The BC Carbon Tax: Consumer response to an environmental gasoline tax

Grant Guenther
6084168

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Supervisor: Professor Jean-Thomas Bernard
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Abstract

I show that the carbon tax in BC, imposed in July 2008 caused a decline in gasoline demand. Furthermore, the carbon tax caused a larger decline in demand than would otherwise be caused by an equivalent price increase in oil prices or other excise taxes. Once the initial shock in demand that occurs following the introduction of the carbon tax is accounted for, subsequent increases to the carbon tax result in a decrease in gasoline demand similar to an equivalent increase in gasoline prices. Unit root tests are also performed on the variables used in regressions. Reductions in gasoline consumption and CO_2 emissions as a result of the carbon tax are also calculated.

1 - Introduction:

There is currently considerable public interest in environmental issues and policies. For example, next to the economy, polls consistently rate the environment as one of the largest concern among Canadian voters[1]. As a result of the public concern for environmental issues, in the last ten years there has been a wide degree of differing policy responses by governments and elected officials. One prominent example is the emissions trading scheme in the European Union[2]. Another is cap and trade system -which is effectively a carbon tax during the phase-in period - recently implemented in Australia[3]. Canada has a history of non-greenhouse gas related environmental taxation. For example, in every province, consumers are required to pay a non-negotiable amount - up to $40 in some cases[4] - on electronic goods. Similarly, in July 1st, 2012, BC introduced eco-fees on a broad range of consumer products[5]. These eco fees, as well as the carbon tax, are a type of pigouvian tax that brings the private cost of consumption closer in line to the social cost. It is also the case that within Canada there are examples of the provinces of Alberta, Quebec, and British Columbia (BC), which have all imposed a type of explicit price on carbon emissions for at least some sectors[6].

In this paper, I intend to show that the BC carbon tax, which implemented a corresponding gasoline price increase, caused a reduction in gasoline demand. This demand reduction resulted in a decrease in CO2 emissions above and beyond what would have occurred if a usual market induced price increase had occurred, or another type of excise tax put in place.

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[1] http://www.cbc.ca/bc/features/feelingtheheat/poll-results-Q1.html
[2] http://ec.europa.eu/clima/policies/ets/index_en.htm
[3] http://www.cleanenergyfuture.gov.au/clean-energy-future/carbon-price/
[4] http://content.dell.com/ca/en/corp/d/corp-comm/canada-recycling-laws
[5] http://www.theglobeandmail.com/news/british-columbia/recycling-advocates-applaud-bc-eco-fees/article4367077/
[6] http://www.rev.gov.bc.ca/documents_library/notices/British_Columbia_Carbon_Tax.pd, http://www.alberta.ca/acn/200905/2588916EB7350-94B1-016E-779CDCE024F9CDBE.html, http://www.gouv.qc.ca/portail/quebec/international/general/quebec/grand_dossiers/climat/?lang=en

The economic literature has covered in detail the policy response of environmental taxations and a review of this literature can help form the hypotheses that are tested within this paper. Goulder(1995) discusses the notion of environmental taxation and the double dividend. In his discussion, he explores the ramifications when taxes are shifted from labour taxation to environmental taxation. He discusses that policy makers must take into account redistributive effects, tax efficiency and administrative costs, and any distortionary effects of the taxes. Essentially, he argues that any non-environmental benefits of a tax shift could be obtained by otherwise moving towards a more efficient tax system, and so should not necessarily be counted as benefits of the tax shift.

A more recent avenue of research has been on the idea of tax saliency[7]. While rational choice models generally predict that consumers should treat all types of price increases equally with respect to their consumption choices, evidence has been found to the contrary. For example, Chetty et al. (2009) presents evidence that consumers react differently to a price change depending on its saliency. They show, by varying price tags between tax inclusive and tax exclusive prices, that consumers have a higher price elasticity when prices are tax inclusive. In the case of gasoline prices in Canada, taxes are always included in the displayed price. However, different price increases could still be more salient than others if consumers were more aware of them. For example, due to the media coverage and large public interest in the BC carbon tax [see appendix, Section A], consumers may have had a heightened sense of awareness of the price increase.

Another applicable theory is that consumers may respond differently to environmental taxation

[7]Chetty (2009), Finkelstein (2009), Godlin and Homonoff (2010)

simply because it is an environmental tax. There is evidence to show that consumers will pay a price premium if they deem a good to be environmentally friendly[8]. It is possible that the carbon tax has the opposite effect. In effect, the environmental tax may remind the consumer that their fuel purchase has a harmful effect on the environment. As a result, this increased awareness of the harmful effects of fuel consumption results in the consumer decreasing consumption. This increased awareness could present itself as an initial reduction in consumption coinciding with the introduction of the environmental tax.

In a similar line of reasoning, Engel and Pötschke (1998) apply the theory of "value and purpose-rational behavior" to economic taxation. In summarizing Weber (1947), they state that "individuals act value-rationally, if they, 'regardless of possible cost to themselves, act to put into practice their convictions of what seems to them to be required by duty, honour, the pursuit of beauty, a religious call, personal loyalty, or the importance of some 'cause' no matter in what it consists'"(pg 321). Individuals act purpose-rationally if they are merely acting towards accomplishing an objective in the most efficient means possible. Often these two notions - purpose-rational and value-rational - conflict while an individual makes a decision. For example, an individual might feel compelled to drive their personal vehicle because it saves time: a purpose-rational based reason. On the other hand, that same individual may feel compelled to take public transit because they believe it to be the right thing for the environment: a value-rational based reason. A tax on carbon may result in that individual to feel more socially responsible for their fuel purchase decision and therefore decrease consumption; they are reminded by the tax of the harmful effects of their actions. Conversely, a tax on carbon may result in that individual to feel less socially responsible for their fuel purchase decision and subsequently increase consumption; they would already be paying their debt to society in the

[8]Roe, Teisl, Levy and Russell (2001), Sedjo and Swallow (1999)

form of a tax on their behavior.

Rivers and Schaufele (2012) examined the effects of the BC carbon tax on gasoline demand. Rivers and Schaufele looked at the difference in price elasticity between the carbon tax and a general price increase. They conclude that consumer response to the BC carbon tax differs from other price increases. Furthermore, they conclude that approximately 80% of the reduction in gasoline demand (and therefore CO2 emissions) is due to the saliency of the tax. 2SLS regressions are also done to verify the robustness of the results. They do not however, examine the impact of the carbon tax as compared to other tax increases. This is an avenue that will be further explored in this paper.

This paper intends to address the issue of environmental taxation and measure the price elasticity in the context of the BC carbon tax, comparing it to general market fluctuations in prices, and excise tax increases. This can be viewed as an extension of the work of Rivers and Schaufele(2012). Specifically, I will test three hypotheses which have been developed from a review of the literature mentioned above. First, is that consumers in BC respond differently to a gasoline tax increases than a price increase caused by oil price fluctuations[9]. Second, consumers in BC respond differently to the carbon tax than other types of tax increases[10]. Third, the effect of the carbon tax on gasoline demand can be disaggregated into two effects: a price effect and an introduction effect. The price effect is similar in behaviour for the carbon tax than for other tax increases. The introduction effect could be explained by two theories. First is that the carbon tax was more salient (Finkelstein, 2009) than other price increases as a result of the heightened public awareness at its onset. Second is that the introduction of the carbon tax caused consumers to alter how they view their gasoline consumption as a value-based decision

[9]Chetty (2009), Rivers and Schaufele (2012)
[10]Roe, Teisl, Levy and Russell (2001), Sedjo and Swallow (1999)

in the context of an individual's social responsibility (Engel and Pötschke, 1998).

Formally stated, there are also three null hypotheses to test. For hypothesis 1, the null hypothesis is that a tax influences consumer demand no differently than a price increase due to oil price fluctuations. For hypothesis 2, it would be that the carbon tax influences consumer demand no differently than a different type of tax increase. For hypothesis 3, the null hypothesis is that once the introduction effect is accounted for, the carbon tax still has a different influence on consumer gasoline demand than other forms of tax increases. Each of these hypotheses -and their respective null hypotheses - will be tested through econometric modelling. Robustness checks will also be performed.

2 - Carbon Tax

As was mentioned above, within Canada, there have been three provinces that have imposed some kind of carbon tax, namely Quebec, Alberta, and British Columbia. Since 2007, Quebec[11] has required energy distributors to pay a tax of approximately \$3/tonne of CO_2, or 0.7 cents a litre. Similarly, since 2007 Alberta[12] has regulated the largest industrial emitters in the province. Essentially the regulation requires all companies with annual emissions greater than 100,000 tonnes per annum to reduce emissions intensity by 12%, or pay \$15 per tonne of CO_2 emitted past their allocation limits. In terms of the effect of these carbon taxes on gasoline prices, the Quebec tax has resulted in a near-negligible increase in price of gasoline inputs, and - by extension - gasoline prices of less than 1 cent per litre, while the Alberta carbon tax only applies to industrial emissions and has no bearing on the gasoline market at all. In contrast, the BC

[11] http://www.gouv.qc.ca/portail/quebec/international/general/quebec/grand_dossiers/climat/?lang=en
[12] http://environment.alberta.ca/01838.html

carbon tax was more broad in scope and larger in amount, which, as was mentioned above and as this paper will demonstrate, caused a sufficient increase in gasoline prices to measurably affect consumption.

In 2008 in an open letter[13] to the BC Minister of Finance, David Green, and 69 other BC-based economists[14] recommended the province adopt a carbon tax. As a result of this letter, and public support for environmental interventions, government action was taken and BC became the first jurisdiction in North America to impose a significant and broad-based carbon tax on fossil fuels.The BC government first published it's intentions to carry out a carbon tax in February 2008[15]. In a notice from the Ministry of Small Businesses and Revenue[16], the Government outlined how the tax would be implemented in five stages. The first stage began July 1st, 2008 with a rate of $10 CAD per tonne of CO_2, or 2.41 cents per litre. The carbon tax then incrementally rose in stages by $5 CAD/tonne per year until it reached $30 CAD/tonne, or 7.24 cents per litre, on July 1, 2012. In 2010, the rates were revised to reflect the biofuel mandate, and the 2012 per litre rate was to be 6.67 cents per litre[17]. This tax is applied to fuels at the point of purchase or, when that is not possible, at the time of consumption, and covers most sources of hydrocarbon based CO_2 emissions that occur within BC, including gasoline, diesel, natural gas, aviation fuel, coal, and coke. Some sources of emissions not covered by the tax are biofuels and other renewable energy, airplane and ocean-shipping trips that do not end and originate in BC, cruise ships that have a port of call outside of BC, and fuel that will be consumed outside of BC.

[13] http://faculty.arts.ubc.ca/dgreen/documents/carbon.doc
[14] http://faculty.arts.ubc.ca/dgreen/documents/let_list.doc
[15] http://www.rev.gov.bc.ca/documents_library/notices/British_Columbia_Carbon_Tax.pdf
[16] http://www.rev.gov.bc.ca/documents_library/notices/British_Columbia_Carbon_Tax.pdf
[17] http://www.sbr.gov.bc.ca/documents_library/shared_documents/Carbon_Tax_Rates_by_fuel_Type_from_Jan_2010.pdf

A key component of the BC carbon tax, was its revenue neutral design. According to the BC Ministry of Finance[18],

> The government has a legal requirement to present an annual plan to the legislature demonstrating how all of the carbon tax revenue will be returned to taxpayers through tax reductions. The money will not be used to fund government programs.

Each increase in the tax would be accompanied by reductions in personal and corporate income tax, as well as cash transfers for low income individuals. Two such examples[19] are the reduction in small business tax and the "Northern and Rural Homeowner Benefit". These actions would ensure the tax shift be progressive as well as revenue neutral.

The carbon tax has been well received[20] in BC. Because it was designed in consultation with BC academics[21], it largely received the support of the academic community. Income tax reductions and low-income cash transfers helped to garner support of individuals, while the corporate tax reduction helped in convincing businesses that, for the most part, their expenses would not drastically increase. Furthermore, the majority of BC's citizens believe climate change is fully or at least partially caused by human activity[22], and therefore it is not unreasonable for them to apply the 'polluter pay principle'[23] to greenhouse gasses. Overall, the carbon tax was designed in a way that led to a general public and academic acceptance of its implementation.

In summary, the tax is generally believed to be well designed and properly implemented, and

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[18] http://www.fin.gov.bc.ca/tbs/tp/climate/A1.htm
[19] http://www.fin.gov.bc.ca/tbs/tp/climate/A2.htm
[20] http://pubs.pembina.org/reports/measuring-the-appepite-for-climate-action-in-bc.pdf
[21] http://thetyee.ca/Views/2007/11/01/CarbonTax/
[22] http://www.ipac-co2.com/uploads/File/Surveys/IPAC-CO2%20-%202012%20-%20National%20Survey.pdf
[23] Polluter pay principle dictates that the cost of an action should be borne by the one responsible for the action.

continues to have significant public support. This is because the details of the tax policy were clearly communicated well in advance providing businesses and consumers time to adjust and prepare for its implementation, it was phased in over several years, reducing any large shocks to the energy market, and the tax is broad based and covers nearly all carbon emissions. Furthermore, any revenues generated resulted in an equivalent reduction in income tax, corporate tax, and low-income subsidies, resulting in the tax shift being both redistributively progressive and (mostly) revenue neutral.

However, in order to properly design a completely revenue neutral tax-shift, one must take into account the shift in consumer behaviour caused by the relative price changes. Specifically, a proper estimate for the price elasticity must be determined. If it is underestimated, there will be a revenue shortfall; overestimated and there will be a windfall; neither are desirable outcomes. In the case of the BC carbon tax, even though the tax shift was designed to be revenue neutral, it was in fact, revenue negative[24]. In the 2011/2012 fiscal year, the carbon tax brought in 960 million, while the tax cuts cost the government 1.1 billion. Although it is impossible to perfectly predict exact consumption of any good in the future, part of the revenue shortfall may have been a result of using an incorrect estimate for price elasticity. In this paper, I will show that part of the revenue shortfall could be explained by policy-makers' failure to properly consider the effects of the BC carbon tax on gasoline demand; one such consideration could be the introduction effect.

3 - Data

For the models and tests demonstrated in this paper, six sources of data were required. These were namely: (a) monthly Canadian provincial gasoline price data, (b) Canadian provincial

[24] http://www.bcbudget.gov.bc.ca/2013/bfp/2013_Budget_Fiscal_Plan.pdf

gasoline tax data, (c) monthly Canadian provincial gasoline sales data, (d) Canadian provincial populations, (e) and Canadian provincial GDP. Ideally, a model examining the effects of the BC carbon tax would include data from before its implementation, during the phase-in period of 2008-2012, and after. However, at the time of writing, GDP and gasoline consumption data were not available to cover the entire period. As a result the models were limited to examining the July 1997 to July 2011 period. Below I describe these data sources in more detail.

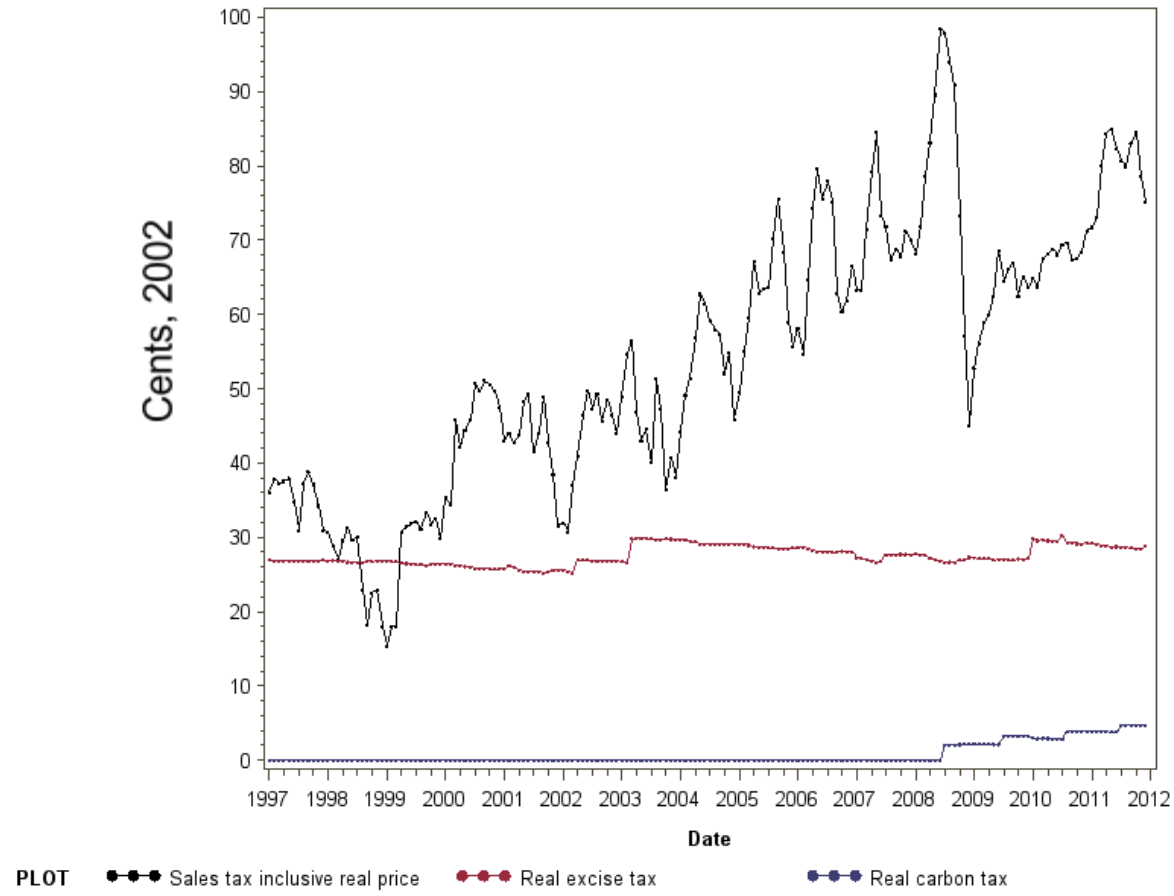
The gasoline price data is taken from Natural Resources Canada[25]. Weekly tax inclusive and tax exclusive price data is available for Canada's major cities. To convert to monthly provincial data, monthly averages of the largest city in each province were used. For example, for British Columbia, the price of gasoline in Vancouver was used [see figure 3.1]. This provides monthly price data for all provinces except Newfoundland as price data from Natural Resources Canada were not available for St. John's. Nominal price data were transformed into real price data by dividing it by the provincial CPI. Price data were also transformed to be the difference in price from previous month in order to correct for serial autocorrelation [described in section 5].

Gasoline tax data is taken from various sources. As previously mentioned, total tax amounts are available through Natural Resources Canada[26]. GST as well as provincial PST, and HST rates, as a percentage of sales price -per dollar - are taken from federal and provincial finance ministries' websites, whenever possible, and from other less official sources when not [see appendix, section b]. Carbon tax information is taken from the BC government's announcement on the carbon tax[27] and from the update as a result of the biofuel mandate[28]. Other taxes - per

[25] http://www2.nrcan.gc.ca/eneene/sources/pripri/prices_bycity_e.cfm
[26] http://www2.nrcan.gc.ca/eneene/sources/pripri/prices_bycity_e.cfm
[27] http://www.rev.gov.bc.ca/documents_library/notices/British_Columbia_Carbon_Tax.pdf
[28] http://www.sbr.gov.bc.ca/documents_library/shared_documents/Carbon_Tax_Rates_by_fuel_Type_from_Jan_2010.pdf

litre excise rates- are implied by taking the difference between total taxes, and the sum of sales taxes and, in the case of BC, the carbon tax [see figure 3.1]. Additionally, the nominal tax rates were converted to real tax rates in the same manner as prices were.

Figure 3.1: BC gasoline price



Monthly Provincial Retail Gasoline sales are available from Statistics Canada[29]. At the time of writing, data were available up to and including 2011. Monthly sales were divided by total population[30] to derive monthly sales per capita. It is known that gasoline sales show a significant seasonal trend. For example, monthly gasoline consumption in BC is on average 12 litres higher per capita in August than in December [see table 3.1]. As a result, seasonal variation was removed by subtracting the seasonal dummy values from the monthly sales data before

[29] http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=4050003&paSer=&pattern=&stByVal=1&p1=1&p2=31&tabMode=dataTable&csid=

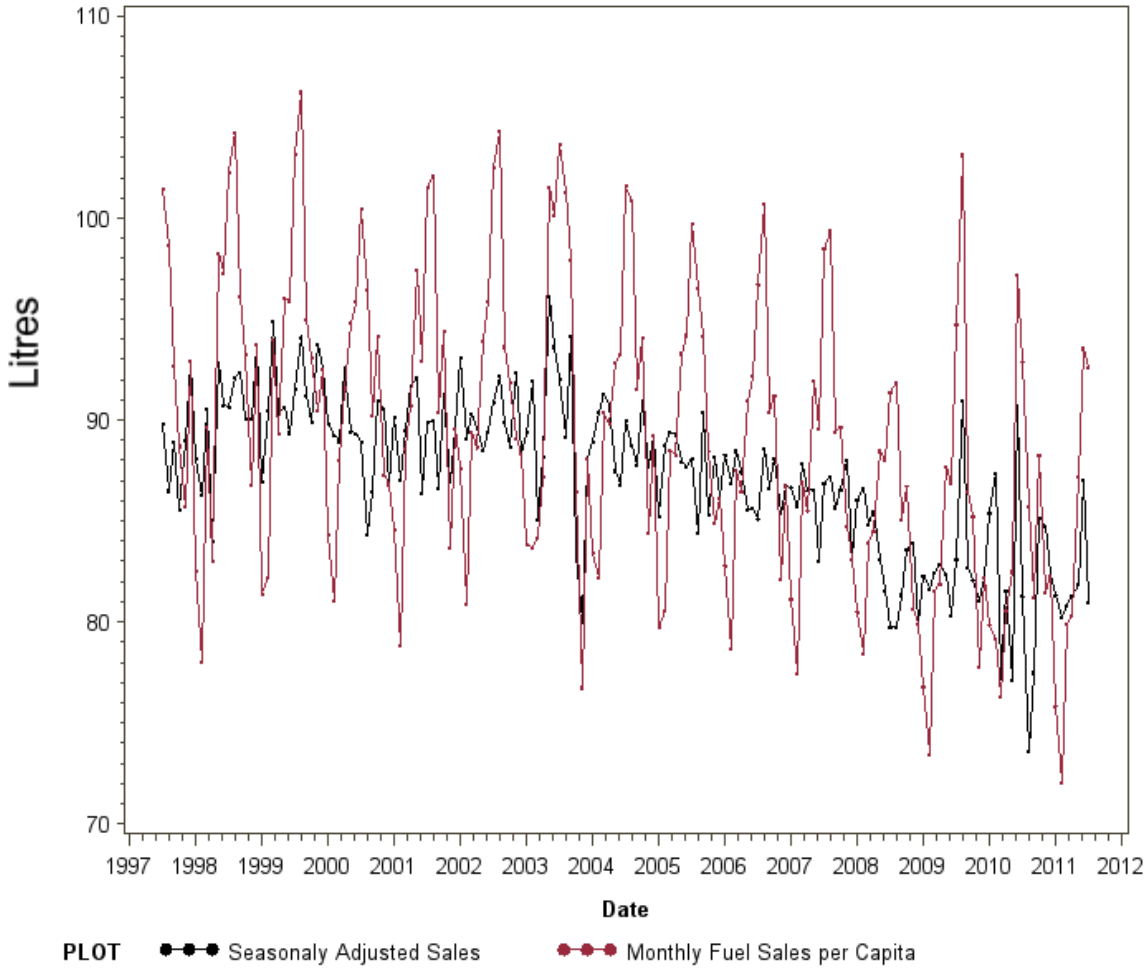
[30] Monthly provincial population was derived from the yearly population value - July of each year - and then extrapolating the other months by using a spline method in SAS. Population statistics are available at http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=0510001&paSer=&pattern=&stByVal=1&p1=1&p2=-1&tabMode=dataTable&csid=;

regression analysis was performed [see figure 3.2].

Table 3.1: Seasonal coefficients for BC

Parameter Estimates						
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	87.26008	1.10849	78.72	<.0001
m_01	January	1	-5.52401	1.56764	-3.52	0.0006
m_02	February	1	-8.21075	1.56764	-5.24	<.0001
m_03	March	1	-0.91082	1.56764	-0.58	0.5621
m_04	April	1	-0.98767	1.56764	-0.63	0.5296
m_05	May	1	5.37919	1.56764	3.43	0.0008
m_06	June	1	6.51657	1.56764	4.16	<.0001
m_07	July	1	11.62451	1.54129	7.54	<.0001
m_08	August	1	12.13146	1.56764	7.74	<.0001
m_09	September	1	3.76104	1.56764	2.40	0.0176
m_10	October	1	3.13617	1.56764	2.00	0.0472
m_11	November	1	-3.27275	1.56764	-2.09	0.0384

Figure 3.2: Monthly sales with and without seasonal trend



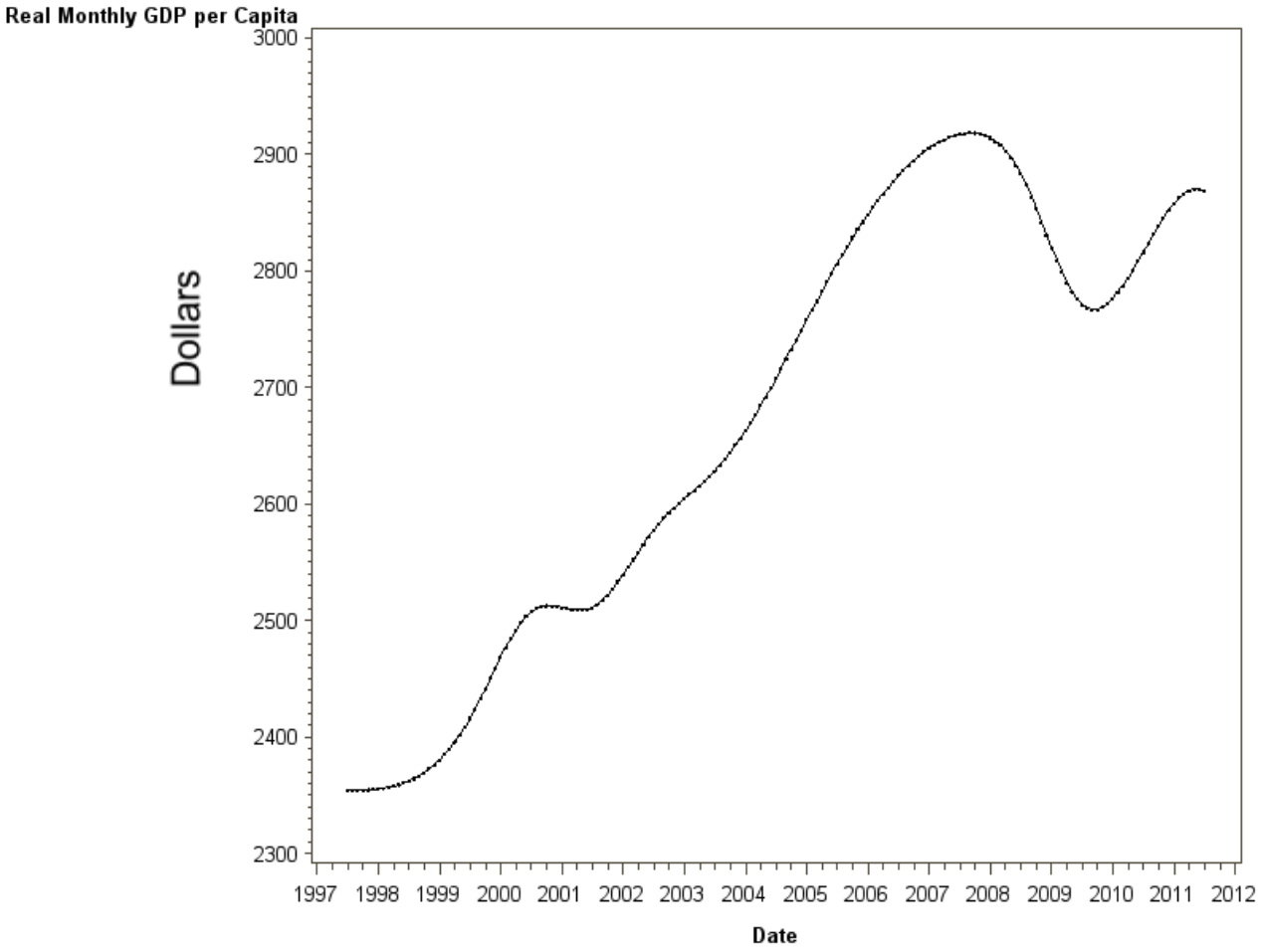
Provincial GDP is available from Statistics Canada[31]. For GDP, the level from the annual series was combined with a monthly trend from labour income data[32] [see figure 3.3]. This value was then divided by the population and by 12 to obtain monthly GDP per capita estimates. In essence, this method allows for an estimation of monthly GDP by ensuring the July values match the annual series, and using the monthly variation from labour income to determine the

[31] http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=3840038&paSer=&pattern=&stByVal=1&p1=1&p2=-1&tabMode=dataTable&csid=

[32] http://www5.statcan.gc.ca/cansim/a26;jsessionid=26F30BC82F52DDCC583458FADDCE141E?lang=eng&retrLang=eng&id=2810049&pattern=281-0041..281-0049&tabMode=dataTable&srchLan=-1&p1=-1&p2=-1

monthly values for the rest of the year.

Figure 3.3: Monthly GDP per capita



4 - Models:

The basic model[33] is as follows:

$$1)\ Y_t = \beta + \delta\, Y_{t-1} + \gamma GDP_t + \alpha P_t + \varepsilon$$

Where Y is monthly Gasoline Sales, GDP is monthly GDP, and P is the gasoline price. This is a partial adjustment model, which allows for the estimation of short-run effects (as well as long-run effects which are not done in this paper). It should also be noted that t-1 refers to the preceding month.

In order to test the theory that not all price changes are equal, it is necessary to distinguish between price increases caused by oil price fluctuations, and those caused by a change in the tax rate. Ideally, it would be best to separate out oil price changes from all changes in tax rates. However, since some of the tax is collected as a (per dollar) rate and thus is perfectly correlated with the oil price - except in the cases where PST or GST change - it is not possible to independently measure their effects. As such, it becomes necessary to divide the price change into two: (a) the oil price and per dollar tax, and (b) the excise (per litre) tax. With these changes the model then becomes as follows:

$$2)\ Y_t = \beta + \delta\, Y_{t-1} + \gamma GDP_t + \alpha_1 P_{1,t} + \alpha_2 P_{2,t} + \varepsilon$$

Which is the same as model 1 with the addition of P_1, the first part of the gasoline price, and P_2, the carbon tax inclusive excise tax portion of the gasoline price.

As indicated by hypothesis 2, it is also possible that consumer reaction to the carbon tax not only

[33]This model is used as the initial model as outlined in the work of Carol H Dahl, "Measuring Global Gasoline and Diesel Price and Income Elasticities" (2011)

differs from a regular price increase, but also differs from any other tax increase. In order to test this, the below model is used:

$$3)\ Y_t = \beta + \delta\, Y_{t-1} + \gamma GDP_t + \alpha_1 P_{1,t} + \alpha_2 P_{2,t} + \alpha_3 P_{3,t} + \varepsilon$$

Which is the same as model 2 with the addition of P_3, the carbon tax portion of the gasoline price, and redefining P_2 to be the carbon tax exclusive portion of the excise tax.

The carbon tax was implemented in 5 phases. The first phase occurred July 1st, 2008, where every tonne of CO_2 was taxed at a rate of $10. Every year thereafter, the rate was increased by $5 per tonne until it reached the price of $30 per tonne on July 1st, 2012. As such, it is possible to test if consumers reacted differently to different phases of the tax rollout. Therefore, to examine this case, which is part of hypothesis 3, the following model is used:

$$4)\ Y_t = \beta + \delta\, Y_{t-1} + \gamma GDP_t + \alpha_1 P_{1,t} + \alpha_2 P_{2,t} + \alpha_3 P_{3,t} + \gamma D_t + \varepsilon$$

Which is the same as model 3 with the addition of D, a vector of dummy variables representing each of the five phases of the rollout. However, since data is only available up to and including July 2011, the fifth phase is not represented in the model.

The following model could also be used to test how consumers reacted to the different phases of the implementation of the carbon tax:

$$5)\ Y_t = \beta + \delta\, Y_{t-1} + \gamma GDP_t + \alpha_1 P_{1,t} + \alpha_2 P_{2,t} + \gamma D_t + \varepsilon$$

Which is the same as model 4 except that the dollar value of the carbon tax is not included in the model. This has the effect of the vector of dummy variables capturing the entire consumer response to the carbon tax.

In order to test the initial shock hypothesis, or hypotheses 3, the below model is used:

$$6)\quad Y_t = \beta + \delta\, Y_{t-1} + \gamma GDP_t + \alpha_1 P_{1,t} + \alpha_2 P_{2,t} + \alpha_3 P_{3,t} + \gamma D \quad + \varepsilon$$

Which is the same as model 5 except rather than a vector of dummy variables, a single dummy variable is used to indicate the presence or absence of the carbon tax, and the carbon tax (P_3) is separate from the excise tax (P_2).

It is also possible to expand the model to include time series from other Canadian provinces. The following model is used:

$$7)\quad Y_t = \beta + \delta\, Y_{t-1,v} + \gamma GDP_{t,v} + \alpha_1 P_{1,t,v} + \alpha_2 P_{2,t,v} + \alpha_3 P_{3,t,v} + \gamma D \quad + \vartheta Prov_v \quad + \varepsilon_{t,v}$$

Which is the same as model 6 except that a vector of provincial dummy variables is added, and each other variable now includes a province dimension.

5 - Unit Root

In order to verify the specification of the model, unit root tests were done on all of the variables. If a unit root problem was suspected, then corrective action was taken. That is to say, that a first degree difference was calculated, and was instead used in the models. Unit root can cause an imbalance in the model. Imbalance can occur if no unit root is present in the explained variable, but is present in one - but not all - of the explanatory variables. If the unit root is not corrected for, the imbalance in the model can cause regression analysis to produce spurious results.

In order to test for unit root, each variable was regressed against the lag of itself, and then a standard Dickey-Fuller test[34] without trend was performed. The results (Table 5.1) showed that

[34] http://support.sas.com/documentation/cdl/en/etsug/60372/HTML/default/viewer.htm#etsug_macros_sect007.htm

a unit root was present in GDP. As a result, the first degree difference was calculated and used as an explanatory variable in the models described in Section 3.

Table 5.1: Unit Root Test[35]

Variable and number of lags	Beta value	T-statistic	P-value
Oil Sales tax Price lag12	0.76	-24.41	~0.00
Total price lag12	0.81	-19.45	~0.00
SALES PER CAP lag12	0.86	-13.67	~0.00
GDP lag12	0.88	-11.79	~0.00
seasonal sales lag12	0.53	-47.50	~0.00
Oil Sales tax Price lag1	0.96	-4.22	~0.00
Total price lag1	0.97	-3.48	~0.00
SALES PER CAP lag1	0.67	-32.51	~0.00
GDP lag1	0.99	-0.88	0.33
seasonal sales lag1	0.63	-37.24	~0.00

Testing and correcting for unit root was not done in the paper by Rivers and Schaufele(2012). Without correcting for unit root, it is possible that regression analysis will indicate correlation when in reality there is none. Even if correcting for unit root does not change the overall results, it is still important to do in order to get a more accurate coefficient estimate. As a result of the unit root test, change in monthly GDP was used instead of GDP. That being said, as will be shown in the results section, the coefficient for GDP is not statistically significant, which should be kept in mind when interpreting results.

6 – Results

In the following section I will present the results of the models and explain how they relate to each of the hypotheses in this paper. First is the hypothesis that consumers behave differently in reaction to a tax increase than an oil price fluctuation. While this is implicitly examined in each of the models except for model 1, it is most apparent in model 2. Second is the hypothesis that an environmental tax causes a different reaction than any other type of tax. This was tested in

[35]A p-value less than 0.05 indicates a that unit root is not detected in the variable.

model 3. Third is the hypothesis that the environmental effect takes the form of a one-time shock to demand, regardless of future environmental tax price fluctuations. This was tested in models 4-7.

Table 6.1 - Model Results[36]

Model	R squared	Value	Intercept	Lag consumption	Change in GDP	Total Price	Change in excise tax exclusive price	Excise and carbon tax	Excise tax	Carbon tax	Introduction effect	Tax dummy '08	Tax dummy '09	Tax dummy '10	Tax dummy '11
1	0.50	Coefficient	71.33	0.265	0.135	-0.093	.	.	.	.	.	.	.	.	.
		Standard Error	7.19	0.074	0.049	0.015	.	.	.	.	.	.	.	.	.
2	0.56	Coefficient	98.12	0.127	0.217	.	-0.064	-0.677	.	.	.	.	.	.	.
		Standard Error	9.09	0.076	0.050	.	0.015	0.132	.	.	.	.	.	.	.
3	0.58	Coefficient	92.55	0.056	0.152	.	-0.073	.	-0.215	-1.214	.	.	.	.	.
		Standard Error	9.01	0.078	0.053	.	0.015	.	0.194	0.212	.	.	.	.	.
4	0.59	Coefficient	92.20	0.048	0.104	.	-0.075	.	-0.163	0.461	.	-4.92	0.06	-1.80	-0.01
		Standard Error	9.50	0.082	0.072	.	0.015	.	0.199	2.676	.	5.69	2.96	2.18	3.92
5	0.59	Coefficient	92.61	0.045	0.103	.	-0.075	.	-0.168	.	.	-3.96	0.51	-1.47	0.46
		Standard Error	9.18	0.080	0.072	.	0.015	.	0.196	.	.	1.24	1.34	1.10	2.83
6	0.59	Coefficient	93.03	0.045	0.112	.	-0.075	.	-0.185	-0.460	-2.65	.	.	.	.
		Standard Error	9.01	0.078	0.064	.	0.015	.	0.195	0.706	2.37	.	.	.	.
7	0.61	Coefficient	88.90	0.056	-0.008	.	-0.067	.	-0.067	0.223	-5.48	.	.	.	.
		Standard Error	2.76	0.024	0.046	.	0.018	.	0.018	2.103	6.66	.	.	.	.
Preferred	0.58	Coefficient	94.77	.	0.083	-0.083	.	.	.	.	-4.15	.	.	.	.
		Standard Error	1.01	.	0.046	0.012	.	.	.	.	0.60	.	.	.	.

The results of the regression analysis allow us to draw several conclusions to the hypotheses for this paper.

The results of model 2 show that we should reject the null hypothesis of model 1. That is to say that we reject the null hypothesis that tax increases cause a similar consumer demand change than a price increase caused by oil price fluctuations. In other words, not all price changes are equal. In model 2, the non-excise tax price coefficient is -0.064 while the excise/carbon tax coefficient is -0.68. Their 95% confidence intervals do not overlap.

The results of model 3 show that we can reject the null hypothesis for hypothesis 2 that a carbon tax-induced price fluctuation is the same as an excise tax price fluctuation. In model 3, the

[36]Provincial dummy coefficients are not reported in the results table, though they are present in model 7.

carbon tax coefficient is -1.25, while the excise tax coefficient is -0.22. The 95% confidence intervals also do not overlap.

Using model 6, the hypothesis that the difference in consumer reaction to an excise tax and the carbon tax was a result of a demand shock from the introduction of the carbon tax - hypothesis 3 - was tested. The results of model 6, indicate that once this initial demand shock is accounted for, the null hypothesis that the introduction effect does not explain all of the difference in consumer reaction between the carbon tax and other excise tax increases cannot be rejected. In other words, once this shock has been accounted for, there is no statistical difference on gasoline demand as a result of a change in excise tax, or carbon tax. Model 5 supports this hypothesis, showing that the demand shock occurs mainly at the introduction of the carbon tax, and not at subsequent increases[37]. Furthermore, once the introduction effect is accounted for, there is no statistical difference in consumer response for a change in excise tax, carbon tax, or any other price fluctuation.

Model 7 also helps illustrate that once the introduction effect is accounted for, there is no difference between the different types of price increases. In fact, once other provinces are added into the regression, the coefficients for excise taxes and non-excise tax price changes are statistically identical.

An additional test was also performed to see if the “carbon tax effect” was actually the result of a change in consumer demand after the 2007-2008 financial crisis. If this was the case, then one would expect to see a similar change in consumer demand elsewhere in Canada. To test for

[37]Model 4 and 5 are slight variations of each other, but model 4 is not very useful for interpretation of the hypotheses. This is likely caused by the high degree of multicollinearity between the coefficient for the carbon tax and the yearly dummy variables. It is included for the sake of full disclosure.

this, a dummy variable was added to the other provinces and set to zero for the time period before the introduction of the BC carbon tax. Following the introduction of the carbon tax, the value of the dummy variable was set to one. A regression was then run with the two carbon dummy - a 'true' carbon dummy for BC set to one after July 2008, and a 'false' carbon dummy set to one for the same time period in the other provinces - effects to see if a similar shift in consumer demand was observed in the other Canadian provinces. A coefficient similar in sign and magnitude to the 'carbon tax (introduction) effect' for the 'false dummy effect' would indicate that the observed change in consumer demand following the introduction of the BC carbon tax had little to do with the tax itself.

Table 6.2 - False Dummy Test

Parameter Estimates					
Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	89.42778	2.77903	32.18	<.0001
Lag(t-1) Consumption	1	0.05540	0.02411	2.30	0.0217
Change in Real GDP from Previous Month	1	0.01157	0.04665	0.25	0.8041
Sales tax inclusive real price	1	-0.07451	0.01852	-4.02	<.0001
Real excise and carbon tax	1	-0.07315	0.01857	-3.94	<.0001
carbon tax effect	1	-4.33948	1.80555	-2.40	0.0164
False Dummy Effect	1	1.05505	0.70894	1.49	0.1369
Alberta dummy	1	31.54269	1.37294	22.97	<.0001
Saskatchewan dummy	1	25.96056	1.28532	20.20	<.0001
Manitoba dummy	1	10.26491	1.13172	9.07	<.0001
Ontario dummy	1	13.28047	1.15112	11.54	<.0001
Quebec dummy	1	0.31722	1.77655	0.18	0.8583
New Brunswick dummy	1	25.08026	1.27229	19.71	<.0001
Nova Scotia dummy	1	16.68569	1.19305	13.99	<.0001
Prince Edward Island dummy	1	24.41699	1.27187	19.20	<.0001

However, this is not what is observed. Not only are the two dummy variables statistically different from one another using a 95% confidence interval, but they also differ in sign. We therefore cannot reject the hypothesis that the change in BC gasoline consumption following the introduction of the carbon tax was a result of the tax, and not a result of a change in nationwide consumption patterns.

As a result of these regressions, the preferred model to measure the impact of the BC carbon tax is as follows:

$$8)\ Y_t = \beta + \gamma GDP_t + \alpha_1 P_t + D_t + \varepsilon_t$$

which has consumption per capita as the explained variable, and income, tax inclusive price, and a dummy for the carbon tax as explanatory variables. The lag of consumption per capita was removed as a result of the coefficient not being statistically significant for models 2-6. Price was not decomposed into separate tax elements as a result of model 6, as it is shown that with the inclusion of the introduction effect, there is no difference on consumer demand response between the different types of price increases.

7 – Implications

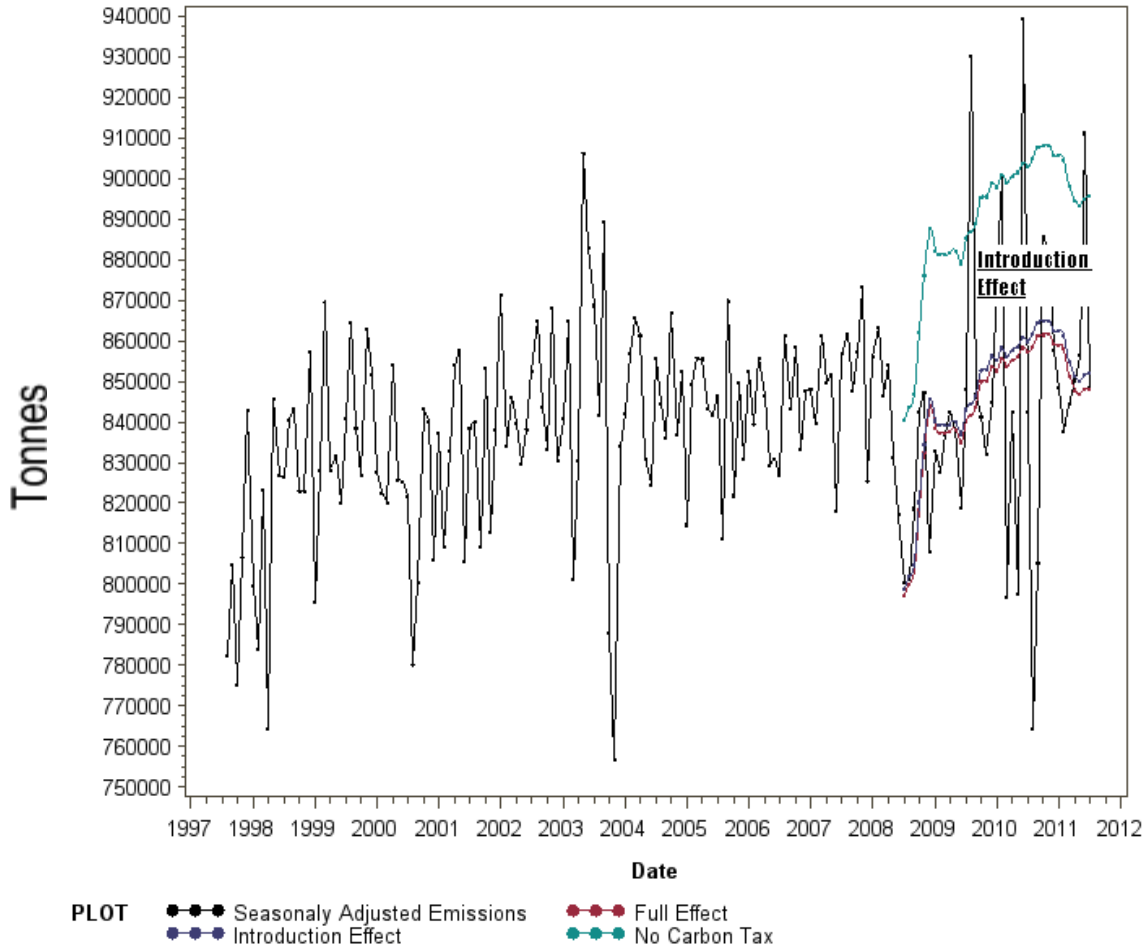
Similar to the work by Rivers and Schaufele (2012), it is possible to estimate the impact of the carbon tax on gasoline sales, and therefore on CO_2 emissions. This effect is broken down into two segments - the introduction effect, and the price effect.

In the preferred model, during the phase-in period between July 2008 and July 2011, the carbon tax resulted in a 4.3-4.6L reduction per capita per month, for a total reduction of 732 million L of gasoline sales. If the effect remains constant over time, it will also result in a reduction of approximately 4.6 L per capita per month beyond June 2012. This would amount to a per annum reduction of approximately 232 Million L of gasoline sales, which is equal to approximately 6% of gasoline sales in 2012. During the 2008-2011 period, 94% of this reduction can be attributed to the introduction effect. After the tax has been fully phased in, the introduction effect accounts for 90% of the total reduction.

Similar conclusions can be drawn for carbon dioxide emissions. In the preferred model, the decrease in gasoline sales caused by the carbon tax resulted in a 9.7-10.2 kg[38] reduction per capita per month, for a total reduction of 1,639,000 Tonnes of CO_2 emissions during the phase-in period between July 2008 and July 2011. Beyond June 2012, provided the effect remains constant over time, it will also result in a per capita monthly reduction of 10.4 kg. This would amount to a per annum reduction of approximately 569,000 T of carbon dioxide emissions. 94% of this reduction can be attributed to the introduction effect during the 2008-2011 period, while 90% of this reduction can be attributed to it after full implementation of the carbon tax.

[38]Gasoline emission factors taken from http://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=AC2B7641-1

Figure 7.1: $C0_2$ Emissions Reductions



Rivers and Schaufele (2012) attribute roughly 80% of the impact of the BC carbon tax on the saliency of the tax. This is done by comparing the impact of the carbon tax to the impact of any other price increase. While the results of the preferred model in this paper differ in magnitude, the extra saliency of the carbon tax is a likely explanation for these results. Furthermore, as shown in model 5, the extra saliency of the carbon tax can only be attributed to the first time it is introduced, and not to subsequent increases in the level of the tax.

8 – Conclusion

The models obtain statistically significant results, and the results are fairly robust. In all of the models, tax increases were shown to have an impact on gasoline sales. Robustness checks were performed on the two largest concerns: unit root and the implications of the financial crisis. The preferred model shows that the carbon tax had a significant impact on BC gasoline demand, much of which is accounted for due to the introduction of the tax, and the rest due to the incremental increase in taxation level.

The results of this paper have implications not only for BC, but also for other jurisdictions looking to implement a revenue neutral carbon tax on gasoline purchases. For the policy makers in BC, this paper helps to explain the cause of some of the discrepancy between predicted and actual revenues. It also helps in predicting future consumer response should BC choose to increase the carbon tax beyond 2012 levels. For other jurisdictions, this paper provides evidence that the introduction of a carbon tax could result in a negative shock to consumer gasoline demand. Once this initial shock is accounted for, a carbon tax behaves similarly to any other tax -or price - increase.

The results contribute to a growing body of literature that suggest consumers do not react uniformly to all price changes. Saliency, permanence, and perception can all be used to partially explain this discrepancy in consumer reaction. The analysis in this paper also shows that in the gasoline market, fuel price is more elastic when the price change is caused by a carbon tax than when it is not, as shown in models 3-7. Furthermore, as shown in model 6, nearly all of the difference can be attributed to the introduction of the environmental tax, and not to subsequent increases in tax level.

Further analysis in the area of environmental taxation could be done to verify the robustness of the results of this study. One avenue of further study could be to look at the impacts on consumer demand in markets other than fuel sales. For example, environmental taxes have been imposed on consumer electronic goods, beverages in the form of bottle deposits, plastic bag levies, and car tires in the form of recycling fees. Another avenue of study could be to look at price elasticity of diesel fuel sales. However, both of these avenues might be difficult to pursue at this time due to a lack of data availability.

In conclusion, this paper contributes to the field of environmental economics, and specifically environmental taxation. As jurisdictions continue to implement environmental taxes and pricing such as the carbon tax, it is increasingly important that price elasticities and consumer responses are modelled using the best available predictions. The importance of this work is compounded due to the reliance governments have on tax revenues generated by the sales of goods such as fuel.

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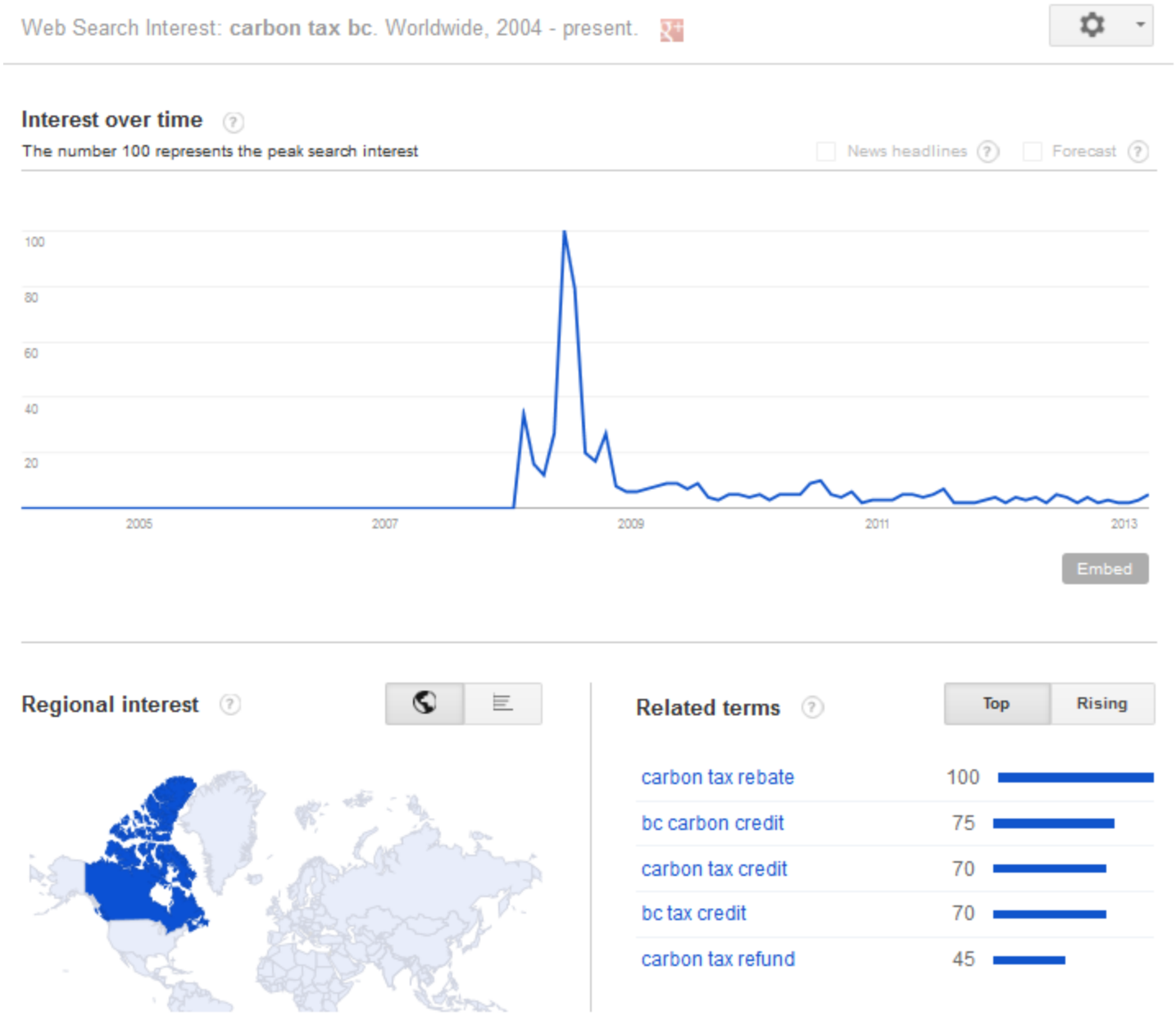
Appendix:

Section A: Public interest in the BC carbon tax over time



Link:http//www.google.com/trends/embed.js?hl=en-US&q=carbon+tax+bc&content=1&cid=TIME SERIES_GRAPH_0&export=5&w=500&h=330

Section B: tax levels

The following sources for gasoline taxes were used:

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