GASOLINE TAX TO CURB CARBON EMISSIONS?

By

Kaitlin Chaput

An essay submitted to the Department of Economics

in partial fulfillment of the requirements for

the degree of Master of Arts

Queen's University

Kingston, Ontario, Canada

February 2012

ABSTRACT

Carbon Emissions are a serious and increasing problem across the globe. In response to this, policy makers around the world are developing methods to mitigate the damage these harmful toxins cause. In 2009, the Ontario government enacted the Green Energy and Green Economy Act to help attract investments and jobs in renewable energy, promote energy conservation, and reduce greenhouse gas emissions (McCarter, 2011). Another large contributor to greenhouse gas emissions in Ontario is the transportation sector. It is for this reason that I develop an empirical model using monthly data for both Canada on a national level as well as a panel of nine provinces for the years 1987-2010 to investigate the correlation of gasoline prices and demand for gasoline. Using the elasticities from the model, and the percentage of carbon emissions emitted from the transportation sector, I calculate the effect a 10-cent gasoline tax would have on carbon emissions in Canada.

ACKNOWLEDGEMENTS

I would like to express my sincere thanks and appreciation to Charles Beach. Without his knowledge, guidance and insights this essay would not have been possible. I would also like to thank Statistics Canada and the Ministry of Natural Resources for providing access to the necessary datasets and many thanks to the Department of Economics, Queen's University, Kingston.

Table of Contents

LIST OF TABLES AND FIGURES

TABLES:

GRAPHS

1 INTRODUCTION

Climate change has recently been at the forefront of global concerns, and Canada is no exception. While Canada contributes only about 1.5% of total global greenhouse gas (GHG) emissions, "it is one of the highest per capita emitters, largely as a result of the country's size, climate (i.e., energy demands), and resource-based economy" (Government of Canada 2008, p.33). In 1990, Canadians released 21.4 tons of GHGs per capita, and by 2008, this had increased to 22.0 tons of GHGs per capita (Government of Canada 2008). The main causes of this problem are greenhouse gases, which absorb and accumulate radiation, causing the earth to heat up as well. There are different types of gases which can be classified as GHGs, and these gases come from a variety of sources. Table 1 details Canada's emissions for 2008.

Table 1: Greenhouse Gas Emissions by Type and Sector, Canada 2008

Source	$C0_2$	CH_4	N_2O	HFC	PFC	SF_6	Totals
Total	574000	99000	52000	5500	2200	2200	734900
Energy	535000	53000	10000				598000
• **Transportation**	190000	600	8000				198600
Industrial Processes	39000		3640	5500	2200	2200	52540
Solvent & Other Product Use			330				330
Waste	200	21000	700				21900
Land Use	-19000	4100	2500				-12400

*all emissions are reported in their kiloton CO2 equivalent
Source: **Government of Canada**. 2008. Table S-1: "Canada's GHG Emissions by Gas and Sector," *National Inventory Report 1990-2008*, 21.

On an individual GHG basis, Carbon Dioxide (CO_2) contributed 78% of the total emissions, with 25% of these coming from the transportation sector. Methane gas (CH_4) accounted for 13% and Nitrous Oxide (N_2O) accounted for 7% of the emissions, while Per fluorocarbons (PFCs), Sulfur Hexafluoride (SF_6) and Hydro Fluorocarbons (HFCs) constituted the remainder (less than 2%).

Table 2: CO_2 Emissions From the Canadian Transportation Sector (1990-2008)

Transportation Sector	1990	2005	2006	2007	2008
Total	145000	192000	191000	199000	198000

Source: **Government of Canada**. 2008. Table S-3: "Canada's GHG Emissions by Sector," *National Inventory Report 1990-2008*, 25**.** All emissions are reported in their kiloton CO2 equivalent

As noted above, one of the main contributors to climate change is CO_2 released into the atmosphere from energy sources as well as from steel and iron manufacturing processes, chemical processes, and wastewater handling. The transportation sector makes up 33% of the total CO_2 emissions in Canada, which equates to 26% of the total GHG emissions (Government of Canada 2008). These high emission levels have led to the adoption and implementation of various policy initiatives, an example of which includes a promise made by the Ontario Liberals to close coal plants by 2014 (Bugge 2006).

In addition, in Canada emissions from the transportation sector increased 38% from 1990 to 2008 (Government of Canada 2008). This is reflected in both the 45% increase in vehicle kilometers travelled and the 56% increase in passenger kilometers travelled (Government of Canada 2008). Canadians travel predominantly via personal passenger vehicles, which represent approximately

85% of all ground-based passenger transport in 2008 (Government of Canada 2010). Given these findings, it is apparent that policies aimed at reducing the overall demand for gasoline are likely to have a significant impact in addressing the environmental consequences of emissions of carbon dioxide (Manzan and Zerom 2008). The McGuinty government appears to be concerned about the amount of emissions produced by the transportation sector. In response to these findings, the McGuinty government has provided Magna International with $50 million in funding to develop new electric vehicle technologies (Wente 2011). Dalton McGuinty has stated he has hopes that by 2020, 5% of cars on Ontario roads will be electric (Wente 2011). He has also given money to support the development of charging stations and battery technology (Wente 2011). The realization of the effect of the growing transportation sector emissions provides the motivation and momentum to deeply examine the transportation sector. Although I am hopeful that the electric vehicle will eventually be part of Canada's emissions abatement solution, I will be examining another aspect of Canada's emissions abatement strategy within the transportation sector, specifically through the demand for gasoline for motor vehicle transportation.

Since the transportation sector accounts for about 25% of Canada's total GHG emissions and is the largest source of GHG emissions in Canada, several policymakers have proposed the adoption of a carbon tax to mitigate this contributor (Government of Canada 2011). Since the carbon tax suggested would be levied on gasoline, this implies that policy discussions surrounding greenhouse gas emissions in Canada should focus on the subsequent fluctuations in gasoline consumption following these proposed tax changes (Davis and Kilian 2010). This paper will closely follow the method previously executed by Davis and Killian in their 2010 paper "Estimating the Effect of a Gasoline Tax on Carbon Emissions" in an attempt to fill the current void in Canadian literature, and offer some estimates on the effect a tax on gasoline may have in Canada. This paper will attempt to estimate the relationship between a gasoline tax and gasoline consumption at both a national and provincial level, and then continue on to estimate the effect of this tax on carbon emissions from gasoline. The paper will be structured as follows. First, a brief introduction to the topic will be presented, and some key theories on how to deal with this problem will be outlined. Further discussions will detail Canada's position on this matter. A literature review will then summarize some of the currently existing literature pertaining to methodology and estimation techniques. Finally, I will then use Canadian data to combine econometric methods and theories to analyze and compute the estimated effects of a gasoline tax for Canada.

2 POLICY ALTERNATIVES

With regard to emission abatement there are many alternative policies and protocols one may wish to take, and each policy has both costs and benefits associated with it. Historically, government policy has tended toward two areas: intervention through price modifications, such as though taxes; and intervention through command and control measures, such as direct regulation with cap and trade.

Cap and trade (Riley 2006) is a market-based approach used to control pollution by providing economic incentives for achieving reductions in the emissions of pollutants. The government would essentially set a limit on the amount of pollutants that can be emitted by firms, and this limit is sold to firms in the form of permits. Firms that need to increase their emissions permits must buy permits from those who require fewer. In effect, the buyer is paying a charge for polluting, while the seller is being rewarded for having reduced emissions. Through this model, firms will have different costs of production. In the end, firms who can reduce emissions cheaply will do so, resulting in a low marginal cost of emissions abatement for this particular firm, and ultimately costing the least to society. Overall emissions trading is likely to be most effective when the following criteria are met: the pollutant is easily measured; the government sets a clearly defined and stable emissions target; there are a large number of participating firms; there are a large number of firms with wide variations in costs of reducing pollution so that trading of surplus permits can take place; the transactions costs of trading permits are low; and there is strict enforcement of this intervention (Riley 2006). Cap and trade can, however, be very complex to implement and manage. Although the public tends to believe that the costs of carbon taxes are borne by consumers and the costs of cap and trade are borne by polluters, they fail to understand that producers will embed the extra costs into the price of their products, resulting in raised costs for the consumer as well (Courchene 2008).

An alternative to cap and trade is an environmental tax (Riley 2006). An environmental tax is levied on goods or services which are deemed to be harmful to the environment, or may also be levied on a component used to produce a final product. A carbon tax would be a tax on the carbon emissions at each stage of production. The carbon taxes accumulate through this process and at each stage the taxes of the inputs are rebated so that only the carbon added is being taxed. Since the tax accumulated at the point of export is rebated, the carbon tax would be export-neutral, and would in large part be paid by the consumer (Courchene 2008). Carbon taxes would increase the private cost of producing goods and services so that people pay extra for creating carbon emissions. In this way, the government would be providing a continuous incentive for the producer or consumer to take full accountability for their emissions. This is based upon the well-known idea that when you raise the price of a product, the level of demand diminishes. From this standpoint, if there is less demand, then there are reduced output levels, subsequently reducing the emissions produced from this output.

Taxes can encourage innovation and development of new technologies, which help promote reduced emissions. The revenue from these taxes can help fund environmental projects. However, as is the case with nearly any policy, there are negative aspects associated with environmental taxes as well. The government may have a hard time accurately valuing the benefits and costs to firms, and may experience difficulty ascribing a monetary value at which the tax should be set. Since taxes raise overall prices, they have an adverse effect on consumers. This is especially evident when demand for a particular product is inelastic, and thus the producer may pass this tax on to the consumer. Taxes do not necessarily allow for a successful reduction of greenhouse gas emissions since it is hard to predict exactly how consumers and producers will respond to higher prices. Whichever policy is chosen, these policies all share a common goal: to achieve a more efficient use of resources, promote substitution between resources, and provide incentives for a reduction of pollution emissions (Riley 2006).

3 EXISTING POLICIES IN CANADA

The atmosphere is a public good, which not only makes it a Canadian problem, but a global problem requiring international cooperation. Public goods are those "which all enjoy in common in the sense that each individual's consumption of such a good leads to no subtraction of any other individual's consumption of that good" (Samuelson 1954, p.387). This relates specifically to the economics of emissions, as each country enjoys the atmosphere at the same time, and no individual country affects any other country's consumption, which may result in several problems arising when trying to regulate emissions. For instance, the Kyoto Conference in 1997 ended with developed countries accepting a protocol designed to reduce emissions of six greenhouse gases by an average of 5.2% from their 1990 levels between the years 2008 and 2012 (Masood 1997). As of 2007, 175 countries were a part of Kyoto, and of these only 37 signatories were required to reduce greenhouse gas emissions (Courchene 2008). Countries that did not sign are free-riding, as they can reap the benefits of exporting their goods and services to countries that are trying to reduce emissions. Since this effectively altered their competitive risk, it acted as a disincentive for many countries to join the fight against global warming.

Another point to note here is that Kyoto recognizes producers of energy as those who emit pollutants. That being said, if a country imports energy, they do not have to account for these emissions environmentally (Courchene 2008). As part of the Kyoto agreement, Canada agreed to reduce greenhouse gas emissions by 6% from its 1990 levels (Courchene 2008). While other countries have successfully closed plants or converted to natural gas for electricity, Canada has actually increased their emissions above their initial levels (Courchene 2008). In 2006, Canada committed to a 20% reduction in 2006 emissions levels by 2020 (Courchene 2008). In September 2008, four provinces agreed to the Western

Climate Initiative: British Columbia, Manitoba, Ontario, and Quebec (Western Climate Initiative 2010). When fully implemented, the initiative will address the reduction of 90% of the greenhouse gas emissions in each region, and will reduce GHG emissions to 15% below 2005 levels by 2020. The Western Climate Initiative not only includes the carbon emissions limits previously discussed, but it also looks into complementary policies such as energy efficiency measures to reduce fuel consumption. Also on the list are clean car standards that reduce carbon emissions, renewable energy that runs on waste material to help meet power needs and reduce greenhouse gas emissions, as well as low-carbon fuel standards that encourage the use of alternative transportation fuels (Western Climate Initiative 2010).

So far in Canada there have been a couple provinces taking action on this matter. On October 1, 2007, Quebec began collecting a carbon tax on hydrocarbons, which include petroleum, natural gas and coal. Although the tax was small, it forced energy producers, distributers and refiners to pay about $200 million a year, and made Quebec the first North American state or province to charge a carbon tax (Grossman 2011). Oil companies were required to pay 0.8 cents per liter for gasoline that was distributed in Quebec, and 0.928 cents per liter of diesel fuel (Grossman 2011). British Columbia began taxing carbon in 2008, which started at a cost of $10 per metric ton of carbon dioxide and was to rise by $5 per ton annually until it reached a cap at $30 per ton in 2012 (Grossman 2011).

Initially this was equivalent to 2.4 cents per liter of gasoline, and by 2012 it will be equivalent to 7.24 cents per liter amounting to approximately 8 times the Quebec tax (Grossman 2011). Through these examples, it is recognized that a carbon tax must be implemented on energy products, such as gasoline, in the form of a consumption tax (Fullerton and West 2002)

4 LITERATURE REVIEW

Historically, a large body of research has been developed assessing the effects of greenhouse gases, and proposing methods of dealing with this ever-increasing problem. However, the amount of existing literature diminishes drastically when we explore work that focuses solely on reducing the carbon emitted from motor gasoline. While we are, as a society, interested in reducing the overall amount of emissions produced by vehicles, researchers must first examine consumers' sensitivity to gasoline prices in response to demand for motor gasoline. From this standpoint, researchers can then use this information as a gauge to adequately estimate how much gasoline will be consumed if prices were to rise, and what the subsequent level of emissions might look like once these market changes occur. The second portion of this analysis, which involves using the demand for gasoline obtained in part one and estimating the effect on carbon emissions, remains constant across different bodies of literature. It is for this reason that I will focus this part of the literature review on dealing with modeling the sensitivity of gasoline demand in response to price changes.

Many of the studies estimating gasoline demand seem to arrive at conflicting results; however, as Dahl and Sterner note in their 1991 paper “This is quite natural since the studies surveyed are based on different models, types of data, countries, time periods, different functional forms and econometric techniques.” (Dahl and Sterner, 1991, p. 203). Although a literature assessing the effect of taxes on emissions levels in Canada is almost non-existent, there are relevant papers from the United States that will provide insights to the same issue. Furthermore, there is a large body of literature available that focuses on the effects of taxation or a price change on consumption of gasoline, which is on the primary focus of this analysis. A common theme arising in the literature is the problem of the endogeneity of gasoline prices and how to deal with this issue. Not only do gas prices affect the Canadian economy, but also there is reverse causality from global macroeconomic aggregates to the price of gasoline (Kilian 2008). Kilian notes “since gasoline is by far the most important form of energy consumed… and the one with the most volatile price, little would be lost by focusing on gasoline prices [and ignoring other energy sources to study] the response of consumer expenditures” (Kilian, 2008, pp. 5/6).

With respect to the existing research in this area, there are a few approaches which one could take when researching this topic. The first approach involves inferring the demand from automobile choice and utilization models, which is demonstrated in Carol A. Dahl's (1979) "Consumer Adjustment to Gas Tax." In 1979, increases in oil imports and oil prices prompted proposals of a per gallon tax on gasoline. Dahl, used US data from 1937 to 1972, excluding 1942 to 1946 and attempted to study the response of consumers to such a tax by breaking the elasticity of demand for gasoline into the following component parts: the price elasticity of demand for automobile miles travelled; minus the price elasticity of miles per gallon of automobiles. She comments on the obvious endogeneity of gasoline prices and chooses to deal with this problem by estimating all three elasticities in a simultaneous system. She concludes that the elasticity of miles per gallon is a larger share of the overall price elasticity of gasoline in the short run than previous estimates suggest.

When modeling the demand for gasoline, she models it as a function of the price of gasoline and the number of in-stock automobiles available to consumers. The stock of automobiles is modeled as a function of the price of automobiles, price of gasoline, consumer income, and lagged stock of automobiles. Ordinary least squares analysis was used, but to avoid the simultaneity bias associated with the price of gasoline she modeled a supply equation as the function of relative wholesale price of kerosene, distillate fuel oil, and residual fuel oil. The retail price of gasoline, which consists of the wholesale price and the gasoline tax, is used in the demand equation. To break the elasticity of demand into two parts, two equations are added to the model. First is a demand for automobile miles travelled depending on gasoline cost per mile traveled, consumer income, and existing stock of automobiles. Secondly, an equation explaining average miles per gallon of the stock of automobiles is determined by size and optional equipment on a vehicle, as well as the maintenance, and driving habits. She includes a pollution dummy for the miles per gallon equation encompassing the year 1968 and beyond when pollution legislation began. Since both equations contain right-hand side endogenous variables, two-stage least squares analysis was used on both. Serial correlation was corrected by using the Cochrane-Orcutt procedure and her final estimate of the elasticity of gasoline consumption with respect to price was -0.292 (Dahl 1979). This means that when the price of gasoline goes up by one percent, the demand for gasoline goes down by .292 percent.

There is a second approach to estimating the demand for gasoline that examines the impact of emissions policies on new car production, consumerism in the automobile sector, and gasoline consumption. We know that recent spikes in gasoline prices highlighted the sensitivity of consumer demand in response to prices, with major automobile companies effectively abandoning trucks and SUVs, and several major companies rethinking sourcing offshore (Bento et al. 2009). In 2009, Antonio M. Bento et al. attempted to model this behavior in their paper "Distributional and Efficiency Impacts of Increased US Gasoline Taxes."

Their paper employed an econometrically based model, using US data from 1983 to 2002 to estimate the effects of a gasoline tax by studying the consumer demand for new, used, and scrapped vehicles. They found that each cent-per-gallon increase in the price of gasoline reduced gasoline consumption by about 0.2%. Within their model, the economic agents in the model are households, producers of new cars, used car suppliers, and scrap firms. The model considers car-ownership and the travelling decisions among approximately twenty thousand households. They adopt a Bayesian framework, which assumes that the analyst has initial beliefs about the unknown parameters that can be summarized by a prior probability distribution. The analyst then combines choice information with the assumed data-generating process to form the likelihood of a certain decision, conditional on alternative values. One further thing worth noting is that this study was carried out with such a large sample that the sample was split into twelve sub-groups based on demographic characteristics, and these groups were then estimated separately, enabling great accountability for observable and unobservable differences among households. Their final mean estimate of the elasticity of gasoline use with respect to gasoline price, across all households and types of cars was -0.35, and they found that the elasticity of demand for gasoline is larger for families with children and owners of trucks and SUVs (Bento et al. 2009).

Lastly, one might examine the impact of gasoline taxes directly by estimating the demand for gasoline as a function of gasoline price and household income. For example, Sarah E. West in her 2004 paper "Distributional Effects of Alternative Vehicle Pollution Control Policies," uses household income level data and data on gasoline consumption to assess the distributional impacts of gasoline taxes and hence the optimal gasoline tax. Although this is the most closely related to the analysis the present study will adopt, we will study the effect at the aggregate level so as to infer effects on carbon emissions at a national level. Davis and Kilian (2010) do just that in their recent work "Estimating the Effect of a Gasoline Tax on Carbon Emissions." They model gasoline consumption at a national level using US monthly data from 1989-2008 to facilitate the identification of the causal effects of a gasoline tax increase. First, by focusing on the construction of price elasticities for gasoline demand, they find an elasticity of -.10. They then model gasoline consumption at the state level using panel data methods, which allows you to include time fixed effects to control for unobserved time-varying consumption factors that may have altered the true elasticity in the national model. They find a price elasticity of -.19, significantly larger than the national level estimate. Recognizing that this does not fully address the issue of the price endogeneity of gasoline, they also attempt to use instrumental variables estimation, using changes in gasoline tax rate changes by state and month as instruments for gasoline prices.

Davis and Kilian's reasoning for this instrument choice is that, even though tax legislation may respond to current prices, the implementation of tax changes typically occurs with a lag, making it reasonable to believe that changes in tax rates are uncorrelated with unobserved changes in demand. With instrumental variable estimation they find a price elasticity for the demand for gasoline of -0.46, which holds true among a variety of alternative variable specifications including ones that control for factors potentially correlated with gasoline tax changes. Lastly they contrast these estimates with estimates obtained from recursively identified vector auto regressions in which the percentage change in gasoline prices is ordered first and the percentage change in gasoline consumption is ordered second (Davis and Kilian 2010). They find that a 10-cent increase in gasoline taxes would lower US emissions by about half of one percent, recognizing that in the long run this reduction would be higher. This is because in the long run people have enough time to adjust to price changes, such as purchasing more efficient vehicles.

Although interest in carbon taxes has quieted down recently as a result of the rapidly deteriorating global economic conditions, that situation is likely to be temporary. Gasoline has become the most heavily taxed and most thoroughly studied of the petroleum products. With increasing prosperity and travel, petroleum dependence and vulnerability to disruption, as well as emissions will also increase (Dahl and Sterner 1991). "Therefore, forecasting gasoline consumption is of interest not only to producers planning to increase capacity, but also to consumer countries concerned about balance of payments and increased energy dependence, and to those concerned by the ecological effects of the transport system" (Dahl and Sterner, 1991, p.203). Despite the policy relevance of the question to be addressed in the present study, empirical evidence on the effectiveness of gasoline taxes on carbon emissions in Canada is virtually non-existent. This study will closely follow the approach taken by Davis and Kilian in 2010, and apply it with Canadian data in an attempt to fill that void and offer some insight into the effects that such a tax on gasoline may have across Canada.

5 DATA

There are two separate data sets to be used in this analysis. The first is a monthly national-level dataset for Canada starting in January 1987 and continuing through to December 2010, yielding 288 observations. The second is monthly provincial-level data for Canada starting in January 1987 and continuing through to December 2010, since this was the largest set of monthly time series data available concerning taxes on gasoline, and this left a total of 2592 observations. Yukon, Northwest Territories, Nunavut and New Brunswick were excluded due to a lack of information pertaining to gasoline consumption. Gasoline price and tax information were collected from Natural Resources Canada's website under "Average Retail Price for Regular Gasoline". I was able to collect petroleum product prices for each year used, and this information was converted to 2009 dollars using the All-Item Canadian Consumer Price Index, from Statistics Canada's Canadian Socioeconomic Database (CANSIM) (Table 326-0020). Gasoline consumption, in thousand liters was collected from CANSIM (Table 134-0004), and the unemployment rate for both males and females over 15 years of age was also collected from CANSIM (Table 282 0001). Population density estimates were also collected from CANSIM (Table 153- 0037), but as these data are collected every 5 years, monthly estimates were made assuming a constant rate of change. The provincial real Gross Domestic Product (GDP) per capita was used as a proxy for real income, and to produce this statistic I used the Gross Domestic Product, adjusted using the CPI detailed above, from the CANSIM database (Table 379-0025) which is monthly provincial GDP, and divided this by provincial population estimates from the same database (Table 051-0001). Table 3 provides measurement units for all variables included in the analysis, while the following tables provide summary statistics by province for each of the variables used.

Table 3: Variables and Measurement Units

Variable	Unit
Population Density	Number per Square Kilometer
Unemployment	Percentage
Real GDP per Capita	Dollars per person
Volume	'000 liters
Real Tax Paid	Cents per liter
Real After Tax Price	Cents per liter

Table 4: Summary Statistics for All Variables in Newfoundland

Variable	#Obs	Mean	Standard Deviation	Minimum	Maximum
Population Density	288	1.4625	0.0484966	1.4	1.5
Unemployment	288	16.77049	2.726269	11	24
Volume	288	46315.78	7497.628	43565	73906
Real GDP per Capita	288	27076.31	6908.626	18380.09	38090.6
Real Tax	288	23.89586	7.846058	10.20193	39.29184
Real After Tax Price	288	61.27229	26.20708	27.34232	139.8556

Table 5: Summary Statistics for All Variables in P.E.I

Variable	#Obs	Mean	Standard Deviation	Minimum	Maximum
Population Density	288	23.34167	0.6154234	22.3	23.9
Unemployment	288	13.34826	3.879392	6	24
Volume	288	15608.66	3124.479	9584	25799
Real GDP per Capita	288	25015.27	3603.173	19379.51	30088.09
Real Tax	288	22.8898	7.047749	10.44776	38.32362
Real After Tax Price	288	61.5609	26.22906	31.58912	140.2654

Table 6: Summary Statistics for All Variables in Nova Scotia

Variable	#Obs	Mean	Standard Deviation	Minimum	Maximum
Population Density	288	17.0625	0.2709835	16.5	17.3
Unemployment	288	10.39271	2.186843	6.4	16.1
Volume	288	90931.88	10296.58	65619	120475
Real GDP per Capita	288	26244.97	3410.66	22299.54	31427.48
Real Tax	288	25.88479	9.122078	10.3863	42.82757
Real After Tax Price	288	62.37742	27.74082	30.82221	145.4908

Table 7: Summary Statistics for All Variables in Quebec

Variable	#Obs	Mean	Standard Deviation	Minimum	Maximum
Population Density	288	5.2375	0.2550876	4.8	5.6
Unemployment	288	9.814931	1.922891	6.2	14.9
Volume	288	603196.5	63068.56	444542	767243
Real GDP per Capita	288	29691.24	3588.641	25122.27	34455.7
Real Tax	288	27.72475	7.379557	14.01229	42.62265
Real After Tax Price	288	63.48891	26.56442	32.3266	147.335

Table 8: Summary Statistics for All Variables in Ontario

Variable	#Obs	Mean	Standard Deviation	Minimum	Maximum
Population Density	288	11.85417	1.144712	10	13.4
Unemployment	288	7.478472	1.790321	4.3	11.7
Volume	288	1085255	144017.2	804529	1615335
Real GDP per Capita	288	36106.76	3788.849	30636.65	41466.24
Real Tax	288	23.04375	5.952189	10.26339	38.20193
Real After Tax Price	288	58.01572	25.76258	27.18806	138.5236

Table 9: Summary Statistics for All Variables in Manitoba

Variable	#Obs	Mean	Standard Deviation	Minimum	Maximum
Population Density	288	2.004167	0.0612016	1.9	2.1
Unemployment	288	6.323958	1.748115	3	11
Volume	288	99566.19	10185.33	10231	123629
Real GDP per Capita	288	29554.52	3556.481	24821.44	35197.87
Real Tax	288	20.42884	4.931355	10.07902	28.58587
Real After Tax Price	288	57.9392	25.97407	26.19236	136.9867

Table 10: Summary Statistics for All Variables in Saskatchewan

Variable	#Obs	Mean	Standard Deviation	Minimum	Maximum
Population Density	288	1.679167	0.0406823	1.6	1.7
Unemployment	288	6.089236	1.423345	3.2	10.1
Volume	288	106849.1	20026.14	60988	169155
Real GDP per Capita	288	32919.79	5141.558	24047.27	40304.88
Real Tax	288	22.81893	6.551271	4.710272	32.37682
Real After Tax Price	288	60.42351	27.58245	18.68306	141.29

Table 11: Summary Statistics for All Variables in Alberta

Variable	#Obs	Mean	Standard Deviation	Minimum	Maximum
Population Density	288	4.345833	0.4812693	3.7	5.1
Unemployment	288	6.339583	2.020529	2.9	11.6
Volume	288	333396.3	52655.26	0	459111
Real GDP per Capita	288	44800.12	5974.916	34515.87	53259.73
Real Tax	288	18.11114	4.759906	5.162423	25.71703
Real After Tax Price	288	54.25638	25.40183	22.55487	130.8392

Table 12: Summary Statistics for All Variables in British Columbia

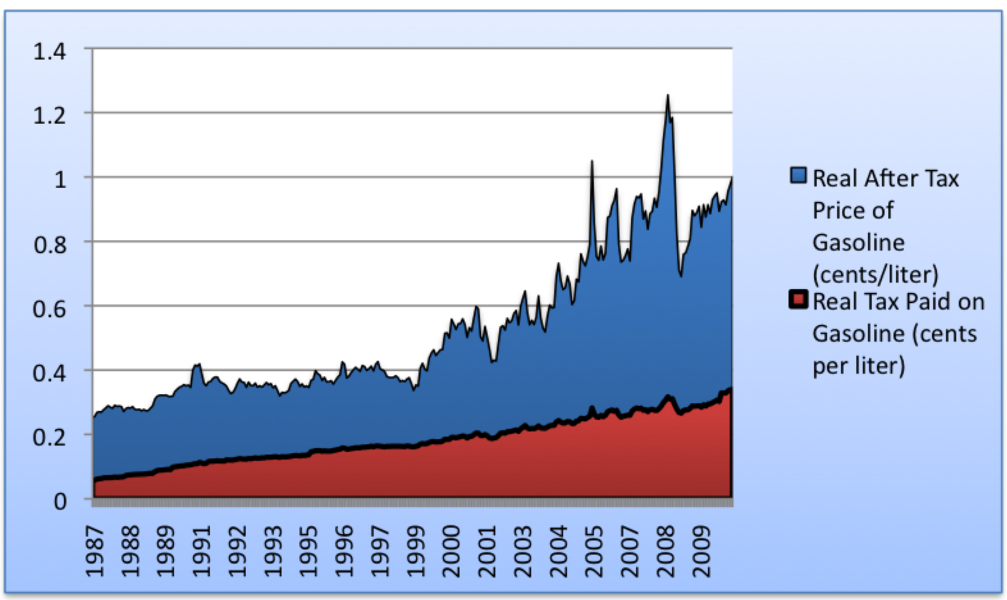
Variable	#Obs	Mean	Standard Deviation	Minimum	Maximum
Population Density	288	3.870833	0.4613078	3.1	4.4
Unemployment	288	8.121181	1.988855	3.8	15
Volume	288	322763.6	45919.47	211877	412413
Real GDP per Capita	288	32704.6	2958.712	29585.22	38143.86
Real Tax	288	25.63248	8.695108	9.648815	45.01633
Real After Tax Price	288	61.96842	29.22988	24.99982	152.1506

Table 13: Summary Statistics for All Variables in Canada

Variable	#Obs	Mean	Standard Deviation	Minimum	Maximum
Population Density	288	3.175	0.2353735	2.8	3.5
Unemployment	288	8.239236	1.630017	5.3	12.5
Volume	288	2572437	541847.3	1175026	3514018
Real GDP per Capita	288	33896.22	4003.472	28751.1	39700.38
Real Tax	288	20.62976	8.205827	6.534233	38.69669
Real After Tax Price	288	59.92322	26.19897	28.82	142.9293

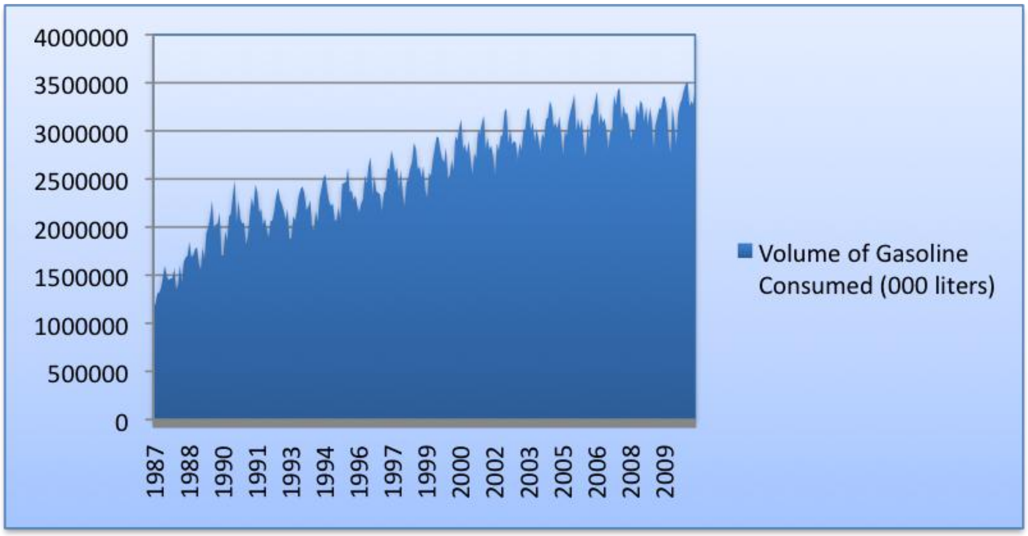
Graphs 1 and 2 describe the national gasoline prices, consumption of gasoline and taxes on gasoline over the period encompassing 1987 to 2010 from National Resources Canada's website.

Graph 1: Real After Tax Price and Real Tax Paid on Motor Gasoline From 1987-2010 (Cents per Liter)



Source: **Government of Canada.** 2011. "Average Retail Prices for Regular Gasoline," *Natural Resources Canada Website.*

Graph 2: Volume of Gasoline Consumed in Canada From 1987-2010 ('000 liters)



Source: **Statistics Canada.** Table 134-0004: "Refined Petroleum Products, Retail Sales of Motor Gasoline," Canadian Socioeconomic Database.

As you can see, national prices, taxes and consumption have been consistently increasing over the years, with prices being considerably more volatile relative to the taxes, which is to be expected. It should be noted that prices from Natural Resource Canada include both federal and provincial taxes. For this study, I construct both a national time series and a panel of provincial-level gasoline taxes and after-tax prices. Although the most common method for taxing gasoline is a 'per unit' tax per liter, a few provinces use ad valorem taxes in addition to per unit taxes; in these cases the ad valorem taxes were excluded from the tax measures. These ad valorem taxes were omitted since tax is used as an instrumental variable, and the gasoline tax in these provinces would be functionally related to price (Davis and Kilian 2010). The main advantage of this data set is it provides monthly data for nine provinces, for the years 1987 to 2010, with a total of 2592 observations for provincial analyses, and 288 for national analyses. This provides plenty of variation, which is explored through regression analyses.

6 MODELS AND METHODOLOGY

6.1 ORDINARY LEAST SQUARES ESTIMATION

Since I am utilizing monthly data, I am able to describe how consumers would respond to changes in price based on gasoline consumption, as opposed to time-related changes in gas consumption. Monthly measures allow the model to capture a lot of the variation in both prices and consumption that may have been smoothed out had yearly data been used instead. Demand theory tells us that demand for anything is based on price and income. In this study the demand for gasoline is assumed linearly dependent on price and income, while taking into account the seasonality of gasoline demand as well as other unobservable time-varying factors. The specifications used in this paper closely mirror those used in Davis and Kilian 2010. The first model estimated was the demand for gasoline consumption at the *national* level, using the following equation (1):

$$\Delta V_t = \beta_0 + \beta_1 \Delta p_t + \beta_2 \Delta y_t + \lambda_t + \varepsilon_t \qquad (1)$$

where V_t represents the logged demand for gasoline in thousand liters in month t, p_t represents the volume-weighted, average, inflation- adjusted, after-tax price of gasoline in logs, y_t is the real gross domestic product (GDP) per capita, λ_t are month-of-year dummy variables, and ε_t is any unobserved time-varying set of factors. Real GDP per capita is included as a proxy for real income, and month-of-year dummies are included because the gasoline market is highly seasonal. I estimated the national aggregate model using log differences, since V_t, p_t and y_t are highly persistent and trending, and as a result of the log specification the estimated β_1 and β_2 coefficients represent the price and income elasticities of demand for gasoline respectively.

I also modeled gasoline consumption at the *provincial* level using a commonly used specification (Davis and Kilian 2010), and my provincial panel of nine provinces shown below in equation (2):

$$\Delta V_{it} = \beta_0 + \beta_1 \Delta p_{it} + \beta_2 \Delta y_{it} + \rho_t + \omega_{it} \qquad (2)$$

where gasoline consumption in logs, V_{it}, for province i and month t, depends linearly on the after-tax price of gasoline p_{it} in logs, the logged real GDP per capita y_{it}, time fixed effects ρ_t, and unobserved province-specific time varying factors ω_{it}. As Davis and Kilian state, the "time-fixed effects control for both seasonal variations (as with the month-of-year dummies) as well as year-to-year variations that remain the same across [provinces]" (Davis and Kilian 2010, p 8).

For the first estimation of both the national and provincial versions of this model I used Ordinary Least Squares estimation, and in both cases the coefficient of primary interest is $\beta_{1.}$ Since both of these models are log-log models, β_1 represents the one-month price elasticity of gasoline. Since we are looking at the policy implications we would tend to be more interested in elasticities over a longer period of time, and I address this issue with later specifications. As Davis and Kilian point out, in order for the national specification to be valid we must assume that price changes are uncorrelated with ε_t.

$$E(\Delta p_t \varepsilon_t) = 0 \qquad \forall_t$$

A correlation will generally cause estimates of the price elasticity to be biased toward zero since some of the predicted change in consumption can be attributed to changes in price; this is known as price endogeneity, and likely does not hold for the national specification because of standard price endogeneity considerations (Davis and Kilian 2010). Increases in gasoline consumption cause prices to increase, leading to a spurious correlation between $\Delta\rho_t$ and ε_t. This is not as much of a concern when dealing with provincial-level data because the time-fixed effects control for unobserved changes in demand over time. It is important to keep in mind that this does not rid us of the problem completely because provincial-level prices may still reflect province-specific changes in gasoline demand (Davis and Kilian 2010).

6.2 INSTRUMENTAL VARIABLE ESTIMATION

To address this potential price endogeneity problem I used instrumental variable estimation to identify movements in gasoline prices driven by tax changes. I account for price change using inflation-adjusted changes in the log of tax per liter for each province i, ($\Delta\ tax_{it}$, i=1…..9), and the results are expressed in 2009 dollars. Similar to Davis and Kilian, but again adding in a real income variable to the specification, the demand for gasoline consumption at the national level, is estimated using the following equation (3):

$$\Delta V_t = \beta_0 + \beta_1 \Delta tax_t + \beta_2 \Delta y_t + \lambda_t + \varepsilon_t \qquad (3)$$

where V_t represents the logged demand for gasoline in thousand liters in month t, tax_t represents the change in tax on gasoline in logs, y_t is the real gross domestic product (GDP) per capita, λ_t are month-of-year dummy variables, and ε_t represents any unobserved time-varying factors. I also remodel gasoline consumption at the provincial level using instrumental variable estimation, and the model used is outlined below in equation (4):

$$\Delta V_{it} = \beta_0 + \beta_1 \Delta tax_{it} + \beta_2 \Delta y_{it} + \rho_t + \omega_{it} \quad (4)$$

where gasoline consumption in logs, V_{it}, for province i and month t, depend linearly on the change in tax on gasoline tax_{it} in logs, the logged real GDP per capita y_{it}, time fixed effects ρ_t, and unobserved province-specific time varying factors ω_{it}. Time-fixed effects control for both seasonal variations as well as year-to-year variations that remain the same across provinces. For the IV estimator to be consistent, changes in taxes must be uncorrelated with the error term. This cannot be readily tested, but Davis and Kilian (2010) make the case that $Cov(tax_{it}\omega_{it})=0$ based on economic arguments.

"At the [provincial] level, gasoline tax legislation is made by democratically elected legislators, and it stands to reason that policy decisions also reflect current economic conditions. In practice however, even though tax legislation may respond to current conditions, the implementation of tax changes typically occurs with a considerable lag. This delay strengthens the case for the validity of tax changes as an instrument" (Davis and Kilian 2010).

After estimating the basic model above, as suggested by Davis and Killian (2010), it is always helpful to check the robustness of the model by re-estimating the model using different variables which may be suspected as playing a role in the demand for gasoline. A typical concern is possible endogeneity of tax changes with respect to omitted variables, so it will be useful to examine why tax changes might be implemented. One reason for this implementation might be to finance investments such as infrastructure investments, which would typically take place during economic booms. This would lead one to believe that a variable such as unemployment rates might be useful in accounting for changes in the macroeconomic conditions. Equation (5) and (6) below represent the national and provincial models respectively, using this specification.

$$\Delta V_t = \beta_0 + \beta_1 \Delta tax_t + \beta_2 \Delta y_t + \beta_3 \Delta unemploy_t + \lambda_t + \varepsilon_t \quad (5)$$

$$\Delta V_{it} = \beta_0 + \beta_1 \Delta tax_{it} + \beta_2 \Delta y_{it} + \beta_3 \Delta unemploy_{it} + \rho_t + \omega_{it} \quad (6)$$

where $unemploy_{it}$ represents the added variable for the change in unemployment rate in province i in month t, and all other factors remain unchanged.

Another possible factor is heterogeneity in population growth across provinces. The national model for this specification is represented by equation (7), while the provincial model for this specification is represented by equation (8).

$$\Delta V_t = \beta_0 + \beta_1 \Delta tax_t + \beta_2 \Delta y_t + \beta_3 \Delta popden_{it} + \lambda_t + \varepsilon_t \quad (7)$$

$$\Delta V_{it} = \beta_0 + \beta_1 \Delta tax_{it} + \beta_2 \Delta y_{it} + \beta_3 \Delta popden_{it} + \rho_t + \omega_{it} \quad (8)$$

where $popden_{it}$ represents the population density for province i in month t and all other variables remain unchanged.

The final model ran as a robustness check includes both the unemployment variable as well as the population density variable, and both the national and provincial models are outlined below in equation (9) and (10), respectively.

$$\Delta V_t = \beta_0 + \beta_1 \Delta tax_t + \beta_2 \Delta y_t + \beta_3 \Delta unemploy_t + \beta_4 \Delta popden_t + \lambda_t + \varepsilon_t \quad (9)$$

$$\Delta V_{it} = \beta_0 + \beta_1 \Delta tax_{it} + \beta_2 \Delta y_{it} + \beta_3 \Delta unemploy_{it} + \beta_4 \Delta popden_{it} + \rho_t + \omega_{it} \quad (10)$$

Although only one specification will be utilized to ultimately estimate the effect on carbon emissions, all results will be reported in the following section.

7 RESULTS

7.1 RESULTS FROM OLS ESTIMATION

Table 14 shows the β_1 parameter estimate and standard error from both the national specification and the provincial level specification, using equations (1) and (2), estimated by ordinary least squares.

Table 14: OLS Estimation of Gasoline Demand Price Elasticity

	National Specification	***Provincial Specification***
Coefficient	-0.0136746	-0.1186978
Standard Error	0.0695608	0.068572
P-value	0.844	0.114
Adj.Rsquared	0.0481	0.0234

Note: Using Stata 10 Regression Package. Standard errors are robust. *indicates significant at 10% level **indicates significant at 5% level ***indicates significant at 1% level.

The national specification has a one-month elasticity of -0.014 and is not statistically significant. The provincial-level panel has a one-month elasticity of -0.119 and is also not statistically significant at conventional levels. In comparison, Davis and Kilian (2010) used similar US national-level data and found a one-month elasticity of 0.10; while using similar state-level data, they found a one-month elasticity of -0.19, which were both significant at the 1% level.

7.2 RESULTS FROM IV ESTIMATION

Table 15 shows the results of the IV estimation for this basic specification using inflation-adjusted changes in the log of tax per liter as an instrumental variable for price changes.

Table 15: IV Estimation of Gasoline Demand (equation 3 and 4)

	National Specification	*Provincial Specification*
Coefficient	-0.1220898	-0.12357808**
Standard Error	0.0965433	0.0580498
P-value	0.206	0.034
Adj.Rsquared	0.0466	0.0234

Note: Using Stata 10 Regression Package. Standard errors are robust *indicates significant at 10% level **indicates significant at 5% level ***indicates significant at 1% level.

With the national-level data, the IV estimate is -0.122 and is not statistically significant, while using provincial-level data gives an IV estimate of -.124 with taxes as an instrumental variable and is statistically significant at the 5% level. The IV estimate is statistically significant, and considerably different from the OLS estimate, so I tried a couple different specifications to check the robustness of the model as suggested by Davis and Kilian (2010). Table 16 represents the first of the models utilized to check the robustness of the model using the change in the unemployment rate from equations (5) and (6).

Table 16: IV Estimation of Gasoline Demand (equations 5 and 6)

	National Specification	*Provincial Specification*
Coefficient	-0.1226443	-0.1345867**
Standard Error	0.0970097	0.0618765
P-value	0.206	0.030
Adj.Rsquared	0.0466	0.0337

Note: Using Stata 10 Regression Package. Standard errors are robust. *indicates significant at 10% level **indicates significant at 5% level ***indicates significant at 1% level.

Table 17 shows the results once population density was added to both the *national* and *provincial* basic models, as outlined in equations (7) and (8) respectively.

Table 17: IV Estimation of Gasoline Demand (equations 7 and 8)

	National Specification	Provincial Specification
Coefficient	-0.1229475	-0.1200355**
Standard Error	0.095963	0.0568862
P-value	0.208	0.035
Adj.Rsquared	0.0582	0.0271

Note: Using Stata 10 Regression Package. Standard errors are robust. *indicates significant at 10% level **indicates significant at 5% level ***indicates significant at 1% level.

Finally, Table 18 includes both unemployment rate and population density data in its specification.

Table 18: IV Estimation of Gasoline Demand (equations 9 and 10)

	National Specification	Provincial Specification
Coefficient	-0.1213349	-0.131764**
Standard Error	0.0963481	0.0604853
P-value	0.208	0.029
Adj.Rsquared	0.0590	0.0348

Note: Using Stata 10 Regression Package. Standard errors are robust. *indicates significant at 10% level **indicates significant at 5% level ***indicates significant at 1% level.

In all cases, the results are similar to the original results found by Davis and Kilian (2010), and therefore the additional controls have little effect on estimates of β_1.

8 CALCULATED EFFECT ON CARBON EMISSIONS

I view the provincial IV estimate with both controls as the most appropriate measure; therefore, -.132 is the estimate I will use for the remaining analysis in the paper. The percent of reduction in gasoline consumption resulting from a tax increase of η cents was evaluated relative to a base after-tax price ρ cents that can be represented by the following formula:

$$\beta(\eta/\rho)*100 \quad (11)$$

where β corresponds to $\hat{\beta}_{iv}$ η=Δtax, where I will be looking at a 10-cent increase in taxes. I evaluate the effect at the volume-weighted mean after-tax price of 86 cents per liter in March 2009. The IV estimate implies a price elasticity of -1.59. That is, a 10-cent increase in taxes would decrease gasoline consumption by 1.57%. By comparison, Davis and Kilian (2010) found that a 10-cent increase in taxes in the United States would decrease consumption by 1.4%.

Although the main data analysis involved in this paper estimated the demand for gasoline, as with Davis and Kilian's paper, the purpose of this paper is to ultimately derive the effect of a change in taxes on carbon emissions. The reasoning of this, which has driven many of the papers examined in the literature review, is the growing issue of carbon emissions and the harmful effects of this air pollutant. There has been much discussion about ways of dealing with excess carbon dioxide and one way would be imposing a tax on gasoline, thereby reducing gasoline purchased and resulting in reduced emissions. A tax on motor gasoline was chosen because the transportation sector accounts for approximately 25% of all carbon dioxide emissions in Canada, and therefore a tax on this could have a large impact. The percentage change in carbon emissions in Canada is calculated by multiplying the gasoline consumption elasticity effect (-1.57) by the fraction of carbon dioxide emissions in Canada (0.25) which are derived from the transportation sector:

$$(-1.57\%)0.25= -.39\%$$

In this formula, -1.57% represented the change in gasoline consumption from a 10-cent gasoline tax increase based on the volume adjusted after-tax mean price in March 2009 of 86 cents per liter. So, a 10-cent tax increase reduces carbon emissions in Canada by 0.39%. Comparatively, Davis and Kilian in their 2010 paper found that the same change in tax would reduce emissions by 0.48% across the United States.

This is relatively small when you compare it with the recent annual increases in carbon emissions; however, you must take into account the restrictions of these estimates. These estimates represent only short-run responses, meaning it takes into account only short-run behavioral changes. For example, drivers can choose to drive slower, walk, or carpool. However, in the long run, additional measures can be taken. For example, investing in more fuel-efficient vehicles will result in a long-term effect on gasoline consumption, yielding higher gasoline tax rates (Davis and Killian 2010). Also, it is critical to note that these results take into account only the effects of a gasoline tax on motor gasoline consumption, meaning that these results are solely centered on the transportation sector. If we looked at taxing all gasoline products, not just motor gasoline, the effect would be higher. Furthermore, if I explored a tax rate change higher than a 10-cent tax increase, it can be presumed that there would be an even greater effect on the amount of emissions produced, resulting in even lower emissions.

9 CONCLUSION

Although interest in carbon taxes has quieted down recently as a result of the rapidly deteriorating global economic conditions, that situation is likely to be temporary. In this paper I looked at monthly Canadian data over the timeframe spanning 1987 to 2010 on gasoline prices, taxes, and consumption, and analyzed econometrically the effect of a gasoline tax on carbon emissions. After identifying the need for instrumental variable estimation I found a price elasticity of gasoline of -.132. Then translating this using a volume-adjusted after-tax mean price in March 2009 of 86 cents, I was able to estimate that a 10-cent increase in the gasoline tax would decrease gasoline consumption by 1.57%. Finally using the fact that Canada's transportation sector accounts for 25% of carbon emissions, I estimated that a 10-cent increase in the gasoline tax would decrease carbon emissions by 0.39%. I point out that, although this rate seems small, the long-term effects may be larger as the introduction of more fuel-efficient vehicles would have a significant impact on carbon emissions. Carbon emissions is a growing concern in Canada, and this is why more analyses are needed to determine the potential impacts of policy changes, such as the 10-cent tax increase discussed above.

REFERENCES

Bento, Antonio M., Lawrence H. Goulder, Mark Jacobsen, and Roger H. Von Haeven. 2009. "Distributional and Efficiency Impacts of Increased US Gasoline Taxes," *American Economic Review*, 99(3): 667-699.

Bugge, Jorgen. 2006. “High-efficiency coal-fired power plants development and perspectives,” *Energy*, 31(10):1437-1445.

Courchene, Thomas. 2008. **“**Climate Change, Competitiveness and Environmental Federalism: The Case for a Carbon Tax,” *Canada 2020 Speakers’ Series,* 1-22.

Dahl, Carol A. 1979. "Consumer Adjustment to a Gasoline Tax," *The Review of Economics and Statistics*, 61(3): 427-432.

Dahl, Carol A. and Thomas Sterner. 1991. "Analysing Gasoline Demand Elasticities: A Survey," *Energy Economics*, 13(3): 203- 210.

Davis, Lucas W. and Lutz Kilian. 2010. "Estimating the Effect of a Gasoline Tax on Carbon Emissions," *Journal of Applied Econometrics*. 26(7), 1187-1214.

Fullerton, Don and Sarah E. West. 2002. "Can Taxes on Cars and on Gasoline Mimic an Unavailable Tax on Emissions" *Journal of Environmental Economics and Management*, 43: 135-157.

Government of Canada. 2008. “Greenhouse Gas Sources and Sinks in Canada,” *National Inventory Report 1990-2008*, 1-221.

Government of Canada. 2011. “Canada's Transportation Sector, *Climate Change Website***.** Retrieved from World Wide Web at URL: http://www.climatechange.gc.ca/default.asp?lang=En&n=21ABF988-1

Grossman, Nick. 2011. “Where Carbon is Taxed,” *Carbon Tax Centre Website*. Retrieved from World Wide Web at URL: http://www.carbontax.org/progress/where-carbon-is-taxed/

Killian, Lutz. 2008. "The Economic Effects of Energy Price Shocks," *Journal of Economic Literature*, 46(4): 871-909.

Manzan, Sebastiano and Dawit Zerom. 2010. "A Semiparametric Analysis of Gasoline Demand in the US: Reexamining the Impact of Price," *Econometric Reviews,* 29(4): 439-468.

Masood, Ehsan. 1997. "Kyoto agreement creates new agenda for climate research," *Nature*, 390(6661):649-50.

McCarter, Jim. 2011. "Annual Report of the Office of the Auditor General of Ontario," *Auditor General Website*. Retrieved from World Wide Web at URL: http://www.auditor.on.ca/en/reports_en/en11/2011ar_en.pdf

Milne, Janet E. 2008."Carbon Taxes in the United States: The Context for the Future," *Vermont Journal of Environmental Law,* 10 (1): 1-31.

Riley, Geoff. 2006. "Externalities-Government Policy Options," *Tutor2U.* Retrieved from the World Wide Web at URL: http://tutor2u.net/economics/revision-notes/a2-micro-externalities-policy-options.html

Samuelson, Paul A. 1954. **"**The Pure Theory of Public Expenditure" *The Review of Economics and Statistics,* 36(4) 387-389.

Shah, Anup. 2002. "Carbon Sinks, Forests and Climate Change," *Global Issues*. Retrieved from World Wide Web at URL: http://www.globalissues.org/article/180/carbon-sinks-forests-and-climate-change

Wente, Margaret. 2011. "The Shocking Truth about Electric Cars," *Globe and Mail*. Retrieved from World Wide Web at URL: http://www.theglobeandmail.com/news/opinions/opinion/the-shocking-truth-about-electric-cars/article2149465/

West, Sarah E. 2004. "Distributional Effects of Alternative Vehicle Pollution Control Policies," *Journal of Public Economics,* 88(3–4): 735–57.

Western Climate Initiative. 2010. "Clean Energy: Creating Jobs, Protecting the Environment," *Western Climate Initiative Website*. Retrieved from World Wide Web at URL: http://www.westernclimateinitiative.org/component/remository/func-startdown/256

Western Climate Initiative. 2010. "The WCI Cap & Trade Program," *Western Climate Initiative*. Retrieved from World Wide Web at URL: http://www.westernclimateinitiative.org/the-wci-cap-and-trade-program

Statistical Data:

Government of Canada. 2008. Table S-1: "Canada's GHG Emissions by Gas and Sector," *National Inventory Report 1990-2008*, 21. Retrieved from World Wide Web at URL: http://www.ec.gc.ca/Public/492D914C-2EAB-47AB-A045-C62B2CDACC29/NationalInventoryReport19902008GreenhouseGasSourcesAndSinksInCanada.pdf

Government of Canada. 2008. Table S-3: "Canada's GHG Emissions by Sector," *National Inventory Report 1990-2008*, 25. Retrieved from World Wide Web at URL: http://www.ec.gc.ca/Public/492D914C-2EAB-47AB-A045-C62B2CDACC29/NationalInventoryReport19902008GreenhouseGasSourcesAndSinksInCanada.pdf

Government of Canada. 2011. "Average Retail Prices for Regular Gasoline," *Natural Resources Canada Website*. Retrieved from World Wide Web at URL: http://www2.nrcan.gc.ca/eneene/sources/pripri/prices_bycity_e.cfm?PriceYear=2010&ProductID=1&LocationID=66,43,10,39,29,12,33,17,2,15#PriceGraph

Statistics Canada. Table 051-0001: "Estimates of Population," Canadian Socioeconomic Database. Retrieved from World Wide Web at URL: http://www5.statcan.gc.ca/cansim/a05?lang=eng&mode=tableSummary&id=510001&pattern=population&stByVal=1&

Statistics Canada. Table 134-0004: "Refined Petroleum Products, Retail Sales of Motor Gasoline," Canadian Socioeconomic Database. Retrieved from World Wide Web at URL: http://dc.chass.utoronto.ca.proxy.queensu.ca/cgi-bin/cansimdim/c2_getArrayDim.pl

Statistics Canada. Table 153-0037: "Total Population Density," Canadian Socioeconomic Database. Retrieved from World Wide Web at URL: http://www5.statcan.gc.ca/cansim/a05?lang=eng&id=1530037&paSer=&pattern=153-0037&stByVal=1&csid=

Statistics Canada. Table 282-0001: "Labour Force Survey Estimates, Unemployment Rate," Canadian Socioeconomic Database. Retrieved from World Wide Web at URL: http://www5.statcan.gc.ca/cansim/a05?lang=eng&id=2820001&paSer=&pattern=282-0001&stByVal=1&csid=

Statistics Canada. Table 326-0020: “Consumer Price Index,” Canadian Socioeconomic Database. Retrieved from World Wide Web at URL: http://www5.statcan.gc.ca/cansim/a05?id=3260020&pattern=cpi&stByVal=1&paSer=&lang=eng

Statistics Canada. Table 379-0025: “Gross Domestic Product (GDP),” Canadian Socioeconomic Database. Retrieved from World Wide Web at URL: http://dc.chass.utoronto.ca.proxy.queensu.ca/cgi- bin/cansimdim/c2_seriesCart.pl