indicator variables (e.g. January 2015, February 2015, etc.) instead of separate month and year indicator variables. The results are again very similar. In the price regression, we find that the coefficient ρ_{TAX} is equal to 0.736, corresponding to 74% passthrough, and is statistically significantly less than one (i.e. incomplete passthrough). We find that the coefficient p_{LEVY} is equal to 1.035, corresponding to 103% passthrough, and not statistically significantly different than one (complete passthrough) even with tight standard errors. The difference in the coefficients is 0.299, and statistically significantly different than zero. The corresponding estimates in the margin regressions are 0.715 and 1.006, for a statistically significant difference of 0.291.

In the third specification ("Include HHI"), we examine whether changes in market structure could potentially confound results. While market structure generally evolves very slowly, there are occasional shocks to market structure resulting from mergers. There was one notable merger during the sample period, in 2016 when Imperial Oil sold its retail assets to various competing firms. Imperial Oil sold 497 stations in all, though most were in Eastern Canada outside our sample area and most of those in Western Canada were in rural areas outside our sample cities. A total of 122 stations were sold in the sample cities, either to 7-Eleven Stores or Parkland Industries, both of whom were only relatively small players in gasoline retailing in urban areas of Western Canada at the time. As a result, the average change in the Herfindahl Hirschman Index (HHI) in the sample cities following the merger was just 0.01 (on a scale from 0 to 1) or 100 (on a scale from 0 to 10,000).

Nonetheless, we test for the effect of market structure by calculating the change in the HHI following the sale, using information from Kent Marketing Ltd., and adding it as an additional control. Our results are robust to this change. In the price regression, the coefficient ρ_{TAX} is equal to 0.710, corresponding to 71% passthrough, and is statistically significantly less than one (i.e. incomplete passthrough). The coefficient p_{LEVY} is equal to 1.001, corresponding to 100% passthrough, and is not statistically significantly different than one (complete passthrough). The difference in the coefficients is 0.291, statistically significantly different than zero. The coefficient on HHI itself (equal to 8.81) is not statistically significant. The corresponding passthrough estimates in the margin regressions are estimated at 0.715 and 1.006, yielding a statistically significant difference of 0.291. We conclude that changes in market structure during our sample period do not meaningfully impact our results.

The fourth and fifth specifications of Table 4A address another concern, that temporary reductions in refinery output, in particular from the 2016 wildfires in the oil producing region of Fort McMurray, Alberta, may be confounding results. We expect this to be unlikely, since the refineries supplied by Fort McMurray supply all of Western Canada, including both control and treatment cities, but it is worth investigating. Marion and Muehlegger (2011) find that refinery utilization can inversely affect passthrough rates.

We test it in two ways. First, we simply exclude the period of reduced refinery utilization during the fires (May and June 2016) and perform our analysis on the remaining sample. The fourth specification ("Exclude Refinery Fire Period") does this and shows that our results do not meaningfully change. In the price regression, the coefficient ρ_{TAX} is equal to 0.749, corresponding to 75% passthrough, statistically significantly less than one (i.e. incomplete passthrough). The coefficient p_{LEVY} is equal to 1.014, corresponding to 101% passthrough, and not statistically significantly different than one (complete passthrough). The difference in the coefficients is 0.265, statistically significantly different than zero. The corresponding passthrough estimates in the margin regressions are similar as well, at 0.730 and 0.991, for a statistically significant difference of 0.261.

In the fifth specification ("Include Refinery Utilization"), we add a direct measure of refinery utilization (refinery output divided by refinery capacity) instead, and add it as an additional control. The results are again very similar. In the price regression, the coefficient ρ_{TAX} is equal to 0.727, corresponding to 73% passthrough, statistically significantly less than one (i.e. incomplete passthrough). The coefficient p_{LEVY} is equal to 1.022, corresponding to 102% passthrough, and not statistically significantly different than one (complete passthrough). The difference in the coefficients is 0.294, statistically significantly different than zero. The coefficient on refinery utilization itself is -5.45, consistent with the negative sign predicted by Marion and Muehlegger (2011), but economically small. The corresponding passthrough estimates in the margin regressions are similar, at 0.714 and 1.005, for a statistically significant difference of 0.290.

In the sixth and seventh specifications of Table 4A ("VAR–ECM Model") , we incorporate short run dynamics using a vector-autoregressive error correction model (VAR-ECM) in the spirit of Engle and Granger (1987). VAR-ECMs have been used to evaluate gasoline prices in numerous past studies, including Borenstein et al. (1997), Noel (2009), Lewis and Noel (2011), and many others. We are interested neither in speed nor asymmetry, but the model allows retail prices to respond to changes in wholesale prices with a lag and potentially asymmetrically for increases and decreases. Deviations from the long run cointegrating relationship are allowed, and the model allows for a gradual reversion back to the long run relationship over time.

We estimate a two step model (Engle and Granger (1987), Bachmeier and Griffin (2003)) where the first step is to re-estimate Equation (1) and the second step is to estimate the short run adjustment equation:

$$
\begin{aligned}
\Delta PRICE_{gct} \quad = \quad & \sum_{s=0}^{S} \gamma_{gs}^{p+} \Delta RACK_{gc,t-s}^{+} + \sum_{s=0}^{S} \gamma_{gs}^{p-} \Delta RACK_{gc,t-s}^{-} \\
& + \sum_{r=1}^{R} \delta_{gr}^{p+} \Delta PRICE_{gc,t-r}^{+} + \sum_{r=1}^{R} \delta_{gr}^{p-} \Delta PRICE_{gc,t-r}^{-} \\
& + \sum_{r=0}^{T} \varphi^{p+} \Delta LEVY_{gc,t-r}^{+} + \sum_{r=0}^{T} \varphi_{gr}^{p+} \Delta EXCISE_{gc,t-r}^{+} \qquad (2) \\
& + \theta^{p+} z_{gc,t-1}^{+} + \theta^{p-} z_{gc,t-1}^{-} \qquad (3)
\end{aligned}
$$

where $z_{gc,t-1}^{+} = \max(0, \Delta z_{gc,t-1})$ and $z_{gc,t-1}^{-} = \min(0, \Delta z_{gc,t-1})$. are the sign-conditional residuals from the first stage. The variables $\Delta RACK_{gc,t-i}^{+}$, $\Delta RACK_{gc,t-i}^{-}$, $\Delta PRICE_{gc,t-i}^{+}$, and $\Delta PRICE_{gc,t-i}^{-}$ are as previously defined and the $\Delta LEVY_{gc,t-i}^{+}$ and $\Delta TAX_{gc,t-i}^{+}$ variables are defined similarly, noting that all tax changes are positive.[16] The "+" and "–" distinction on the z-residuals allows for different rates of reversion to the long run equilibrium depending on the direction of the initial deviation, and the "+" and "-" distinction on the other regressors allows for different short run reactions depending on direction. Consistent with Engle and Granger, standard errors are corrected for superconsistency by taking the first stage residual $z_{gc,t-1}$ as known instead of estimated.

The first stage of the model reproduces the overall average passthrough rates ($\rho_{TAX} = 0.732$ and $\rho_{LEVY} = 1.027$) from Table 2 so we do not repeat these in the table. The second stage reveals the shorter run dynamics underlying the overall rates, i.e. the cumulative degree of passthrough up to each week in time, and the difference between them.

We find that the passthrough on the carbon tax always exceeds that of excise tax, and the difference between them peaks at a statistically significant 0.396 difference in the second week after the shock ($\rho_{TAX} = 0.215$ and $\rho_{LEVY} = 0.611$). The difference varies in statistical significance over the first month before becoming permanently statistically significant at the 10% level in the sixth week after the shock ($\rho_{TAX} = 0.588$, $\rho_{LEVY} = 0.796$, difference = 0.207), and at the 5% level in the seventh week after the shock. In the table, we report passthrough rates and the difference between them for the seventh week ($\rho_{TAX} = 0.637$, $\rho_{LEVY} = 0.837$, difference = 0.200) and the twenty-sixth

[16] We use $R = 8$ and $S = T = 4$ based on a testing down rule, but results are unaffected with other reasonable lag lengths.

week, six months later ($\rho_{TAX} = 0.871$, $\rho_{LEVY} = 0.980$, difference $= 0.109$). Passthrough rates are largely at their asymptotes by about the twentieth week. The dynamics show that passthrough of excise tax increase was slower than that of the carbon levy in the early months after the shock and had not reached 100% by the end of the sample.

We perform a margins version of the VAR–ECM model as well, by restricting β^p_{4g} from the first stage to be equal to zero and using margins instead of prices on the left hand side in both stages. We find similar patterns and results, as seen in the table.

Finally, in the eighth specification of Table 4A ("Ad Valorem Tax Inclusive"), we show the effects of not excluding ad valorem taxes in our data. Whether ad valorem taxes are included or not included depends on the definition of passthrough one is interested in, and both are correct, but they measure different things and their interpretation is different, something that has not always been well recognized. Gasoline is a unique commodity in that both specific (i.e. per liter) taxes and ad valorem taxes often apply, and the ad valorem tax is generally charged on top of the specific-tax-inclusive price. That means that a 20% ad valorem tax added on top of a one cent per liter specific tax increase, assuming complete passthrough, would actually result in a 1.2 cent per liter price increase. Because the ad valorem tax in our analysis is rather small (5%) and the tax changes are also relatively small compared to the price of gasoline, the choice of ad-valorem-inclusive or -exclusive prices makes only minor difference in our setting. The coefficient ρ_{TAX} rises to 0.768 and the coefficient ρ_{LEVY} rises to 1.078, all compared to the otherwise equivalent second specification of Table 2 excluding the ad valorem tax. There, ρ_{TAX} was 0.732 and the coefficient ρ_{LEVY} was 1.027 cents per liter. The 5% ad valorem tax simply appears as a 5% inflation in the estimated passthrough coefficients.

The difference is small, but the point is a more general one. Ad-valorem-tax-inclusive and ad-valorem-tax-exclusive degrees of passthrough measure different things, and it is important to be explicit about what is being estimated in order to interpret the coefficients properly. Since ad valorem taxes, especially in Europe, are as high as 20% and excise taxes are as high as 91 cents per liter, the difference in measured passthrough using an ad-valorem-tax-inclusive rate or an ad-valorem-tax-exclusive rate can be as high as 18 cents per liter, or 70 U.S. cents per gallon. It is a meaningful difference that has not always been clearly separated, but needs to be.

We repeat the entire set of robustness checks in Table 4A, but for premium grade gasoline instead, and report the results in Table 4B. Similar to our robustness checks on regular grade gasoline, our results for premium grade gasoline continue to hold under this battery of tests. We find that passthrough on the additional excise tax are higher for premium grade gasoline than for regular grade gasoline (with 95% average passthrough, instead of 75%) and passthrough on the carbon levy remains exceptionally close to 100%. Each is significantly different from zero, insignificantly different from complete passthrough, and insignificantly different from one another now. Whereas the ρ_{TAX} and ρ_{LEVY} coefficients are significantly different in every specification in Table 4A, they are not statistically significantly different in any corresponding specification in Table 4B.

The results for premium grade gasoline supports our initial intuition. Premium grade gasoline is more expensive and tends to be purchased by wealthier, inelastic consumers whose more expensive vehicles require it. While consumers of regular grade gasoline may view and respond to the two types of taxes differently with different (albeit low) degrees of responsiveness, premium grade gasoline consumers are especially inelastic causing passthrough to top out at 100% after a tax under any name.

5 Discussion and Conclusion

In this study, we examine two distinct types of gasoline taxes – an increase in the excise tax and the introduction of a new carbon levy – and calculate the consumer incidence of each tax or, equivalently, the degree of tax passthrough. We are interested in exploring how naming a tax and attaching a transparent set of benefits to it can potentially affect consumer behavior. The two taxes were similar in cost-side transparency but very different in benefit-side transparency, with the benefits of the carbon levy being the more transparent of the two. We postulate that if consumers are on average more accepting of a tax whose benefits are more transparent, it can affect their response to that tax in a less negative way. In our context, this would imply a lower demand response, i.e. a more inelastic response, and a higher degree of passthrough for the more transparent carbon levy, relative to the less transparent excise tax increase.

We have several findings. First, we found that consumer incidence of both taxes was high as a general matter. Using panel data of regular and premium grade gasoline prices from Alberta and other Western Canadian cities from 2013 to 2017, we estimate the degree of passthrough of tax increases into retail prices to be approximately 90% overall on regular grade gasoline. The result is consistent with the bulk of the literature that finds high degrees of passthrough. The evidence in the literature is mixed on whether gasoline taxes are passed through to consumers completely (100%) or incompletely (less than 100%), and an interesting result in our study is that we find examples of both – we find that the carbon levy is passed through completely and that the excise tax is passed through incompletely in our sample.

Our second finding is that transparency on the benefit side of a tax appears to matter. In the case of the carbon levy, passthrough is especially high, essentially 100%, whereas passthrough for the additional excise tax tend is only in the neighborhood of 75%. The general pattern of coefficients is consistent with the hypothesis that greater transparency in the benefits of a tax may lead to less negative consumer responses to that tax.

The differences across the taxes vanishes once we examine premium grade gasoline. Passthrough on both the carbon levy and the excise tax for premium grade gasoline are indistinguishable from each other and 100%.

Relatively little has been done to date to explore different kinds of taxes and their potentially differential effects on tax incidence (Chouinard and Perloff (2014) and Li et al. (2014) being exceptions). Our study contributes to this small but important literature. We overcome the identification problem by exploiting a unique natural experiment in which a single jurisdiction (Alberta) implemented both an excise tax increase and a new carbon levy, with similar costs but dissimilar transparency in terms of benefits, at separate times though not too far apart, all the while gasoline taxes remained stable in neighboring jurisdictions.

Our results suggest that consumers in gasoline markets may exhibit more complex preferences towards different taxes and that behavioral considerations can be important in predicting taxation outcomes. It would interesting to see whether the results found here are also robust to other situations, including other industries, other types of taxes, or geographies. To the extent there are differences, it would be interesting to explore the sources of heterogeneity resulting in those differences. We think it is an important area of future research. There are clear policy implications if the naming and transparency of benefits of a tax matters for consumers, including implications for the incidence of the tax, the distribution of surplus, and ultimately the efficacy of the tax itself.

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Table 1. Summary Statistics

	Num. Obs.	Mean	Std. Dev.	Minimum	Maximum
Main Dataset - Western Canada					
Regular Grade Retail Price	3393	109.84	15.61	57.9	154.2
Regular Grade Wholesale Price	3393	69.49	12.87	31.0	96.7
Premium Grade Retail Price	3393	124.97	15.33	74.8	169.5
Premium Grade Wholesale Price	3393	77.17	12.55	39.0	104.1
Extended Dataset - Western Canada and Ontario					
Regular Grade Retail Price	6003	112.76	15.38	57.9	154.2
Regular Grade Wholesale Price	6003	69.53	12.65	31.0	96.8
Premium Grade Retail Price	6003	128.04	14.93	74.8	169.5
Premium Grade Wholesale Price	6003	77.44	12.43	39.0	104.8

All prices in Canadian cents per liter.

Table 2. Excise Tax and Carbon Levy Passthrough

	Retail Prices		Retail Margins	
	Regular (1)	Premium (2)	Regular (3)	Premium (4)
ρ_{TAX}	0.732**	0.947**	0.714**	0.949**
	(0.061)	(0.062)	(0.061)	(0.062)
ρ_{LEVY}	1.027**	1.017**	1.004**	1.019**
	(0.070)	(0.072)	(0.070)	(0.071)
TAX	-0.387**	-0.480**	-0.328**	-0.485**
	(0.085)	(0.086)	(0.081)	(0.084)
LEVY	0.773**	0.952**	0.580**	0.965**
	(0.110)	(0.106)	(0.089)	(0.089)
RACK	1.038**	0.997**		
	(0.013)	(0.012)		
Difference	0.295**	0.070	0.290**	0.070
	(0.112)	(0.115)	(0.112)	(0.115)
City Indicator Variables	Y	Y	Y	Y
Month Indicator Variables	Y	Y	Y	Y
Year Indicator Variables	Y	Y	Y	Y
Adj. R-Squared	0.956	0.954	0.823	0.861
Num. Obs.	3289	3289	3289	3289

** Significant at the 5% level. * Significant at the 10% level. Standard errors in parentheses.

Table 3. Excise Tax and Carbon Levy Passthrough - Extended Sample

	Retail Prices		Retail Margins	
	Regular	Premium	Regular	Premium
	(1)	(2)	(3)	(4)
ρ_{TAX}	0.775**	0.880**	0.769**	0.878**
	(0.053)	(0.054)	(0.052)	(0.054)
ρ_{LEVY}	0.982**	0.918**	0.943**	0.909**
	(0.061)	(0.062)	(0.060)	(0.062)
TAX	-0.359**	-0.348**	-0.290**	-0.331**
	(0.060)	(0.061)	(0.058)	(0.059)
LEVY	0.798**	1.073**	0.572**	1.022**
	(0.077)	(0.076)	(0.061)	(0.062)
RACK	1.044**	1.011**		
	(0.009)	(0.009)		
Difference	0.207**	0.038	0.175*	0.031
	(0.098)	(0.101)	(0.097)	(0.101)
City Indicator Variables	Y	Y	Y	Y
Month Indicator Variables	Y	Y	Y	Y
Year Indicator Variables	Y	Y	Y	Y
Adj. R-Squared	0.957	0.953	0.773	0.818
Num. Obs.	5819	5819	5819	5819

** Significant at the 5% level. * Significant at the 10% level. Standard errors in parentheses.

Table 4A. Excise Tax and Carbon Levy Passthrough, Regular Grade Gasoline - Alternate Specifications

		Regular Retail Prices			Regular Retail Margins		
	Num. Obs.	Excise Tax	Carbon Levy	Difference	Excise Tax	Carbon Levy	Difference
CPI-Adjusted Prices	3289	0.814**	1.065**	0.251**	0.795**	1.045**	0.250**
		(0.060)	(0.067)	(0.109)	(0.060)	(0.067)	(0.109)
Month-of-Sample Indicators	3289	0.736**	1.035**	0.299**	0.715**	1.006**	0.291**
		(0.060)	(0.065)	(0.106)	(0.059)	(0.065)	(0.106)
Include HHI	3289	0.710**	1.001**	0.291**	0.683**	0.967**	0.284**
		(0.065)	(0.072)	(0.112)	(0.065)	(0.072)	(0.112)
Exclude Refinery Fire Period	3172	0.749**	1.014**	0.265**	0.730**	0.991**	0.261**
		(0.063)	(0.071)	(0.116)	(0.063)	(0.071)	(0.116)
Include Refinery Utilization	3289	0.727**	1.022**	0.294**	0.714**	1.005**	0.290**
		(0.061)	(0.069)	(0.111)	(0.060)	(0.069)	(0.111)
VAR-ECM Model (7 weeks)	3224	0.681**	0.863**	0.182**	0.617**	0.788**	0.171**
		(0.055)	(0.041)	(0.068)	(0.053)	(0.045)	(0.070)
VAR-ECM Model (26 weeks)	3224	0.871**	0.980**	0.109**	0.857**	0.970**	0.112**
		(0.002)	(0.003)	(0.003)	(0.009)	(0.007)	(0.011)
Ad Valorem Tax Inclusive	3289	0.768**	1.078**	0.310**	0.727**	1.024**	0.263**
		(0.064)	(0.073)	(0.117)	(0.064)	(0.074)	(0.115)

** Significant at the 5% level. * Significant at the 10% level.

Table 4B. Excise Tax and Carbon Levy Pass-through, Premium Grade Gasoline - Alternate Specifications

		Premium Retail Prices			Premium Retail Margins		
	Num. Obs.	Excise Tax	Carbon Levy	Delta	Excise Tax	Carbon Levy	Delta
CPI-Adjusted Prices	3289	1.024**	1.065**	0.041	1.028**	1.068**	0.040
		(0.061)	(0.069)	(0.112)	(0.061)	(0.069)	(0.112)
Month-of-Sample Indicators	3289	0.892**	0.965**	0.073	0.949**	1.020**	0.070
		(0.061)	(0.065)	(0.108)	(0.060)	(0.065)	(0.109)
Include HHI	3289	0.889**	0.950**	0.060	0.897**	0.957**	0.060
		(0.067)	(0.074)	(0.115)	(0.067)	(0.073)	(0.114)
Exclude Refinery Fire Period	3172	0.964**	1.003**	0.040	0.965**	1.005**	0.040
		(0.064)	(0.073)	(0.120)	(0.065)	(0.073)	(0.120)
Include Refinery Utilization	3289	0.941**	1.012**	0.071	0.949**	1.019**	0.071
		(0.062)	(0.071)	(0.114)	(0.062)	(0.071)	(0.114)
VAR-ECM Model (7 weeks)	3224	0.832**	0.876**	0.044	0.747**	0.794**	0.047
		(0.071)	(0.048)	(0.085)	(0.069)	(0.052)	(0.087)
VAR-ECM Model (26 weeks)	3224	1.008**	0.964**	-0.044	1.024**	0.964**	-0.060
		(0.042)	(0.028)	(0.051)	(0.035)	(0.025)	(0.043)
Ad Valorem Tax Inclusive	3289	0.994**	1.068**	0.074	0.961**	1.037**	0.043
		(0.065)	(0.075)	(0.120)	(0.065)	(0.076)	(0.117)

** Significant at the 5% level. * Significant at the 10% level.

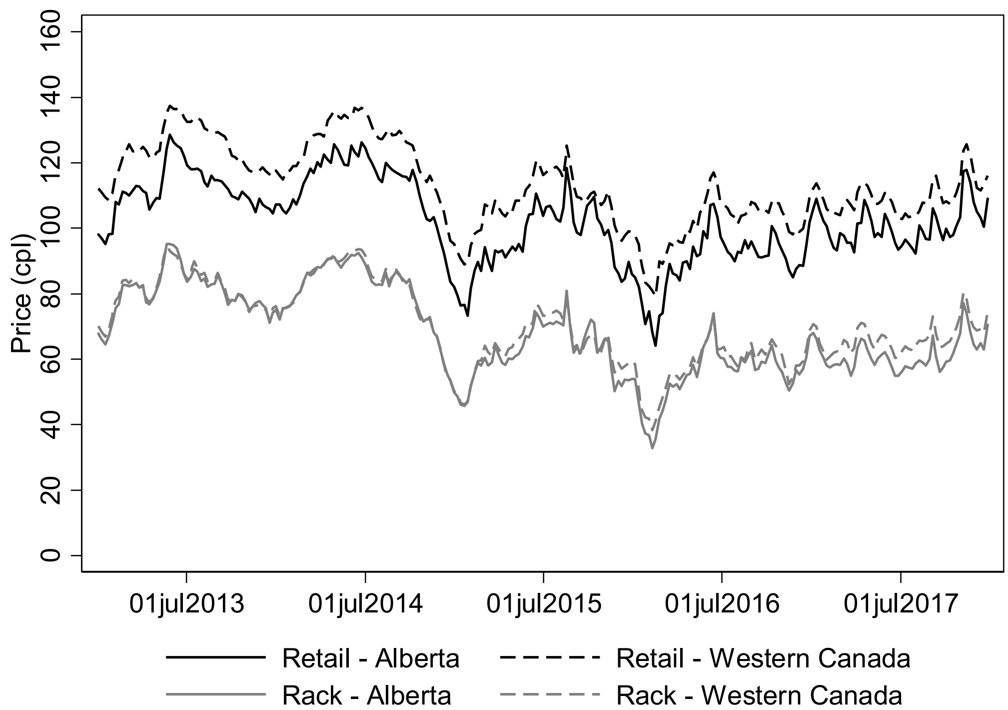

Figure 1. Regular Retail and Rack Prices, Alberta and the Rest of Western Canada

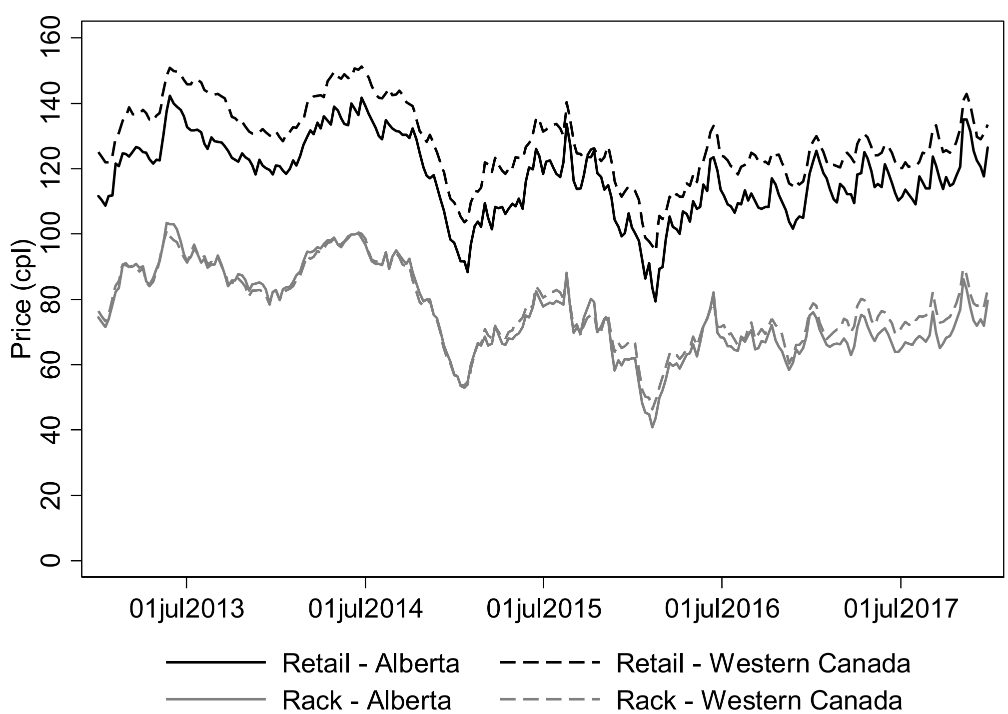

Figure 2. Premium Retail and Rack Prices, Alberta and the Rest of Western Canada