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British Columbia's revenue-neutral carbon tax: A review of the latest "grand experiment" in environmental policy

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HIGHLIGHTS

- We review the experience with the carbon tax in British Columbia.
- The carbon tax has reduced greenhouse gas emissions by 5–15%.
- The carbon tax has a negligible impact on overall economic activity.
- Public support for the carbon tax increased over time.

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ABSTRACT

In 2008, British Columbia implemented the first comprehensive and substantial carbon tax in North America. By 2012, the tax had reached a level of C$30/t CO_2, and it covers about three-quarters of all greenhouse gas emissions in the province. This paper reviews existing evidence on the effect of the tax on greenhouse emissions, the economy, and the distribution of income, and provides new evidence on public perceptions of the tax. Empirical and simulation models suggest that the tax has reduced emissions in the province by between 5% and 15% since being implemented. At the same time, models show that the tax has had negligible effects on the aggregate economy, despite some evidence that certain emissions-intensive sectors face challenges. Studies differ on the effects of the policy on the distribution of income, however all studies agree that the effects are relatively small in this dimension. Finally, polling data shows that the tax was initially opposed by the majority of the public, but that three years post-implementation, the public generally supported the carbon tax.

1. Introduction

In a 1998 article in the *Journal of Economic Perspectives* titled "What Can We Learn from the Grand Policy Experiment?", Robert Stavins examined the performance of the SO_2 allowance ("acid rain") trading program in the United States in its first several years (Stavins, 1998). Stavins' interest was motivated by the fact that the SO_2 trading program was by far the most ambitious application of emissions trading, a textbook policy approach that economists had been prescribing for decades as an alternative to "command-and-control" regulation, yet with little uptake from environmental regulators to date. Stavins examined the policy's application from several angles, providing insights into its cost-effectiveness, the political economy forces that led to its selection, and normative prescriptions for policy design.[1]

In the economist's playbook on environmental policy, nothing competes with emissions permit trading for space more than environmental taxation (Weitzman, 1974). And no contemporary environmental issue has emphasized the choice between these two instruments more than climate change (Goulder and Schein, 2013). Putting a price on carbon dioxide (CO_2) and other

[1] Fifteen years later, Stavins and Richard Schmalensee revisited the grand policy experiment in the pages of the same journal, highlighting what they referred to as an ironic history of the policy, including policy design choices that "worked" despite their flaws, the rejection of emissions trading by some of the political constituencies that initially argued on its behalf, and a massive change in the regulation underlying the market that caused it to collapse (Schmalensee and Stavins, 2013).

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greenhouse gas (GHG) emissions has long been the foundation of economists' prescription for the climate change problem. And regulators have taken notice. Carbon pricing has firmly taken root over the last decade, with mandatory pricing systems (existing or planned) found in places on every continent except Antarctica (World Bank, 2014). Currently emissions trading systems (ETS), or *cap-and-trade* programs, are the most prevalent carbon pricing approach from an emissions coverage standpoint. Some of the historic preference for an ETS over a tax may be due to the political economy factors referenced by Stavins (1998) and addressed through a political science lens by Paterson (2012), but an exploration of the reasoning behind those choices is beyond the scope of this paper.

While ETS predominates in climate policy, several jurisdictions either have or are considering a tax alone or in combination with an ETS. While some countries (e.g., Sweden) have had a carbon tax since the 1990s, and Ireland and other EU countries have recently implemented them, these tax systems have often been part of larger energy and excise tax reform efforts, rather than focused on GHG emissions. Those European tax systems also have different scopes of coverage, rates and are coupled with the EU ETS. Thus it is difficult to assess the effectiveness of the tax in isolation. In contrast, the Canadian province of British Columbia (BC) instituted in 2008 a stand-alone carbon tax that covered about three quarters of all emissions sources in the province at a levy rate that was as high as or higher than carbon prices emerging from ETS throughout the world. Among the unique elements of the BC carbon tax is its goal of *revenue-neutrality*, meaning that all revenues raised by the tax are to be recycled to BC households and businesses, largely in the form of tax cuts. As discussed later in the paper, economists often favor revenue-neutral carbon taxation because it has the potential to enhance economic growth by lowering distortions from the current tax system. As such, it may provide the purest example of the economist's carbon tax prescription in practice. Thus we can view the BC carbon tax today as another grand policy experiment that we can assess post-implementation much in the way that Stavins viewed SO_2 allowance trading in the 1990s. As such, is worth examining its effectiveness in achieving environmental, economic, and political objectives.

Having now been in place for seven years, there has been some targeted *ex post* empirical work on the BC carbon tax's effect on emissions, economic indicators, and political acceptance. However, no papers have looked broadly to gauge its performance across the policy's multiple outcomes of interest. This paper seeks to do that by drawing from the small but growing empirical literature to distill the evidence on effectiveness across many dimensions – emissions, economy, equity and public acceptance.

The paper is structured as follows. Section 2 provides a brief history of how the BC carbon tax came about, focusing on political and economic factors underlying its introduction. Section 3 briefly summarizes the key design elements of the tax such as its coverage base, levy rate and use of revenues. Section 4 reviews the studies that have estimated the effect of the BC carbon tax on the province's emissions profile. Section 5 synthesizes the research on the economic effects of the tax, exploring whether it has impeded or enhanced economic growth, given theoretical priors that it could go either way with judicious recycling of the revenues. Section 6 explores the distributional consequences of these economic effects across different parts of the BC population. Section 7 reviews evidence on public acceptance of the tax and Section 8 concludes the paper with a summary of findings.

2. History of the tax

The BC carbon tax was implemented on July 1, 2008, borne of a unique confluence of social, political, and economic forces. Public concern over climate change risks surged in Canada and elsewhere during the first decade of the 21st century. This was due to several factors, including mounting scientific evidence of human influence on the climate system (IPCC, 2007), increased attention in the press and in popular culture to climate change with a call for political action (Gore, 2006), and emerging expectations that all major emitting countries were poised to take serious action to reduce GHG emissions under the Un Framework Convention on Climate Change (UNFCCC). These concerns and expectations were coupled with the evolution of carbon pricing mechanisms as the recommended policy instrument to address climate change.

These factors driving global action coincided with characteristics present in British Columbia at the time to chart the course for enactment of the carbon tax. Harrison (2013) attributes passage of the BC carbon tax to five distinct factors in the province: (1) the prevalence of hydro power as the source of electricity generation, (2) intense voter interest in the issue of climate change from an electorate with strong environmental views, (3) the presence of a right-center majority government with bona fide support in the business community that could perhaps push an environmental agenda further than a government seen as hostile to business interests, (4) strong commitment by BC Premier Gordon Campbell, who essentially staked his political career on passage of the carbon tax, and (5) a political institutional structure that gives great power to the leader of the party that holds a majority of seats in the legislature, as was the case with Campbell and his party.

Even with this favorable combination of factors, passage was not easy. To capture support of the business community, the tax was made revenue-neutral, i.e., revenues raised are countered by tax cuts elsewhere, and the tax was applied to both businesses and households (Harrison, 2013). This created political backlash in some corners from concern that the tax would unfairly burden low income and rural (especially northern) communities (Beck et al., 2015). Ultimately, the tax was designed to direct some of the proceeds as payments and tax reductions for northern rural households and low income groups.

The 2009 provincial election was viewed by some as a referendum on the BC carbon tax, with the opposition party calling for its abolition as part of an "Axe the Tax" campaign.[2] However, the state of the economy in the midst of the global recession appeared foremost in voters' minds and the ruling party was seen more favorably by voters than the opposition was on economic issues (Harrison, 2013). Perhaps for this reason, more than the carbon tax itself, the ruling party survived the 2009 election, as did the carbon tax.

The BC government is entitled to review the progress of the carbon tax toward its stated goals, and chose to do so as part of its 2012–13 annual budget process (BC Ministry of Finance, 2013). The review covered key aspects of the carbon tax, including revenue neutrality, and the impact of the carbon tax on the competitiveness of BC businesses. The review largely confirmed that the tax was achieving its goals and recommended no major changes to the program going forward.

3. Key design features

Table 1 summarizes the key provisions of the BC carbon tax. As the first comprehensive carbon tax in North America, it is simple in its design and application.

[2] The opposition party in British Columbia at the time was the New Democratic Party or NDP, generally regarded as a left-center party. The party in power was the Liberal party, which is regarded as representing right-center interests.

Table 1
British Columbia carbon tax: key provisions.

Provision	Description
GHG emission sources covered	Fossil fuels used within the province, accounting for 70–75% of all GHG emissions in the province. Greenhouse gases are converted to carbon dioxide equivalents using 100-year global warming potentials.
Notable exemptions	• Fuels exported from BC. • Fuel use by planes and ships traveling to or from BC. • Greenhouse operations and fuel used in agriculture (starting in 2012 and 2013, respectively). • All non-fossil fuel GHG emissions including those from industrial processes, landfills, forestry and agriculture. • Fugitive emissions of methane (CH_4) from production and transmission of fossil fuels.
Tax rate	Started at C$10/t CO_2 in 2008, rising to $30/t by 2012. This tax per ton CO_2 is then transformed to the units of sale (e.g., $ per litre of gasoline) for assessment at the point of purchase. See Table 2 for respective tax rate per unit of the most common fuels.
Use of tax revenues	Tax aspires to revenue-neutrality, meaning all revenues are redistributed back to households in the form of tax reductions or directed transfers rather than used to increase government spending. Actual experience has revealed tax cuts and targeted payments in excess of the revenue raised by the carbon tax and some movement from general household and business tax reductions to expenditures targeted for specific purposes.
Transparency provisions	BC Ministry of Finance is required each year to prepare a three-year plan for recycling carbon tax revenues through tax reductions. The plan is presented to the Legislative Assembly for review and approval.

3.1. Coverage

The tax covers greenhouse gas emissions resulting from the combustion of all fossil fuels used within the province, with some minor exceptions. The taxed fuels include liquid transportation fuels such as gasoline and diesel, as well as natural gas or coal used to power electric plants, along with other types of fuels. It covers 70–75% of the province's GHG emissions, with the remainder coming from non-combustion CO_2 in industrial processes (e.g., lime production in cement manufacture), methane (CH_4) emissions from natural gas extraction and transmission, methane and nitrous oxide (N_2O) emissions from agriculture and CO_2 emissions from forestry (British Columbia Ministry of Finance, 2015).

The tax as originally implemented offered no exemptions for particular sectors, and used the same tax rate for all covered sectors, which distinguished it from other carbon pricing efforts worldwide. However, in 2012, responding to concerns raised by greenhouse growers that the carbon tax was rendering their operations uncompetitive with California and Mexico, government offered a one-time exemption (worth $7.6 million) from the carbon tax. This was followed in the 2013 budget with an ongoing 80% exemption from the carbon tax for greenhouse growers. In the 2014 budget, government announced that gasoline and diesel used for agriculture would be exempt from the carbon tax (Rivers and Schaufele, 2015).

3.2. Tax rate-absolute and relative

The tax started at C$10 (Canadian dollar) per ton of carbon dioxide equivalent when introduced in 2008. It then rose C$5 per ton each year until it reached C$30 per ton in 2012, where it remains today. Because different fuels have different carbon contents, the tax rate per unit of fuel differs as does the impact on final price, as shown for selected fuels in Table 2. The carbon tax translates to a set price per unit of fuel output, rather than fixed percentage; however it is useful to see how much the tax contributes to the final price of different fuels. The carbon tax accounts for a relatively modest share of the final price for gasoline, diesel and propane, but can account for a very large share of the price of natural gas and coal. The differences in relative price impact are due primarily to the fact that the raw fossil fuel costs are lower as a proportion of final costs for refined fuels such as gasoline, diesel and propane than they are for primary energy fuels such as coal and natural gas. This does suggest that the carbon tax has a higher potential effect on coal and gas use than transportation fuel use, for instance; however, virtually all of the coal mined in BC is used elsewhere and not subject to the BC tax.

Table 2
Selected carbon tax rates by fuel.

Fuel type	Units for tax	Tax rate (in 2015)	Tax % of final fuel price (2014)
Gasoline	C¢/liter	6.67	4.4%
Diesel (light fuel oil)	C¢/liter	7.67	5.1%
Natural gas	C¢/cubic meter	5.7	33.9%
Propane	¢/liter	4.62	7.1%
Coal-high heat value	C$/ton	62.31	54.7%
Coal-low heat value	C$/ton	53.31	46.8%

See http://www.sbr.gov.bc.ca/documents_library/bulletins/mft-ct_005.pdf for the full list of tax on all covered fuels.
Source for tax data: British Columbia Ministry of Finance (2015).
Source for price data:
Natural Resources Canada, 2015 (Gasoline and diesel, for Vancouver, BC).
Natural Resources Canada, 2014 (Natural gas and propane for Canada).
British Columbia Ministry of Metals and Mines. 2013 (Coal).

To place the BC carbon tax in context, Table 3 compares it to carbon prices found in several other programs in North America and EU. To enable comparisons, we convert the prices from their domestic currency and units to U.S. dollars (US$) per (metric) ton CO_2e. BC has the highest price of the cohort, twice as high, for instance, as the fee paid in Alberta for entities that exceed the emissions intensity target. The exceedance fee in Alberta, however, is only paid on the amount that the realized emissions rate exceeds the intensity target, whereas the BC carbon tax is paid on all covered emissions, so the carbon cost difference between BC and Alberta is even more pronounced than Table 3 implies. All other carbon pricing systems in Table 3 emanate from cap and trade programs, which makes the price comparison a bit more fluid. Whereas a carbon tax sets a fixed price, a cap and trade program sets a fixed emissions cap which is met by parties trading emission allowance permits at a market price. This price will vary constantly in response to shifts in market demand for emission allowances

Table 3
BC carbon tax level compared to other carbon prices.

Region	Program	Domestic price (2015)*	US$/t [d]
British Columbia	Carbon tax	C$ 30/t	24.00
Alberta	Emission intensity target (fee for exceedance)	C$ 15/t	12.00
California-Quebec	Cap and trade (economywide)	US$12.21/t[a]	12.21
Northeastern U.S.	Cap and trade (electric power sector)	US$ 5.41/short t[b]	6.06
European Union	Cap and trade (economywide)	€ 6.80/t[c]	7.34
France	Carbon tax on transport fuels and domestic heating fuels	€ 14.50/t (rising to €22 in 2016)	15.66

* Nearest quote to April 8, 2015

[a] US Energy Information Administration, 2015. California and Quebec complete second joint carbon dioxide emissions allowance auction. March, 2015, http://www.eia.gov/todayinenergy/detail.cfm?id=20312.

[b] RGGI Incorporated, 2015. Market Monitor Report for Auction 27. March 13, 2015, http://www.rggi.org/docs/Auctions/27/Auction_27_Market_Monitor_Report.pdf. Note: a short ton is equal to 2000 pounds, which is 0.9072 t (metric ton).

[c] Bloomberg Professional Services data base. Downloaded April 14, 2015

[d] Exchange rates between Canadian dollar and U.S. dollar (0.80) and euro and U.S. dollar (1.08), quoted on April 8, 2015, XE Currency Converter (http://www.xe.com/currencyconverter/).

caused by macroeconomic, energy market and policy shocks (Murray and Maniloff, in preperation).

3.3. Use of revenues

One key aspect of the BC carbon tax is its intended revenue-neutrality. Rather than raise taxes and increase government expenditure, it operates as a tax shift, wherein carbon tax revenues are countered by cuts in other taxes or direct transfers to households. These include cuts in business taxes, personal income tax (targeted at lower income categories), low income tax credits, and direct grants to rural households.

To address potential skepticism that the BC government might not follow-up on promises to keep the tax revenue neutral, the BC Ministry of Finance must file a report each year showing how the tax proceeds are being used.[3] The report is subject to review and approval by the BC Legislative Assembly as part of the broader annual budget review process. Between its inception in 2008 and 2015, the BC carbon tax has generated C$6.1 billion in revenue, yet corresponding tax cuts have been more than C$7.1 billion. Thus the tax has not truly been revenue-neutral to date, a point we will return to later in the paper. Slightly more than half the tax cuts have been directed to businesses and the remainder to households.

Fig. 1 illustrates the distribution of uses of the carbon tax revenue from its inception in Fiscal Year 2008–09 through planned future budgets out to 2017–18. From implementation to 2012, virtually all tax revenues were recycled back through tax rate cuts and credits in personal and business tax rates, with specific targeting of low income households. Starting in 2012–13, when the tax rate reached its target rate of C$30 and revenues climbed accordingly, some of the revenue started to be targeted for specific business purposes. For example, in that year, a portion of the carbon tax revenue was directed to an "Interactive digital media tax credit." The dynamic began to change considerably from 2013 to 2014 onward, first with certain exemptions (to greenhouse

[3] A true assessment of revenue neutrality requires knowledge of what government would have done in the absence of the tax. It is possible, for example, that some of the tax cuts that were made concurrently with the tax would have been made even without implementation of the carbon tax.

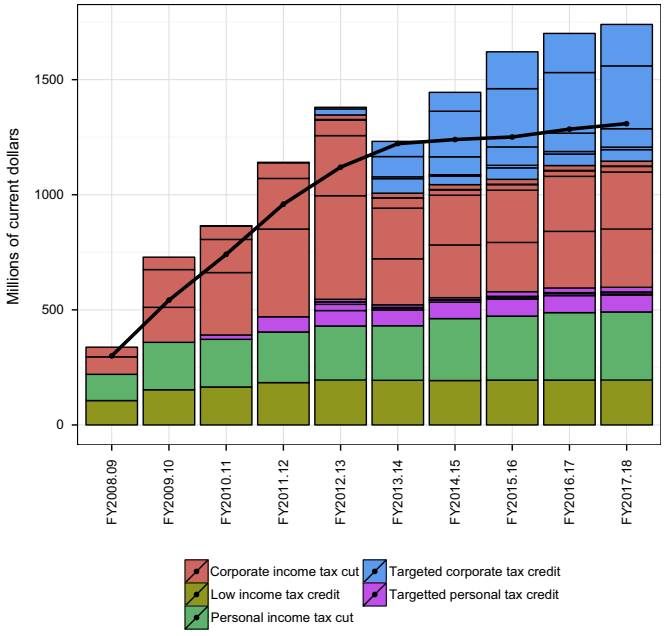

Fig. 1. Distribution of uses of BC carbon tax revenues: 2008–2018. The solid line represents revenue from the carbon tax, and the bars represent expenditures of carbon tax revenue. Values for FY2015–16 and beyond are forecasts from the most recent budget.
BC Budget and Fiscal Plans, 2008–09 to 2015–16. www.gov.bc.ca/fin/.

growers and then to the broader agricultural sector (Rivers and Schaufele, 2015)) lowering the tax base slightly, and a partial reversal of the corporate income tax rate cut reducing those broad business tax cuts as a use of revenues. After that point, virtually all of the tax's revenue growth is for targeted corporate tax credits in certain sectors, in particular the motion picture industry. What started out as using carbon tax revenues for general tax reform to reduce distortions and promote economic growth (straight out of the economist's playbook) seems to have evolved into a system with more "industrial policy" objectives of promoting certain sectors.

4. Effect on BC emissions

BC's carbon tax was implemented with the aim of reducing greenhouse gas emissions. Determining the success of the policy in this regard requires comparing actual greenhouse gas emissions in the province after the policy was implemented with a counterfactual scenario estimating emissions in the province in the absence of the tax. As with other evaluation studies, constructing the counterfactual scenario is the key to successfully identifying the effect of the policy. Two general approaches to constructing this counterfactual scenario have been used in empirical studies of the carbon tax. In some studies, numerical simulation models are used. In this case, the models are simulated with and without the carbon tax, and the effect of the carbon tax is the difference in these two scenarios. The challenge with this approach is that the models require a large number of functional form and parametric assumptions, and are often not validated against empirical data. In other studies, an econometric approach is taken. The existing literature typically uses a difference-in-difference approach, by comparing BC before and after implementation of the tax, and to other provinces. The challenge with econometric studies is accounting for unobserved variables that are correlated with the tax, such as other policies or economic conditions. We review results from both types of studies in Table 4.

Table 4
Summary of studies that estimate the effect of BCs carbon tax on greenhouse gas emissions and fuel consumption.

Source	Method	Results
British Columbia (2008)	Numerical simulation model with technological detail	Approximately 5% reduction in greenhouse gas emissions.
Beck et al. (forthcoming)	Computable general equilibrium model	8.5% reduction in greenhouse gas emissions.
Elgie and McClay (2013)	Difference-in-difference with no additional controls	18.8% reduction in per capita sales of petroleum fuels subject to the tax.
Elgie and McClay (2013)	Difference-in-difference with no additional controls	9% reduction in per capita greenhouse gas emissions (data to 2011 only).
Rivers and Schaufele (2012)	Difference-in-difference with controls	11–17% reduction in per capita gasoline sales.
Gulati and Gholami (2015)	Difference-in-difference with controls	15% reduction in residential natural gas demand; 67% reduction in commercial natural gas demand.
Bernard et al. (2014)	Time series analysis	Roughly 7% reduction in per capita gasoline sales.

In the original Climate Action Plan that accompanied the introduction of the tax, modeling work using the CIMS energy–economy model was conducted that suggested the tax would reduce greenhouse gas emissions by about 3 Mt CO_2 annually by the year 2020 in the absence of any other policies (British Columbia, 2008, p. 20), or by roughly 5% compared to the reference case (counterfactual) forecast.

Beck et al. (forthcoming) conduct a similar analysis using a computable general equilibrium model, and estimate that the tax is likely to reduce greenhouse gas emissions by 8.5% relative to the counterfactual scenario.

Recent work uses data on fuel consumption and greenhouse gas emissions from after the tax's introduction to estimate the effect of the tax on emissions. Most studies use a difference-in-difference method, comparing fuel sales in British Columbia to those in other provinces, and comparing periods before and after the tax's introduction, as in Fig. 2. Elgie and McClay (2013) conduct such a study, comparing trends before and after the tax's introduction in BC and other provinces. They find roughly a 19% reduction in per capita sales of fuels subject to the tax over the 2008–2012 period relative to other Canadian provinces. Importantly, they find that for fuels not subject to the carbon tax, such as aviation fuel, there was no such reduction in emissions. In the same study, they use a different data set on aggregate greenhouse gas emissions and find a 9% reduction in per capita greenhouse gas emissions. Notably, their analysis does not control for any other factors affecting fossil fuel sales, so although their analysis is suggestive of a strong effect from the tax, it is not possible to interpret directly as causal evidence.

Rivers and Schaufele (2012) estimate the effect of the BC tax on gasoline sales. They conduct a difference-in-difference type analysis as above, but include a number of controls for other covariates that could impact gasoline sales, such as income, prices, the business cycle, public transit investments, and other factors. Their coefficients suggest that at \$30/t CO_2, the carbon tax caused a reduction of 11% to 17% in gasoline sales. They note that this is a much larger effect (about 4 times as large) than would be expected if consumers responded to the carbon tax in the same way as they responded to other changes in gasoline price. They explain that this unexpectedly large effect could be due to the high 'salience' of the carbon tax resulting from media coverage and significant public debate. They also suggest that the carbon tax could play a role in reducing free-ridership in emissions mitigation, since all households now pay a penalty for emitting greenhouse gases.

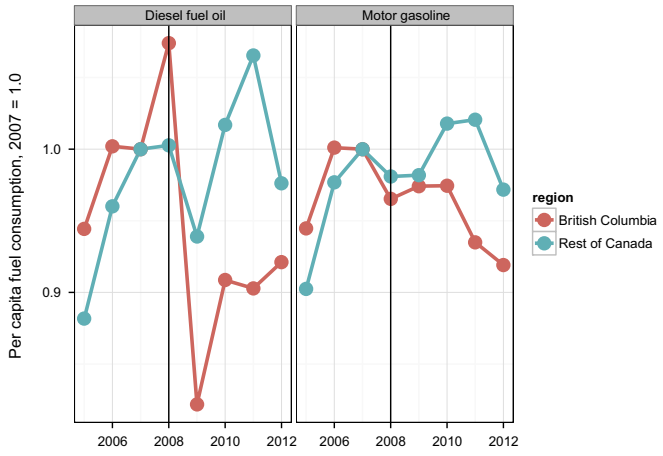

Fig. 2. Trends in gasoline and diesel fuel oil sales in British Columbia and the rest of Canada, 2005–2012. Introduction of the carbon tax is indicated by the vertical black line. Data from Statistics Canada, Tables 134-0004 and 0051-0001.

Gulati and Gholami (2015) analyze residential and commercial natural gas sales using a similar difference-in-difference approach. Similar to Rivers and Schaufele (2012), they find that the carbon tax appears to have reduced commercial natural gas consumption by a larger amount than would be expected based on the normal response to changing commercial natural gas prices. In the case of residential natural gas consumption, however, they find no such amplified response to the tax relative to the natural gas price; for residential consumption, their estimates suggest that the carbon tax likely reduced consumption by about 15%.

Bernard et al. (2014) conduct a time series analysis of the effect of the carbon tax on gasoline sales in British Columbia, using monthly data on sales, excise taxes, the carbon tax, and gasoline price. They find that both carbon taxes and excise taxes cause a much larger reduction in gasoline sales than other price movements, and overall estimate a reduction in per capita gasoline sales due to the carbon tax of about 7%.

Although there are differences in the estimates reported in Table 4, the fact that they use quite different methods and report overall effects that are of roughly the same magnitude provides some confidence in the results. Based on these results, it is reasonable to claim that the effect of the tax was to reduce fuel consumption and greenhouse gas emissions by between about 5% and 15% in British Columbia.

5. Effect on the BC economy

A carbon tax will induce taxed parties subject to reduce emissions up to the point that the marginal cost of the reduction just equals the tax. If the tax is set commensurately with the marginal benefit emission reduction, an economically efficient outcome can be achieved. Because the marginal damage or "social cost of carbon" can be difficult to estimate (Pizer et al., 2014), the carbon tax may not be set at the social optimum. Nevertheless, any tax rate should achieve a given level of emissions reduction at the lowest cost possible because it equalizes the marginal cost of

reductions across all parties subject to the policy.

Despite assurances from economists that carbon taxes represent a cost-effective approach to reducing emissions, many policy makers and public citizens have significant concerns that a carbon tax might impose a large burden on the economy. Such a burden might arise, in particular, by raising the prices for particular goods and potentially by causing firms to reduce output and consumers to reduce demand in response. These economically depressing actions generate discomfort about the broader impacts of the tax on overall economic activity. Particular concern is often focused on how the tax might affect employment.

These public concerns about the negative economic impact of carbon taxes are cast against a number of economic studies suggesting that modest carbon taxes are unlikely to cause significant negative impacts, and in some cases may have a positive effect on economic output (Anderson et al., 2007). The idea that a carbon tax could lead to economic growth is known as the *double dividend hypothesis*. The critical factor here is that the BC carbon tax is revenue-neutral and used to reduce income taxes on BC households, as discussed in Section 3. Because income taxes introduce price distortions that reduce economic output, lowering income taxes via the introduction of a carbon tax can produce a double-dividend effect, wherein the tax not only reduces GHG pollution, but also raises total economic output (Pearce, 1991; Tullock, 1967). This suggests that the net economic effect of a carbon tax could be positive under some circumstances.[4] While the robustness of the double dividend hypothesis has been challenged on theoretical grounds (Bovenberg and Goulder, 2000; Fullerton and Metcalf 1998), the BC carbon tax remains one of the few cases where such a hypothesis can be put to the test empirically given the size of the tax and the fact that the revenues do directly reduce other taxes.[5]

5.1. BC's economic growth under the carbon tax – descriptive statistics

On the issue of whether the carbon tax has modified economic performance in BC, one can start with simple observations of GDP per capita in BC relative to the rest of Canada, which suggest either a slightly higher performance (Elgie and McClay (2013) comparing growth rates after the introduction of the tax in 2008) or slightly lower performance (Metcalf (2015) comparing relative growth rates of BC before and after the tax was imposed). For instance, the real annual GDP growth rate from 2008 to 2013 was 0.5% in BC and 0.4% in the rest of Canada.[6] But the more important key point, acknowledged by both studies, is that one cannot draw any defensible conclusions without a statistically rigorous assessment that controls for the wide range of factors other than the carbon price that may have affected economic performance in BC and the other Canadian provinces to which it is being compared.

5.2. Evidence from economic modeling and econometric studies

In its first comprehensive review of the carbon tax (British Columbia Ministry of Finance, 2013), the government conducted a numerical modeling study to estimate the tax on economic indicators. The review states that "Economic analysis conducted for the carbon tax review indicates that BC's carbon tax has had, and will continue to have, a small negative impact on gross domestic product (GDP) in the province." However, details of the analysis were not provided in the review and subsequent efforts to obtain the results of this analysis from the BC government were unsuccessful.

Beck et al. (forthcoming) use a computable general equilibrium model of the Canadian economy to simulate the expected macroeconomic consequences of the BC carbon tax. Their simulations show very modest aggregate effects: a drop in household welfare of 0.08%. The modest effects are affected by the recycling of carbon tax revenues; they simulate a decline in welfare of 0.13% if tax revenues were not recycled by offsetting tax breaks. These findings support the "weak" double dividend hypothesis that revenue recycling can mitigate economic losses from a carbon tax, though do not support the "strong" double dividend hypothesis that the tax generates net economic growth on net.

It is important to recognize that Beck et al. (forthcoming) and British Columbia Ministry of Finance (2013) develop estimates of the impact of the carbon tax with model simulations of the policy with and without the tax. This contrasts with the econometric studies described next, which estimate observed economic outcomes against counterfactual statistical estimates of the outcomes without the policy. As with estimating the effect of the tax on emissions, these two approaches embody different assumptions, and it is useful to compare the two approaches.

Metcalf (2015) uses econometric analysis to test whether growth rates in BC differed from the rest of Canada after imposition of the carbon tax. He does so using difference-in-difference regressions of provincial GDP from 1999 to 2013, while controlling for other factors. The results indicate no statistically significant effect of the carbon tax on BC's economic growth. Metcalf asserts this finding is unsurprising, given the relative size of the tax burden – the carbon tax accounts for only 5–6% of all tax revenue. He also suggests that the economic benefits of the tax cuts may have counter-balanced the direct negative effects of higher energy prices, which is the intention of such environmental fiscal reforms such as a revenue-neutral carbon tax.

Yamazaki (2015) explores labor market effects of the BC carbon tax. He develops a partial equilibrium demand model for labor as a function of the carbon tax. Using data from 2001 to 2013, he uses econometric methods to estimate a labor demand function using industry level data on employment across provinces, controlling for industry, province and time fixed effects as well as the emissions intensity and trade intensity of an industry. His results indicate negative employment effects for emission-intensive and trade-exposed (EITE) sectors in BC, but positive effects for non-EITE sectors and for the labor market overall. For instance, he estimates a 30% drop in employment in basic chemical manufacturing, but gains in other sectors that more than make up for it. Yamazaki tests for whether this is purely a demand effect or how much is due to supply shift, for instance, labor induced into the market from pro-growth tax cuts. He finds evidence that the supply effect is stronger, suggesting the policy caused new labor to enter into the market. This also created a decline in the wage rate, which is expected if the labor supply shift dominates the demand shift. This result seems to imply that the tax created more jobs with lower wages, and thus may have more nuanced distributional consequences, though these issues were not directly addressed in the paper.

The studies just referenced examine economic effects across all sectors of the economy, but there are certain sectors that may be considered more exposed to economic hardship than average. One sector with the potential for disproportionate impact is agriculture, where BC has an active flow of exports and imports to and

[4] Of course, the full economic impact of the tax is intended to be positive once the reduced environmental damages from climate change are taken into account. The reversed negative impact referenced here speaks to the cost side of the equation, wherein the costs to the economy could be negative if the carbon tax is used to reduce distortionary taxes, as they are in British Columbia.

[5] In fact, the BC government has reduced other taxes by more than the revenues taken in by the carbon tax, by amounts ranging from 2% to 35% per year (Metcalf 2015). Thus the tax has not been strictly revenue neutral and any economic growth benefit that does accrue to tax reduction cannot entirely be attributed to the carbon tax.

[6] Data from Statistics Canada, 2015. Table 384-0038.

from other countries whose producers do not face a carbon price, especially the United States. BC agriculture was subject to the tax from 2008 to 2011, but as described above the BC government opted to effectively exempt parts of the agriculture sector after 2012 under the premise of trade and competitiveness concerns (BC Ministry of Finance, 2013). Rivers and Schaufele (2015) examined whether the imposition of the carbon tax between 2008 and 2011 affected BC agricultural trade flows. Using econometric estimation of trade flow equations (net exports and imports), and controlling for heterogeneity and other key factors, they could find no statistically significant impact of the carbon price on BC agricultural trade flows.

In summary, though based on a somewhat limited number of studies, the empirical evidence on the effects of the BC carbon tax on economic performance suggests little net impact in either direction. There is some evidence of negative effects in emissions intensive sectors, such as cement, but the positive impacts in other sectors appear to compensate for those losses.

6. Distributional effects within BC

A persistent concern relating to taxes on energy, carbon, and certain other types of consumption goods is that they can be regressive, weighing more heavily on low-income than high-income households. The basis for this concern is illustrated in Fig. 3, which uses data from the annual Survey of Household Spending conducted by Statistics Canada to estimate expenditure on energy goods as a share of income. Households in the lowest income decile in British Columbia report spending approximately 10% of total income on carbon-based energy goods (we exclude electricity from this figure because it is nearly 100% carbon-free in BC). The large majority of these expenditures are for gasoline, at about 7% of total income. In contrast, households in the upper half of the income distribution reported spending only about 4% of total income on energy goods. All else equal, it follows that increases in the price of energy goods resulting from a carbon tax would reduce disposable income by a larger proportion for lower income households.

Implementation of the carbon tax was sensitive to this issue. The revenue recycling system that accompanied the tax's introduction allocated a substantial portion of the total revenue that was collected by the tax to low income households, with the goal of alleviating concerns related to its distributional incidence, as described above. The revenue recycling mechanisms include the Low Income Climate Action Tax Credit, which (in 2011) returned

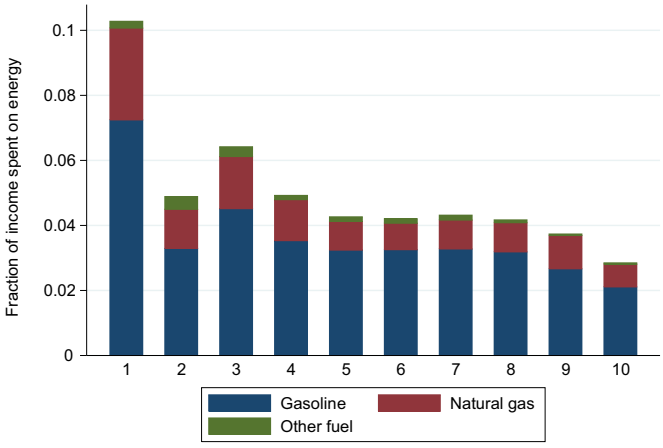

Fig. 3. Expenditure on energy as a share of income by household income decile for households in British Columbia. Data from Statistics Canada Survey of Household Spending 2009.

up to $115.50 (Canadian dollars) per adult and $34.50 per child to households with incomes of less than about $31,700 (for singles) or $37,000 (for couples). In addition, reductions in the personal income tax rate were implemented on the first two income tax brackets (a 5% reduction in the tax rate for households with income up to about $75,000), which results in a larger reduction in the average tax rate for low-income individuals compared to high-income individuals (but does not directly benefit individuals with incomes below the start of the first income tax bracket).

Some analysis has been conducted to determine the ultimate incidence of the tax, accounting for the revenue-recycling mechanisms that target low-income households. The original government document that accompanied the tax's introduction conducted a number of simulations of the tax's impact on different types of households (British Columbia, 2008). The model used in that study was very simple, in that it did not account for changes in behavior following the tax, assumed 100% pass-through of the tax, and did not account for any price changes except for energy goods. It suggested that in 2008 and 2009, the tax would result in an increase in disposable income for three prototypical low-income households with incomes of $30,000 (a single mother, senior couple, and senior single). Overall, the government claimed that "Low income families are protected… most will be better off" (British Columbia, 2008, p. 14).

Lee and Sanger (2008) use a similar static model to examine distributional incidence, but also include indirect expenditures on carbon by assuming a carbon content for non-energy expenditures. Like the government's analysis, they use a simple micro-simulation model and assume no behavioral response on the part of households to the tax, and also assume that the entire incidence of the tax is passed forward to consumers. They project that the carbon tax would be "moderately progressive" in the first year of its introduction. However, they find that the schedule of carbon tax increases from 2008 to 2012 is more aggressive than the accompanying measures targeting low-income households, such that the tax is forecast to be "moderately regressive" without further increases in the low-income tax credit. Fig. 1 supports this conclusion, by showing the steadily declining fraction of total tax revenues that are used to support low income households. More precisely, by 2011/12 they find that the tax and coupled revenue recycling mechanisms would result in a 0.3% reduction in income for households in the lowest income quintile, and a 0.2% increase in income for households in the highest income quintile.

Beck et al. (forthcoming) conduct an analysis of the distribution of the tax using a computable general equilibrium model. Using a general equilibrium model allows them to estimate the impact of the tax on both expenditures as well as on sources of income (i.e., they do not assume complete pass-through of the tax to consumer prices, but estimate the incidence of the tax based on the properties of the model). They find that even before the revenue recycling measures are considered, the carbon tax in British Columbia is "highly progressive." They suggest that this is a result of the tax incidence falling partly on wages (and partly on the prices of energy goods). Because low-income households derive most income from government transfers, they are insulated from falling real wages. In contrast, high-income households derive most income from wages, and so bear most of the incidence of the tax. Beck et al. (forthcoming) also report that the revenue recycling measures make the tax more progressive.

Beck et al. (2015) use a similar model to estimate the differential impacts on the tax on urban and rural households. As described above, the impact of the tax on rural households was a key point of contention related to the introduction of the tax. They find that rural households were initially disadvantaged by the tax, but that the introduction of a Northern and Rural Homeowner tax credit was sufficient to make these households net beneficiaries

from the tax on average.

7. Public perception of the tax

Although carbon taxes have long been supported by economists and other policy analysts advocating for cost effective reduction of greenhouse gas emissions, their implementation has been limited by a concern that public support for such measures lags significantly behind support by economists. Implementation of the tax in BC provides a test-bed for understanding how public support for a carbon tax unfolds after a tax has been implemented.

Residents of British Columbia have been polled regularly regarding their support for or opposition to the carbon tax. In particular, the polling firm Environics has conducted polls roughly annually since the tax was introduced. Polls use a standard survey methodology, sampling between 1000 and 2000 randomly selected residents of the country by telephone in each survey wave. Respondents both in and outside of the province have been asked about their perception of the tax, with residents in British Columbia asked whether they support the tax, and those outside of the province whether they would support the introduction of a similar tax in their province. Responses are categorized into four levels – strongly support, somewhat support, somewhat oppose, and strongly oppose. In the following results, we aggregate the two categories of opposition and the two categories of support to summarize the overall level of opposition to the tax, as well as to explain opposition to the tax as a function of demographic and other variables.[7]

Fig. 4 shows the main results of this polling over time. Overall waves of the survey in the figure, the carbon tax was strongly or somewhat supported by 50.5% of respondents in British Columbia, and strongly or somewhat supported by 51.4% of respondents in other provinces. Support for the policy generally improves over time, although unevenly. In particular, respondents appear more favorable to the tax in polls taken in the November 2011 wave of the survey and after (support for the carbon tax in November 2011 and later polls was 57.7% compared to 46.2% prior to November 2011).

Table 5 shows the results of a regression analysis that predicts opposition to the carbon tax based on selected demographic and other variables. In the first four columns, we model opposition to the carbon tax as a discrete variable that takes on a value of one if the respondent indicates that they somewhat or strongly oppose the tax and zero if they somewhat or strongly support the tax (we drop observations with no response or an uninformative response). The first column uses a linear probability model for the entire sample. The second column restricts the sample to just respondents in British Columbia, and the third and fourth columns use the entire sample, but with probit and logit functions, respectively. The fifth column uses the entire sample and a linear model, but adjusts the dependent variable so that a value of 4 indicates strong opposition, 3 indicates some opposition, 2 indicates some support, and 1 indicates strong support.

Coefficient estimates in all models are similar in sign and meaning. In particular, young people (under 30) are much less likely to oppose the tax than others. On average, being young reduces the probability that a respondent states opposition to the tax by 11 percentage points. Considering the average level of support for the policy is about 50%, this implies young people are over 20% more likely to support a carbon tax than older people. Likewise, people in high income households (more than $100,000 per year) are significantly less likely to oppose the tax than others. In fact, opposition to the tax increases smoothly with reductions in

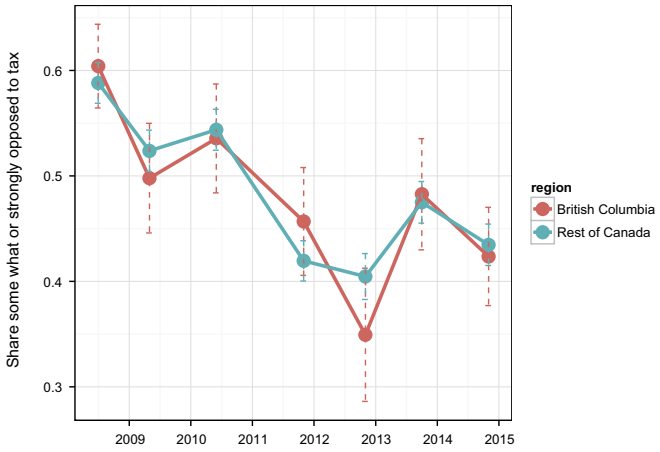

Fig. 4. Polling results on the BC carbon tax from 2008 to 2014. 95% confidence intervals indicated by dashed lines. Polling data was provided by Environics.

Table 5
Regression results for the determinants of opposition to the BC carbon tax.

	Dependent variable: opposetax (0–1)				*Oppose* (1–4)
	OLS (1)	*OLS* (2)	*Probit* (3)	*Logistic* (4)	*OLS* (5)
Age: 55 or more	0.007	0.028	0.019	0.03	0.027
	−0.011	−0.03	−0.028	−0.044	−0.023
Age: less than 30	−0.113***	−0.074	−0.294***	−0.475***	−0.238***
	−0.018	−0.053	−0.046	−0.075	−0.038
Income: 30,000 to 60,000	0.035**	0.052	0.090**	0.145**	0.053*
	−0.014	−0.038	−0.035	−0.057	−0.03
Income: 60,000 to 80,000	0.039**	0.06	0.100**	0.160**	0.094***
	−0.016	−0.045	−0.042	−0.068	−0.035
Income: 80,000 to 100,000	0.014	0.02	0.035	0.057	0.025
	−0.017	−0.045	−0.043	−0.069	−0.036
Income: less than 30,000	0.044***	0.011	0.114***	0.184***	0.062*
	−0.015	−0.044	−0.04	−0.064	−0.033
Community: Small	0.064***	0.038	0.163***	0.262***	0.165***
	−0.01	−0.027	−0.025	−0.041	−0.021
Region: Rest of Canada	−0.009		−0.024	−0.039	−0.008
	−0.014		−0.037	−0.059	−0.031
Gender: Female	−0.068***	−0.077***	−0.176***	−0.282***	−0.146***
	−0.01	−0.027	−0.025	−0.04	−0.021
Year: 2009	−0.073***	−0.071	−0.187***	−0.300***	−0.173***
	−0.018	−0.047	−0.046	−0.074	−0.039
Year: 2010	−0.051***	−0.045	−0.132***	−0.212***	−0.117***
	−0.018	−0.047	−0.046	−0.074	−0.039
Year: 2011	−0.161***	−0.143***	−0.411***	−0.658***	−0.387***
	−0.018	−0.046	−0.045	−0.073	−0.038
Year: 2012	−0.181***	−0.228***	−0.465***	−0.747***	−0.404***
	−0.019	−0.052	−0.048	−0.078	−0.04
Year: 2013	−0.126***	−0.113**	−0.323***	−0.517***	−0.298***
	−0.018	−0.047	−0.046	−0.074	−0.039
Year: 2014	−0.147***	−0.167***	−0.376***	−0.603***	−0.398***
	−0.019	−0.046	−0.048	−0.077	−0.04
Constant	0.574***	0.577***	0.189***	0.304***	2.812***
	−0.021	−0.042	−0.053	−0.085	−0.044
Observations	10,339	1357	10,339	10,339	10,339

The first column is a linear probability model on all survey respondents where the dependent variable is a dummy that takes on a value of one if the respondent opposes (somewhat or strongly) the carbon tax. The second column restricts the sample to BC residents. The third and fourth columns are similar to the first but with probit and logit specifications, respectively. The fourth column uses a numerical dependent variable that takes on a value of 4 if the respondent strongly opposes the tax, and 1 if the respondent strongly supports the tax (with 2 and 3 for somewhat support and oppose).

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

[7] This analysis is based on the Environics Institute for Survey Research Microdata files which contain anonymized data collected for Focus Canada. All computations on these microdata were prepared by the authors and the responsibility for the interpretation is that of the authors.

household income, and is highest for the lowest income households. Specifically, households with less than $30,000 have a probability of supporting the tax that is about 4.4 percentage points lower than households with incomes over $100,000. Households in small communities (less than 100,000 people) are also significantly more likely to oppose the tax. Our analysis suggests that households in small communities have a 6.5% greater probability of opposing the tax than residents of large cities. Likewise, males are much more likely (by 7 percentage points) to state opposition to the tax than females. Support for the tax does not appear to be different in British Columbia than in other parts of Canada, as suggested in Fig. 4. Finally, opposition to the tax appears to have declined substantially over time, consistent with the trends in Fig. 4.

We can use the model to construct a profile of respondents that are most likely to support the tax, and those that are more likely to oppose the tax. For example, a middle-aged male, with low or middle income, living in a small community has roughly a 70% chance of opposing the tax. On the other side, a young female with high income living in a large urban area has less than a 40% chance of opposing the tax (i.e., more than 60% probability of supporting the tax).

In addition to survey responses from telephone polls, another useful point of evidence that relates to public support for the carbon tax comes from elections. British Columbia has fixed election dates, and elections were held within one year of the introduction of the carbon tax (in May, 2009). Polling from this period suggests that residents of the province were roughly evenly divided on the carbon tax, and the carbon tax was certainly a key issue for voters at the time of the election. As mentioned above, the main opposition New Democratic Party ran an "Axe the tax" campaign, promising to replace the tax with a cap and trade system if elected (Harrison, 2013). The election was won by the incumbent Liberal party (which introduced the tax), with both popular vote and seat shares changing little compared to the 2005 election. Importantly, environmental NGOs were strong supporters of the carbon tax and active during the election, likely playing a role in the election outcome in particular by motivating some environmentally-motivated voters to support the Liberals, normally seen as the business-friendly party in BC. By the time of the 2013 election, the New Democratic Party (more left-leaning than the Liberal party) had changed its position on the carbon tax, such that it was no longer an important election issue.

8. Conclusion and policy implications

British Columbia has given the world perhaps the closest example of an economist's textbook prescription for the use of a carbon tax to reduce GHG emissions. The tax covers a wide base, started low to ease the transition, and rose to a more substantive level, roughly in line with recent mid-range estimates of the marginal damages per ton or the "social cost of carbon" (Pizer et al., 2014), and the highest broad-based carbon price seen in practice today (2015). The intended use of tax revenues is to lower preexisting distortionary income taxes on businesses and households, as well as targeted transfers to presumptively disadvantaged low income households. Reporting of the sources and uses of carbon tax funds is subject to a highly transparent process, under which politicians and their constituencies can track how the revenues are used each year. With these features in mind, the BC carbon tax provides an excellent field test of a widely prescribed policy.

We have assembled and reviewed existing studies of the BC carbon tax's effect on emissions, economic performance, distributional outcomes across household income levels, and public acceptance. We also conduct our own original statistical analysis of household perceptions of the tax in BC or a hypothetical similar tax in other Canadian provinces. Although the published work in this area is fairly thin in numbers, we find findings that are fairly consistent across studies within a category and are consistent with economic and demographic theory. We briefly summarize here, the key take home messages from this assembled body of work.

8.1. Signals of success

The primary objective of the tax is to reduce GHG emissions and essentially all studies show it is doing just that, with reductions anywhere from 5% to 15% below the counterfactual reference level. Some studies suggest that the tax has an amplified effect on fuel-consuming (emitting) behavior above what an equivalent change in fuel price would produce. Those studies provide a range of explanations of why this may be the case, and also find consistency with results on other taxes and policy interventions that produce outsize responses.

A secondary goal of the carbon tax is fiscal reform-to enable the use of a tax on "bads" (pollution) to displace a tax on "goods" (labor and capital), with the attendant possibility that this might generate a double dividend – pollution reductions and economic growth. The evidence, while not decidedly pointing to a strong form of double dividend, tends to show no statistically significant effect at all on net growth for the province. At minimum, this suggests any negative economic effects are minimal. Note that these studies do not estimate the economic benefits from avoided climate change, which would also contribute to policy goals.

A main concern regarding implementation of a carbon tax (shared with other consumption taxes) is that the incidence may fall especially on lower-income households. This concern was addressed when the tax was implemented by dedicating a portion of revenues to low income tax credits and to cuts in the lowest income tax brackets. Existing analysis confirms that this mitigated any regressive impact of the tax when it was first implemented. However, there is debate about the incidence of the tax as it was scaled up, since tax rebates for low income households were not increased proportionately to the tax rate. The body of research does agree that the overall effects on the distribution of income are likely to be small.

Although carbon taxes are often prescribed by economists, implementation is rare as a result of limited public support. Implementation of the carbon tax in British Columbia provides a case study to allow for understanding support for a carbon tax post-implementation. Using multiple waves of polling data, we find that support for the carbon tax in British Columbia increases over time following implementation, such that three years post-implementation the tax achieved majority support.

8.2. Shortcomings

While the preceding discussion suggests that the tax has been a success overall, there are some potential shortcomings. First, although the empirical literature suggests that the carbon tax has reduced emissions from covered fuels in British Columbia, there has been no effort to date to quantify the effect on emissions elsewhere. There is a large body of literature on emissions "leakage" which suggests that at least some of the reductions in emissions observed in British Columbia are likely to be associated with increases in emissions elsewhere (see Caron et al. (2015) for an analysis of leakage from California). To date, we know of no studies that have attempted to quantify the magnitude of this effect.

Second, although the carbon tax in British Columbia was originally implemented as a "textbook" policy, with wide coverage,

no exemptions, and revenue used for broad-based tax cuts and low-income tax credits, in recent years there have been some deviations from this model. Exemptions from the tax were granted starting in 2012 to some agricultural sub-sectors and in 2014 to liquid fuel use for the entire agricultural sector. In addition, rather than broad-based tax cuts that accompanied the tax in its original implementation, in recent years more of the tax revenue has been used to support particular industries through targeted tax credits (especially the film production industry). These trends likely reduce the cost effectiveness of the tax overall.

Finally, although the tax is now supported by more than half of the population in BC, it remains a politically difficult policy to implement, in particular because support and opposition are concentrated in particular groups. In particular, opposition to the tax remains high in middle and low income, older, male, and rural groups, which are important electoral demographics.

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