Carbon Pricing Costs for Households and the Progressivity of Revenue Recycling Options in Canada †

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Abstract

Canadian federal policy mandates a floor price on greenhouse gas emissions in all provinces and territories or an equivalent quantity instrument. Provinces that implement a system consistent with the federal benchmark maintain control of revenues. Provinces that do not implement a carbon price are subject to a federally administered pricing system, with revenue recycling via lump sum household rebates. Using rich synthetic household microdata we quantify the direct and indirect tax burden on households, and carbon pricing revenues in each province. We also calculate carbon pricing revenue available to each province. Using these data, we measure the net cost to households and the overall progressivity of carbon pricing under four revenue-recycling scenarios: (1) a means-tested sales tax credit increase; (2) a lump sum dividend; (3) a sales tax rate reduction; and (4) a personal income tax basic exemption increase. We find the carbon tax is generally progressive even without revenue recycling, the sales tax credit and lump sum rebate are progressive, the sales tax rate reduction is mostly regressive, and the income tax change is regressive. We also show that Canada's output-based pricing system for large emitters helps mitigate indirect carbon pricing costs with a notable effect in reducing household costs.

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Keywords: carbon pricing; household costs; Canadian climate policy; distributional effects

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1 INTRODUCTION

The Government of Canada's *Greenhouse Gas Pollution Pricing Act* (GHGPPA) mandates a floor price on greenhouse gas emissions and implements a backstop pricing system; provinces can comply by implementing direct pricing or an equivalent quantity instrument (Environment and Climate Change Canada, 2020a, 2021b). All provinces and territories in Canada were required to implement a carbon price by 2019. Starting at $10 CAD per tonne in 2018, it increased $10 per year to $50/tonne by 2022, and will increase by $15 per year to reach $170/tonne by 2030 (Environment and Climate Change Canada, 2021b). Provinces not in compliance with benchmark stringency criteria — minimum price or cap on emissions and minimum scope of priced emissions — are subject to the federal "backstop" system (Environment and Climate Change Canada, 2021b). However, carbon pricing is politically fraught in Canada. Several provinces voluntarily implemented carbon pricing, some implemented pricing with exemptions, others adopted plans in compliance with the GHGPPA and subsequently retracted those plans, while others refused to implement carbon pricing and had the federal backstop imposed (Dobson et al., 2019; Winter, 2020; Environment and Climate Change Canada, 2022a). Several provinces launched court challenges on the constitutionality of the *Greenhouse Gas Pollution Pricing Act*; in March 2021, Canada's Supreme Court upheld the federal statute. Most recently, in 2022 high energy prices and concerns about overall affordability prompted numerous calls to pause the carbon tax increase (Lévesque, 2022; Ontario Ministry of Finance, 2022; Poitras, 2022; Tran et al., 2022). As an evolving policy area, there is little research on the expected or observed effects of carbon pricing in Canada, particularly related to the burden on households and net effects from revenue recycling. We address this question.

We model the tax burden and distributional effects of carbon pricing for households in each province in Canada using rich synthetic microdata. We use costs synonymously with (net) tax burden; our estimates are not an economic or social cost but rather transfers from households to government. We base our modelling on the federal backstop; it includes a consumer-facing fuel charge on combustion emissions (a broad-based carbon tax) and an output-based pricing system

(OBPS) for emissions-intensive and trade-exposed large industrial emitters. The OBPS is a tradeable emissions performance standard and output subsidy, maintaining a defined marginal effective price per tonne of CO_2e while also allowing for a lower average effective price per tonne (Environment and Climate Change Canada, 2020d).[1]

Some provinces have designed unique carbon pricing systems, including cap-and-trade systems in Quebec and Nova Scotia, and others include unique exemptions (e.g. heating oil in some Atlantic provinces). There is also variation in revenue-recycling choices, for both households and large-emitter systems. We model a consistent backstop-style system for ease of comparison, rather than actual provincial or federal policies. Modelling the backstop also addresses the relative fluidity of carbon pricing policy in Canada (Figure 1), including cases where provinces implement their own system, and after a change in government cancel the policy (e.g. Alberta and Ontario). We quantify the direct and indirect costs of carbon pricing for households in each province and across the income distribution, and identify the net tax burden under four revenue-recycling scenarios: (1) a means-tested sales tax credit increase; (2) a lump sum dividend; (3) a sales tax rate reduction; and (4) a personal income tax basic exemption increase. We construct estimates of household energy use (electricity, natural gas, gasoline and home heating oil) and use these data to calculate direct carbon pricing costs. We follow Fellows and Dobson (2017) and use expenditure data and estimates of indirect emissions-intensities to calculate indirect carbon pricing costs; these are the carbon pricing costs embodied in products purchased by Canadian households. We restrict revenue-recycling to revenues raised in each province, consistent with the federal backstop (where carbon tax revenues are recycled only within-province) or provincial compliance resulting in provincial control of revenues. Our counterfactual choices are most naturally thought of as provincial policy, though functionally either order of government could implement them.[2] Importantly, we explore the mechanical effects of emissions pricing on household tax burden, rather

[1] Appendix A provides more detail on the distinction between the marginal and average effective tax rates for large emitters under an OBPS.

[2] Ownership of carbon tax revenue does matter in giving provinces more flexibility, and it also matters in determining the level of federal transfers to provinces via changing the tax base used in calculating transfers (Snoddon and Tombe, 2019).

than a full general-equilibrium analysis. Our inclusion of indirect costs allows us to investigate the effect of the OBPS in mitigating households' costs. We pursue five distinct but related research questions, building on Winter (2017, 2018a). First, what are the energy use patterns of Canadian households, the corresponding expected direct effects of carbon pricing, and how do these effects differ across Canadian provinces? Second, what are the expenditure patterns of Canadian households and the corresponding indirect effects of carbon pricing, and how do these effects differ across provinces? Third, what is the net financial impact of revenue recycling options? Fourth, are carbon taxes progressive or regressive, and how do revenue recycling options change this? Fifth, what is the role of complementary support policies for businesses such as the OBPS in mitigating costs to households?

Our work has broad policy relevance for Canada. First, current concerns about energy affordability and political resistance to carbon tax increases means research demonstrating ways to mitigate the tax burden is important for current policy discussions. Second, there is substantial variety in how provinces tax emissions and recycle revenue; BC has a means-tested tax credit and lowered personal income taxes (and is currently consulting on changes to the tax credit); Alberta switched from voluntary implementation with a means-tested tax credit to being a backstop province; the federal rebate is lump-sum; Prince Edward Island and Newfoundland and Labrador exempt home heating oil from the carbon tax due to affordability concerns; and New Brunswick lowered personal income taxes and fuel taxes. The benchmark stringency guidelines for 2023-2026 makes clear that exemptions and lowering fuel taxes will not be in compliance with the minimum national standard. Accordingly, provinces face a renewed choice in program design and revenue use. Finally, provincial systems are regularly assessed against the benchmark, and so there is an ongoing risk of losing control of revenue and our counterfactual experiments demonstrate the trade-offs.

The newness of carbon pricing and politicized nature of carbon pricing discussions in Canada means there are both misleading estimates of households' tax burden and a limited understanding of the true expected costs. For example, in 2018 the New Brunswick's Progressive Conservative Party's estimates were \$1200 for a family (Poitras, 2018). This estimate is overly high in addition to ignoring revenue recycling (Winter, 2017, 2018b). Other estimates are similarly inaccurate, relying on an overly simplistic approach of multiplying total Canadian emissions by the per-tonne price, and then dividing by the number of households (Bowes, 2016). Most recently, Saskatchewan estimates compliance costs with the federal fuel charge are $1.9 billion annually, ignoring revenue use (Saskatchewan Ministry of Finance, 2022). Given the political prominence and importance of this issue[3], precise estimates of the costs and benefits of carbon pricing and options for revenue recycling is imperative. Canadian academics and think-tanks have developed household cost estimates (Rivers, 2012; Tombe, 2016; Tombe and Rivers, 2017; Sawyer, 2018; Winter, 2018b; Moffatt et al., 2020), as has the Parliamentary Budget Officer (2019; 2020; 2022). Detailed and comprehensive work on the distributional consequences of carbon pricing in light of revenue recycling for each province is outstanding. We fill this gap.

There is some extant research on the effects of carbon pricing on Canadian households. Rivers (2012) examines the potential distributional burden of carbon pricing, but does not examine specific options for revenue recycling. Parry and Mylonas (2018) present a first-order incidence analysis for British Columbia, Alberta, Saskatchewan, Ontario and Quebec. Closest to our work, Cameron (2018) and Sawyer (2018) explore the cost impacts and distributional consequences of the federal backstop —– along with several revenue-recycling options —– on households in Alberta, Saskatchewan and Ontario. Moffatt et al. (2020) examine the distributional effects of recycling carbon pricing revenues in Ontario, comparing four policy options roughly similar to what we consider below. The Parliamentary Budget Officer 2019 examines the distribution of household costs and net costs with the federal backstop by income quintile for Saskatchewan, Manitoba, Ontario and New Brunswick; the 2020 report updates these provinces and adds Alberta (Parliamentary Budget Officer, 2019, 2020). Parliamentary Budget Officer (2022) includes the effect of carbon pricing on the growth of incomes and returns to capital relative to a scenario with no climate policy. Our analysis is more comprehensive than the above as we evaluate all ten provinces and explore

[3] Advocacy groups and federal and provincial politicians have proclaimed the carbon tax unaffordable and a cash-grab, and criticized for its revenue use (Hayes, 2019; The Canadian Press, 2019; Sims, 2020, 2021; Canadian Federation of Independent Business, 2021; Conservative Party of Canada, 2021; Hudes, 2021; Moulton, 2021).

a greater number of revenue recycling options, as well as explicitly accounting for the OBPS in indirect costs. We do not, however, consider the effect of carbon pricing on the growth rate of incomes and returns to capital.

We add to the literature on the distributional effects of carbon pricing with a three-fold contribution. First, a comprehensive assessment of the burden of carbon taxes across the income distribution for all 10 provinces. Second, identifying the progressivity of carbon pricing in Canada with and without revenue recycling. Three, showing the role of the OBPS in mitigating the tax burden. A progressive policy is one in which the tax burden (typically as a share of income) is lower for low-income groups, and higher for high-income groups. Extant research has mixed results in terms of the progressivity of carbon pricing. Jiang and Shao (2014), Wang et al. (2016) and Berry (2019) find carbon pricing without revenue recycling is regressive. Dissou and Siddiqui (2014) find that carbon pricing will have different effects on income inequality depending on the level of the price, while Dorband et al. (2019) find that carbon pricing can be progressive for lower-income countries and regressive for higher-income countries. Beck et al. (2015) analyze the progressivity of British Columbia's carbon pricing system, finding carbon pricing is progressive even before revenue recycling. They use a computable general equilibrium model and find carbon pricing generates a decline in real wages, which affects higher-income households more than low-income households. We do not use a computable general equilibrium model, and so do not capture these general equilibrium effects. Instead, we use rich synthetic microdata to conduct a partial equilibrium analysis of the progressivity of carbon pricing in Canada. This approach allows us to present rich distributional detail, capturing the effects of carbon pricing across the income distribution. Like Rivers (2012), we consider these "first order" effects, which hold household expenditure levels constant and do not capture behavioural responses to carbon pricing. We find emissions pricing is regressive when measured as a share of income, and uniform when measured as a share of expenditure; the former is indicative of short-term effects while the latter is closer to life-cycle effects. A key innovation in our paper is that we also assess the progressivity of carbon pricing after applying four approaches to recycling carbon pricing revenues. Metcalf (1999), Chiroleu-Assouline and

Fodha (2014), and Klenert and Mattauch (2016) conclude that the design of revenue recycling can improve the progressivity of an environmental tax and carbon price. We use the West and Williams (2004) progressivity index to evaluate the progressivity of carbon pricing with and without revenue recycling. We show that the design of revenue recycling plays an important role in determining the progressivity of carbon pricing in Canada. Means-tested rebates and lump-sum dividends lead to progressive outcomes, while cuts to sales and income taxes produce regressive outcomes. We find that despite differences in energy use, the distributional consequences of recycling options are similar across all provinces. There are some differences in the magnitude of the progressivity or regressivity of revenue recycling across provinces, tied to the amount of revenue available to recycle. Our results are particularly relevant in an era of concern about the distributional consequences of carbon taxes; the current federal approach is progressive. Finally, industry support in the form of an OBPS has a non-trivial role in mitigating indirect costs. We transparently outline the consequences of different revenue recycling options, which has relevance for Canadian policymakers and specifically provinces subject to the federal fuel charge.

We next outline the policy context and characteristics of provincial energy systems in Canada. We then describe our methodology for estimating direct costs and indirect costs, our construction of revenue estimates, and the revenue recycling policy experiments we explore. In the fourth section, we present results at \$50 CAD per tonne for the ten Canadian provinces. We first document our estimates of the distribution of carbon pricing costs across income quintiles, and explore the distributional incidence of revenue recycling policies, calculating the progressivity of each counterfactual. We then explore the role of the federal output-based pricing system for large emitters in mitigating households' costs. We conclude with a summary of our results and thoughts on future work.

2 POLICY CONTEXT AND ENERGY SYSTEMS IN CANADA

2.1 Policy Context: Emissions Pricing in Canada

Canada created a minimum standard — both the emissions price and the type of emissions priced — that all provincial pricing plans must meet, called the 'benchmark'. Provinces whose plans do not meet the benchmark are subject to the federal 'backstop' policy. The backstop is a combined regulatory charge on fuel and a separate pricing system for large industrial emitters. The Government of Canada's carbon pricing system for large industrial emitters is an output-based pricing system (OBPS).[4] Facilities are generally assessed an industry-specific emissions-intensity standard and are required to comply with that standard either directly (through a change in emissions intensity) or indirectly by purchasing credits as a compliance option to account for their excess emissions. Facilities with emissions intensities below the standard are rewarded with credits equal to the amount by which they outperform the intensity standard.[5]

Despite a common federal backstop there is substantial variation in pricing systems across Canada (Figure 1).[6] Systems differ in emissions priced, sector-level exemptions, treatment of large emitters, and revenue use (Dobson and Winter, 2018; Dobson et al., 2019; Environment and Climate Change Canada, 2021a, 2022a). This, combined with differences in energy systems, creates variation in carbon pricing costs and the net tax burden across provinces, which motivates our analysis. This is particularly true when considering indirect costs, which depend on each province's built environment and electricity profile, and household consumption patterns. Moreover, the federal government regularly assesses provincial and territorial systems against its benchmark, creat-

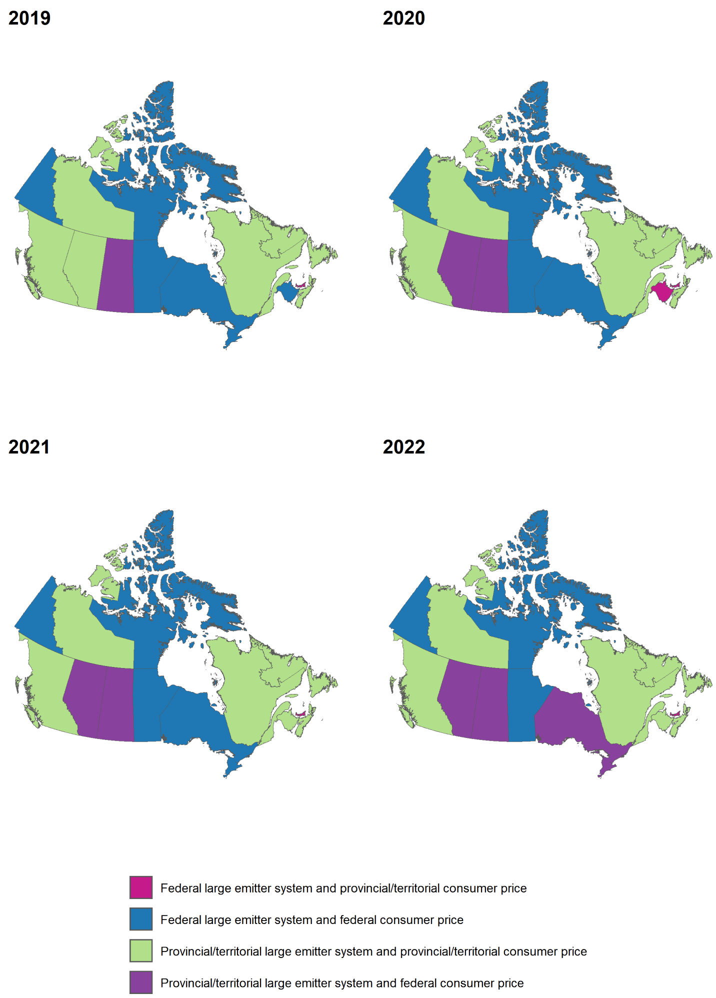
[4] See Dobson and Winter (2018) and Appendix A for the mechanics of the system.

[5] For example, a new gas-fired electricity generation facility has a 2022 standard of 329 tonnes of CO_2e per GWh. If the facility produces 10 GWh of electricity, it and produces 3,290 tonnes of CO_2e it exactly complies with the intensity standard. If it produces more emissions it must purchase credits or pay the prevailing carbon tax to offset the excess emissions. If it produces less than 3,290 tonnes of CO_2e the facility will receive credits it can sell to other large emitters or bank for future use. The intensity standard for new natural gas-fired plants decreases each year, reaching zero in 2030. This means that by 2030 all emissions for gas plants built after January 1, 2021 face a positive marginal price (Environment and Climate Change Canada, 2020d).

[6] For a brief overview of the history and development of emissions pricing in Canada, see Winter (2020). For status as of June 2022, see Environment and Climate Change Canada (2022a). For a discussion of the equivalency of four provincial carbon pricing systems see Mascher (2018).

ing variation over time as provinces fully or partially move in and out of the backstop.

Figure 1: Emissions Pricing Systems across Canada, 2019 to 2022



Note: Policies in place as of October 2022. Saskatchewan's OBPS has a federal top-up, though this is proposed to change in 2023. Quebec and Nova Scotia have cap and trade systems.
Source: Environment and Climate Change Canada (2020b, 2021a, 2022a,b); Government of Saskatchewan (2022); Sawyer et al. (2021).

2.2 Characteristics of Energy Systems and Energy Use

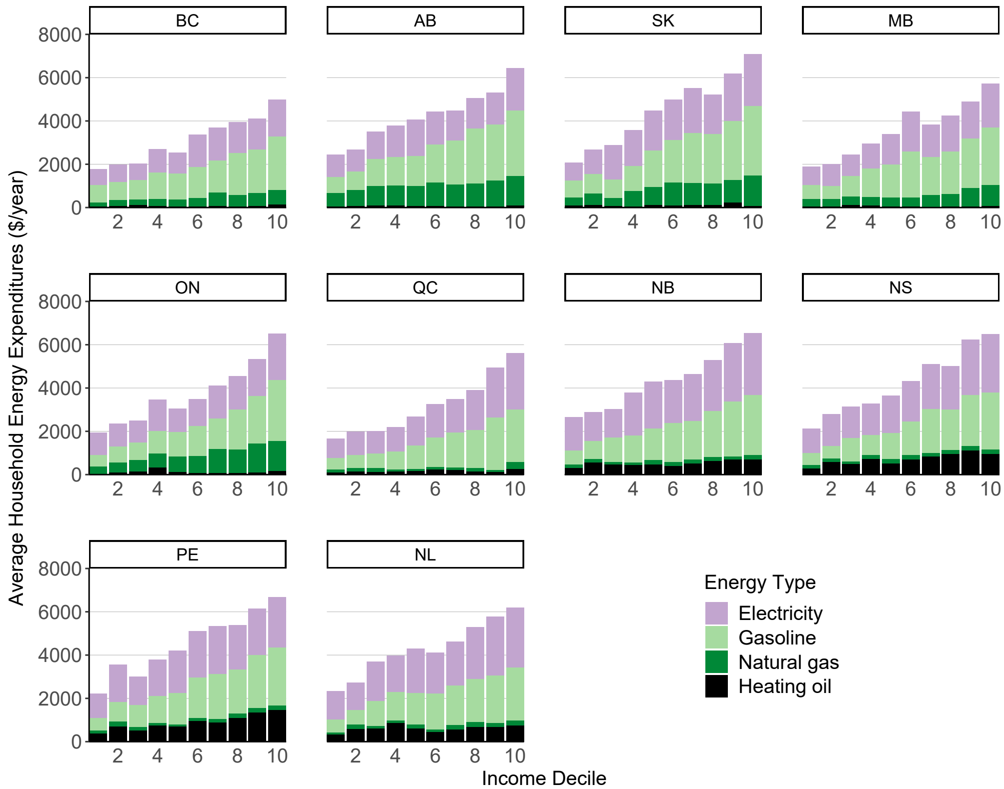
There are three broad types of Canadian household energy use: electricity, fuel for personal transportation (primarily gasoline and diesel), and natural gas and heating oil for space and water heating. (Other sources are a small proportion of overall household energy use.) The direct impact of carbon pricing on Canadian households will depend on the types of energy used by each household (for example, whether a household uses electricity, natural gas or heating oil for home heating), the emissions intensity of electricity in each province, and additional federal or provincial policies to mitigate impacts. In this section, we briefly describe the characteristics of provincial energy systems and energy use.

Expenditures on energy vary by province and across the income distribution (Figure 2 and Figure 3). Gasoline is a significant expenditure item in all provinces, while the magnitude of electricity, natural gas and heating oil expenditures vary by province. Natural gas provides space and water heat in Ontario and Western Canada, while Quebec relies largely on electricity for heat, and a relatively higher proportion of households use heating oil for heat in Atlantic Canada (Natural Resources Canada, nd). This emphasizes the importance of accounting for differences in household energy use and energy systems when constructing households' carbon tax costs.

As incomes rise, energy expenditures generally increase (Figure 2). Direct expenditures on energy generally comprise between six and ten percent of household expenditures (Figure 3). Households in provinces with lower than average incomes, such as Newfoundland and Labrador, have energy expenditures that make up a greater share of their total expenditure (Figure 3).

The greenhouse gas (GHG) emissions intensity of provincial electricity generation also affects carbon price exposure for households. Canadian provinces vary in terms of electricity generation mix (Figure 4). British Columbia (BC), Manitoba (MB), Quebec (QC), and Newfoundland and Labrador (NL) comprise the "hydro" provinces. Ontario (ON) and New Brunswick (NB) are the only two provinces in Canada that generate electricity using nuclear energy. Alberta (AB), Saskatchewan (SK), New Brunswick (NB), and Nova Scotia (NS) are in the process of retiring their coal-fired power plants. These plants must be retired by 2030 or equipped with carbon capture and storage to comply with the federal government's coal-fired power regulations (Canada, 2012, 2018). Natural gas-fired plants comprise increasing shares of electricity generation in provinces like Alberta and Saskatchewan, where medium-term electricity plans involve retrofitting coal plants to burn natural gas (Alberta), and building new natural gas-fired power plants (Alberta and Saskatchewan). While natural gas plants are less emissions-intensive than coal plants, they still emit GHGs and are subject to emissions pricing under provincial large-emitter

Figure 2: Average Household Energy Expenditures by Province and Income Decile ($2020 dollars)



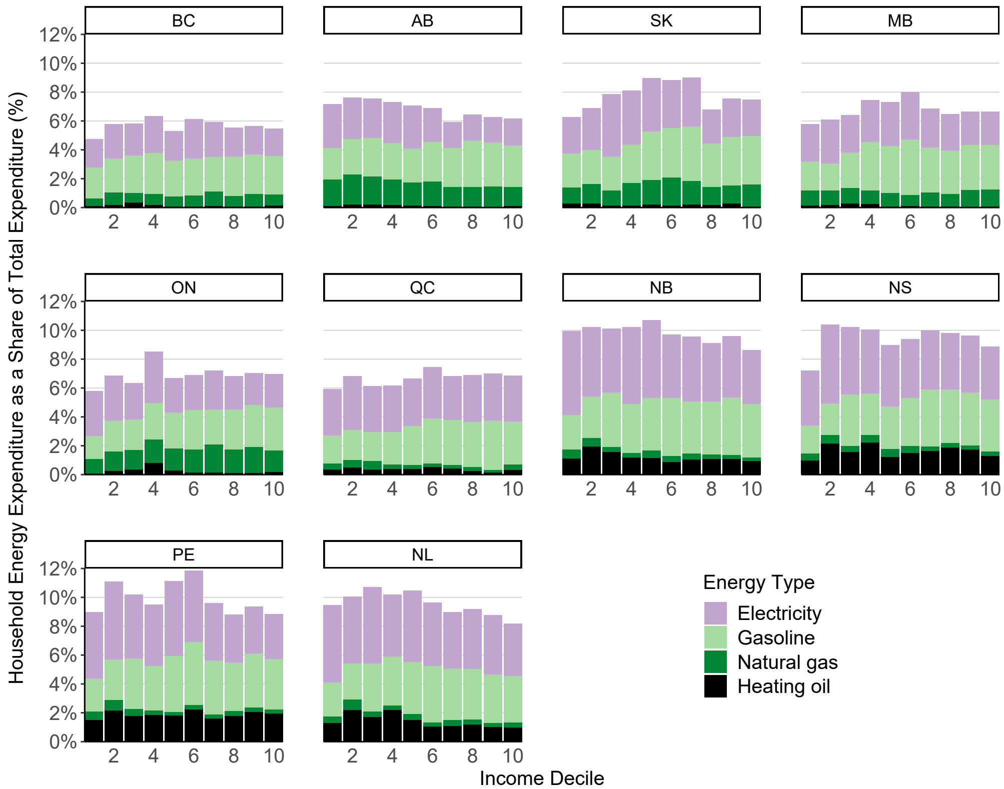
Note: Presents average within-decile energy expenditure. Income decile 1 corresponds to the lowest decile, while decile 10 corresponds to the highest income decile.
Source: Authors' calculations from Statistics Canada (ndb).

systems or the federal OBPS. Prince Edward Island (PE) is unique in that it produces 40 percent of its electricity requirements using domestically produced wind energy, and then imports the remaining 60 percent of its electricity from neighbouring New Brunswick via undersea cables (Canada Energy Regulator, 2020).

The diverse electricity generation profiles result in a wide range of GHG emissions intensities (Table 1). Unsurprisingly, provinces with coal-fired power (AB, SK, NS, NB) have higher electricity generation intensities. The hydro provinces (BC, MB, NL, QC) have electricity generation intensities near zero.

In 2022, the federal OBPS requires coal-fired power plants to achieve a GHG emissions-intensity standard of 594 tonnes/GWh. Most coal plants operate at a GHG intensity of greater than 1000 tonnes/GWh and pay for emissions above the 594 tonnes/GWh standard. Similarly, ex-

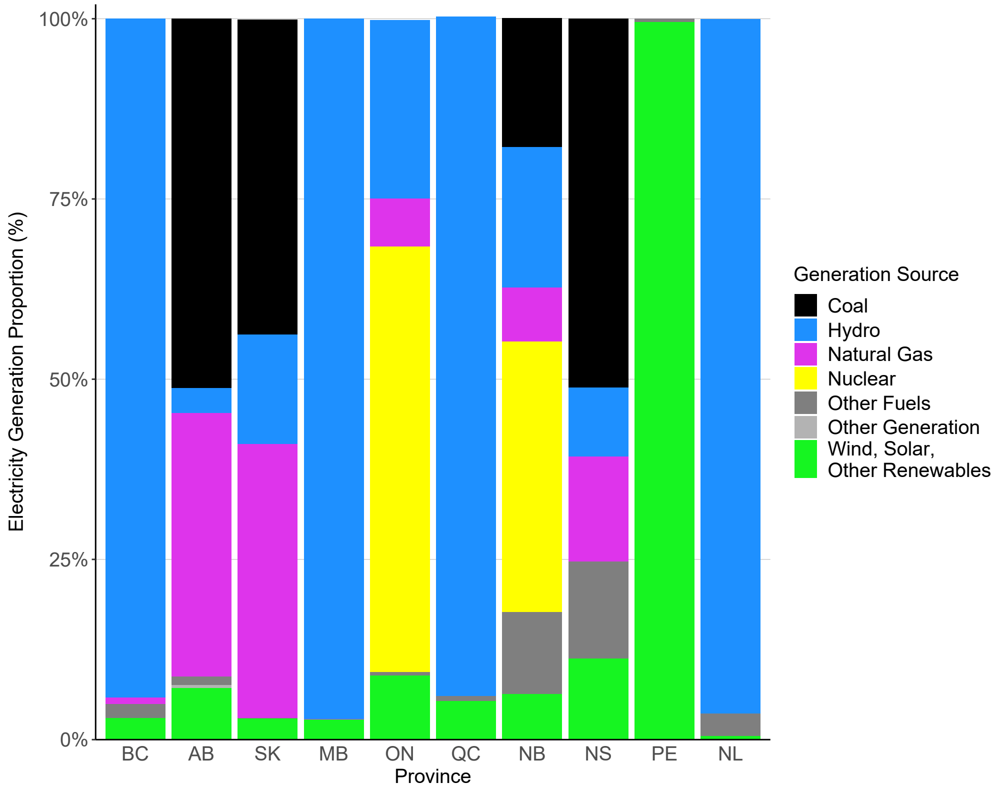
Figure 3: Average Household Energy Expenditures as a Share of Total Expenditure by Province and Income Decile



Note: Presents average within-decile energy expenditure as a share of total expenditure. Income decile 1 corresponds to the lowest decile, while decile 10 corresponds to the highest income decile. Energy shares are expressed as share of total expenditures.
Source: Authors' calculations from Statistics Canada (ndb).

isting natural gas plants have an emissions intensity standard of 370 tonnes/GWh, while natural gas plants built after January 1, 2021 receive declining OBPS credits (Environment and Climate Change Canada, 2020d). Plants that use liquid fuel (e.g. oil-burning plants in New Brunswick) have an intensity standard of 550 tonnes/GWh (Environment and Climate Change Canada, 2020d). Columns three through five of Table 1 show our estimates of the priced intensity of electricity production in each province. Priced intensities represent the carbon cost per GWh that would be charged in each province under the OBPS assuming 2018 emissions intensities. The OBPS lowers the average cost of emissions relative to full carbon pricing and subsequently lowers electricity prices (again, relative to full emissions pricing). This lowers the direct carbon pricing costs paid by households, and the indirect carbon pricing costs passed on by businesses. Gasoline, natural

Figure 4: 2018 Electricity Generation Mix by Province



Note: Based on 2018 electricity generation.
Source: Environment and Climate Change Canada (2020c).

gas and heating oil have combustion GHG emissions intensities unaffected by the OBPS. Table 1 and Table 2 summarize the GHG intensities used in our calculations and the effect on fuel prices at carbon prices of \$50, \$110, and \$170 per tonne (Department of Finance, 2020; Environment and Climate Change Canada, 2020c).

3 METHODOLOGY

We estimate carbon pricing costs (the tax burden of carbon pricing) for households in each province using detailed and rich synthetic microdata from Statistics Canada's Social Policy Simulation Database and Model (Statistics Canada, ndb), version 28.0; 2017 province-specific energy prices; and 2018 province- and energy-specific emissions-intensities. The Social Policy Simulation Database and Model (SPSD/M) includes detailed tax and transfer and expenditure data for over one million 'composite' individuals in over 300,000 households across Canada's ten provinces, along with sev-

Table 1: 2018 Electricity Sector Greenhouse Gas Emissions Intensities by Province ($g\ CO_2e/kWh$)

Province	Generation Intensity	Consumption Intensity	Priced Intensity 2022	Priced Intensity 2026	Priced Intensity 2030	Effective Price ($/kWh) 2022	Effective Price ($/kWh) 2026	Effective Price ($/kWh) 2030
BC	12.3	12.8	7.7	7.7	7.7	0.0004	0.0009	0.0014
AB	630.0	680.0	191.4	249.0	306.5	0.0101	0.0290	0.0552
SK	680.0	710.0	279.7	328.7	377.7	0.0148	0.0383	0.0680
MB	1.3	1.4	0.3	0.3	0.4	0.0000	0.0000	0.0001
ON	29.0	32.0	3.6	3.6	3.6	0.0002	0.0004	0.0006
QC	1.3	1.7	0.0	0.0	0.0	0.0000	0.0000	0.0000
NB	290.0	300.0	87.5	107.6	127.6	0.0046	0.0125	0.0230
NS	720.0	760.0	288.5	345.8	403.1	0.0153	0.0403	0.0726
PE	4.0	180.0	1.8	1.8	1.8	0.0001	0.0002	0.0003
NL	26.0	27.0	8.7	8.7	8.7	0.0005	0.0010	0.0016

Note: All values are in $g\ CO_2e/kWh$. Consumption intensity is the intensity of electricity once it has been delivered to the end-use consumer. These intensities are higher because they account for line loss during transmission and distribution. Priced intensity assumes presence of federal output-based pricing system. Effective price is the product of the priced intensity and carbon price in each respective year, multiplied by a line loss factor of 5.9% to account for line loss during transmission and distribution. This is the average line loss calculated from Environment and Climate Change Canada (2020c). Emissions prices are $50 per tonne CAD in 2022, $110 per tonne in 2026 and $170 per tonne in 2030.
Source: Environment and Climate Change Canada (2020c) and authors' calculations.

Table 2: Greenhouse Gas Emissions Intensities and Carbon Costs by Fuel

	Unit	Emissions Intensity (tonnes/unit)	Carbon Cost per tonne $50	Carbon Cost per tonne $110	Carbon Cost per tonne $170
Natural gas	per GJ	0.05168	2.5838	5.6844	8.7849
Heating oil	per Litre	0.00268	0.1341	0.2950	0.4559
Gasoline	per Litre	0.00220	0.1105	0.2431	0.3757

Source: Department of Finance (2020) and authors' calculations.

eral hundred variables with detailed socio-economic and demographic data.[7] It also allows us to simulate various revenue-recycling policies that could be implemented using carbon pricing revenues. For all results, we use the SPSD/M definition of household as "all individuals sharing the same dwelling" (Statistics Canada, 2019).

We deliberately adopt a 'worst case scenario' approach to measuring carbon pricing costs, to transparently identify the mechanical effects of pricing on households. We assume no behavioural change in response to the implementation of carbon pricing, and do not account for improvements

[7]This is in contrast to public-use microdata files from the Survey of Household Spending, which in 2017 includes data for close to 12,500 households in the interview microdata and just over 4,000 households in the diary microdata.

in the energy efficiency of energy-consuming goods such as vehicles and household appliances, or changes to the electricity generation mix. We use this approach to provide a first-order estimate of household carbon pricing costs and government carbon pricing revenues derived from households. Our approach allows us to cleanly identify the mechanical effects of emissions pricing on households. We divide carbon pricing costs into two categories: direct carbon pricing costs from households' expenditures on gasoline, natural gas, electricity, and heating oil; and indirect carbon costs embodied in the purchase of goods. Indirect carbon pricing costs are those costs embodied in the price of goods and services. Several factors affect households' indirect carbon pricing costs; household expenditure levels, the mix of goods and services purchased, the emissions intensity of households' consumption basket, and the presence of policies like the OBPS that reduce the carbon pricing costs borne by industry. The GHG intensity of electricity is also an important factor influencing indirect costs, as electricity is a universal input to production. Appendix B provides a summary of the embodied emissions per dollar for consumption good types by province, which vary by province.[8]

We outline our approach to estimating each cost type below. We then outline revenue-recycling options and several indicators of the progressivity of the carbon tax on its own and combined with revenue-recycling options.

3.1 Direct Costs Across the Income Distribution

Our approach to constructing direct carbon tax costs relies on imputing household energy use from expenditure. The database portion of SPSD/M includes household expenditure on electricity, natural gas, other fuels[9], and motor fuels and lubricants.[10] We assume all expenditure on 'other fuels' is fuel oil and all expenditure on motor fuels and lubricants is gasoline (we conduct a sensitivity analysis using shares of gasoline and diesel and find no significant difference in imputed energy

[8]Detailed intensity coefficients for consumption and expenditure categories are available upon request. Including all eight levels of aggregation there are 315 consumption and expenditure categories in the Survey of Household Spending. Across ten provinces and five quintiles this amounts to 11,350 individual indirect intensities (not all categories can be assigned an individual intensity at all levels of aggregation). See Appendix B.2 for details.

[9]Other fuels includes fuel oil, other liquid fuel, and other fuels (e.g. wood).

[10]Variable names fxio7, fxio8, fxio9 and fxio15, respectively.

use).

Backing out estimates of energy consumption from expenditure data requires dividing expenditure by energy prices, while making adjustments for fixed costs such as distribution charges for natural gas or electricity. This is all publicly available information and requires collecting and compiling the requisite price information from various sources. We use 2017 price data, allowing for comparison to publicly available Survey of Household Spending data.[11]

One of the challenges we face in collecting energy price data is that in some provinces, households have choice in their utility providers. These utility providers differ in bills' fixed costs and the price of energy, as well as location of service. We adjust for these differences by constructing weighted-average energy prices and weighted-average fixed costs, where the weights are each firm's share of production or sales in its province, or regions within a province, as appropriate. We present natural gas and electricity prices in Table C1 in Appendix C. Residential natural gas prices are unavailable in Atlantic Canada, save for New Brunswick in 2017, which reflects low natural gas use in the region.

For gasoline, diesel and heating oil prices (Table C2 in Appendix C), we use 2017 data from Kalibrate, which has publicly available price data for major cities within each province.[12] We use the simple average for our primary results. We conduct a sensitivity analysis using population-weighted average prices and find that prices vary by only a few percentage points. For transportation fuel, the baseline price we use is regular gasoline. We compare the results using price of other grades of gasoline and diesel in a sensitivity analysis and find no appreciable difference.

SPSD/M provides households' energy expenditures exclusive of tax. Using this energy expenditure data and the energy prices detailed in Tables C1 and C2, we impute energy use of type j in

[11]Statistics Canada constructs synthetic expenditure data in SPSD/M from pooled Survey of Household Spending data from the base year, the year prior to the base year, and the year after the base year, with greater weight given the the base year. The base year for SPSD/M version 28.0 is 2016.

[12]Kalibrate did not have heating oil prices for Saskatchewan, Manitoba and Alberta and we impute these prices using data from Statistics Canada (ndd). We calculate the ratio of tax-exclusive heating oil prices to tax-inclusive heating oil prices for the other seven provinces. This produces an adjustment factor of 0.897. We then multiply the tax-inclusive heating oil prices for Saskatchewan and Manitoba from Statistics Canada (ndd) by this adjustment factor of 0.897 to impute tax-exclusive heating oil prices for those two provinces. A heating oil price for Alberta is also unavailable from Statistics Canada (ndd) and we assign Saskatchewan's imputed heating oil price to Alberta due to the proximity and similar industrial structure of the two provinces.

province p and year t for household h as follows:

$$use_{j,p,h,t} = \frac{E_{j,p,h,t} - f_{j,p,t}}{c_{j,p,t}} \tag{1}$$

where E is expenditure on energy, f is fixed costs, and c is the variable cost of energy purchased by consumers.[13] Motor gasoline, diesel, and fuel oil prices do not include fixed costs, and we set $f = 0$ for those energy types.

Once we convert energy expenditures into consumption of energy in natural units (e.g. GJ, kWh), we multiply by the cost of carbon per energy unit. In our scenarios we focus on emissions prices of \$50, \$110, and \$170 per tonne of CO_2e, corresponding to the Government of Canada's announced carbon pricing schedule of \$50 per tonne CO_2e in 2022, \$110 per tonne CO_2e in 2026, and \$170 per tonne CO_2e in 2030 (Environment and Climate Change Canada, 2020a). We then sum across all households within a province to calculate total direct carbon pricing revenue.

3.2 Indirect Costs

To estimate indirect costs, we adapt the Fellows and Dobson (2017) consumption-based greenhouse gas accounting model; we describe our application of the model in detail in Appendix B. Briefly, the model calculates the emissions embodied in final consumption goods using a multi-province, multi-sector input-output matrix derived from Statistics Canada's Provincial Symmetric Input-Output Tables (Catalogue 15-211-XCE). The approach is similar to a conventional input-output (IO) model. Where a typical IO model defines multipliers for productive inputs like labour (e.g. jobs generated per \$1000 in expenditure), in this application the model defines multipliers for emissions (tonnes of CO_2e per \$1000 in expenditure). This is done by substituting a vector of direct emissions (at the province-by-sector level) into a typical inter-regional IO model where there would conventionally be a vector of factors of production (e.g. labour). Using this approach, we produce multipliers relating the generation of all upstream emissions (direct and indirect) from the production of final goods in each province-sector pair.

[13] For electricity expenditures in BC and Quebec we also adjust for a two-tiered pricing system.

Our indirect multipliers relate upstream emissions to final goods' production for each province-sector pair. We map these intensities onto household expenditures and expenditure categories by province and quintile using 2017 data from Statistics Canada Table 11-10-0223 (Statistics Canada, ndc). The end result is a dataset encompassing the average indirect carbon costs per dollar of expenditure embodied in households' consumption by quintile and province, both with and without the federal OBPS. We then multiply these indirect emissions intensities by household expenditures for each household in SPSD/M to produce indirect carbon costs for each household. As with our calculation of direct costs, our indirect carbon cost estimates are of the 'worst-case' variety since we assume full pass-through of carbon pricing costs from businesses to households. This means that our indirect costs are an upper bound on potential household indirect carbon costs.

3.3 Revenue Availability and Recycling Counterfactuals

We compare the distributional effects of methods of spending carbon pricing revenues, motivated by current and past policy choices. To calibrate various revenue recycling options, we estimate the revenue that is available for recycling in each province. This calculation accounts for carbon tax revenue raised through the export of products to other Canadian provinces, and lost through the purchase of imports from other Canadian provinces (see Appendix B.1.1 for details). For example, Alberta is a net exporter of embodied emissions to the rest of Canada; the carbon tax costs paid upstream on oil and gas products exported from Alberta to British Columbia are collected within Alberta and can be spent within Alberta. This means that Alberta's available carbon pricing revenue exceeds aggregate household carbon costs in the province. Ontario, on the other hand, is a net importer of embodied emissions and its available carbon pricing revenues are less than aggregate household carbon costs within the province.[14]

To calculate available revenue we use direct carbon costs and our estimated indirect available revenue per household. Total direct carbon costs remain the same for gasoline, natural gas, elec-

[14]While the model we use to identify indirect costs assumes full carbon tax pass-through, because our methodology relies on identifying revenue raised from domestic households there is no revenue associated with carbon tax pass-through to international export markets.

tricity and heating oil when calculating available revenue since they are paid within each province. Indirect available revenue per household is multiplied by the number of households in each income quintile within each province. We sum the total direct costs and indirect available revenue within each province to produce an estimate of available carbon pricing revenue.

We calculate available revenue under two scenarios. First, we account for the existing federal OBPS, assuming it applies in all provinces. We do this for ease of analysis, though there are differences in actual large-emitter systems. Our simplifying assumption is unlikely to be material, particularly as the federal government requires provincial systems to be at least as stringent and have similar scope as the backstop (Environment and Climate Change Canada, 2021b). The presence of the OBPS affects the magnitude of electricity costs and indirect costs. In OBPS scenarios we assume that the full cost-savings provided by the OBPS are passed to households. Second, we estimate available revenue in a scenario without the OBPS, where large emitters face the full carbon price. This second scenario leads to higher direct and indirect carbon costs for households, and a greater amount of available revenue for recycling. In both cases, we assume full pass-through of costs to households.

After calculating total household carbon tax costs and available carbon tax revenues for each province, we analyse revenue recycling options using Statistics Canada's Social Policy Simulation Database and Model (SPSD/M).[15] The SPSD/M is a static microsimulation model for analyzing the distributional impacts of government tax and expenditure policy. It contains rich microdata at the individual and household level and detailed representations of existing federal and provincial taxation and fiscal policy. Using the SPSD/M we explore the distributional effects of four revenue-recycling options, motivated by existing policy. For example, BC has a means-tested lump sum rebate and personal income tax reductions, the federal rebate in backstop provinces is lump-sum, Alberta had a means-tested lump sum rebate before becoming a backstop province, and New Brunswick reduced personal income taxes and fuel taxes.

[15] This analysis is based on Statistic's Canada's Social Policy Simulation Database and Model, version 28.0. The assumptions and calculations underlying the simulation results were prepared by the authors and the responsibility for the use and interpretation of these data is entirely that of the authors.

First, we evaluate means-tested rebates, by simulating increases to the federal sales tax (GST) credit. Second, we model a lump-sum dividend, similar to the Climate Action Incentive provided to households in backstop provinces. Our revenue recycling counterfactual in this instance differs from the federal policy in two important ways. First, we use all revenue from the fuel charge and return it to households. Second, we incorporate revenue from large emitters (net of the OBPS subsidy) into available revenue. In contrast, the backstop rebates approximately 90 percent of revenue from the federal fuel charge to households (Government of Canada, nd) and does not use revenue from large emitters. Our third simulation is cuts to the provincial portion of sales taxes (where applicable).[16] Fourth, we evaluate changes to personal income taxes, via increasing the provincial basic personal exemption. The first two options are implementable by either federal or provincial governments (provincial low-income tax credits are rebated in conjunction with the federal GST credit). The latter two are more naturally thought of as provincial revenue-recycling options; though they could be implemented federally — through province-specific federal tax rates or tax-point transfers to provinces — it would create interprovincial inequities. We do not model fuel tax decreases due to their narrow scope for reducing household costs and their counterproductive effect on emissions.

3.4 Progressivity Indicators

There is no agreed-upon measure to identify the progressivity or regressivity of tax systems and tax changes (Rosen et al., 2016). Approaches specific to carbon pricing or energy policy include a Lorenz curve, Gini coefficients, the Suits (1977) index, and average tax burden (tax cost as a share of income) to indicate progressivity or regressivity of the carbon tax itself (see, for example, Metcalf (1999); West and Williams III (2004); Rivers (2012); Dissou and Siddiqui (2014); Meng et al. (2014); Beck et al. (2015); Goulder et al. (2019)). The Suits index is analogous to a Gini coefficient, and ranges between -1 and $+1$. However, West and Williams (2004) show the Suits index can give misleading results when examining two tax changes with opposite effects. Specifi-

[16] Alberta does not have a sales tax.

cally, a revenue-neutral tax reform (which we model) has two exactly offsetting effects, and so the Suits index is undefined. West and Williams propose an alternative index to resolve this problem:

$$W_i = \sum_{i=1}^{5} t_i - \sum_{i=1}^{5} \left[\left(-t_i + 2 \sum_{j=1}^{i} t_j \right) \cdot y_i \right], \tag{2}$$

where y_i is quintile i's share of total expenditure and t_i is the burden of the tax change on quintile i, expressed as a fraction of total expenditure, and is positive for a tax increase on quintile i, and negative for a tax decrease.[17] Here, $\sum_{i=1}^{5} t_i$ is the aggregate burden of a tax change as a share of expenditure. The West and Williams index is positive when the tax change is progressive, negative when the tax change is regressive and zero when the tax change is neutral (i.e., a flat tax). The sum of the West and Williams indices for the carbon tax and the corresponding revenue recycling scenario gives the progressivity of the overall tax change.

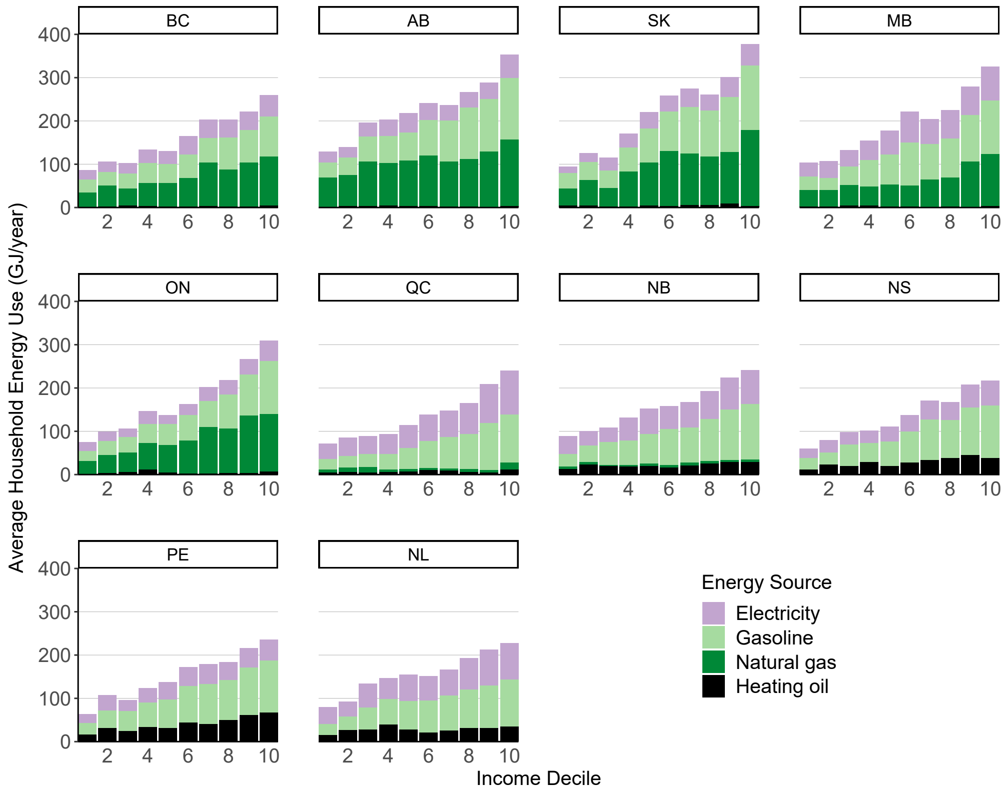
4 RESULTS AND ANALYSIS

4.1 Energy Use by Households

We present average within-decile imputed energy use by province in Figure 5. Echoing the results in Figures 2 and 3, energy use generally increases with income. This is especially true for gasoline. Use of heating fuels such as natural gas is more variable, likely related to differences in the size and energy efficiency of homes, and differing climates across the country. There is a stark East-West divide in natural gas use, with very little use in Quebec or Atlantic provinces, and similarly stark differences in heating oil use. Electricity use is higher in provinces like Quebec and Newfoundland and Labrador where electric heating is more prevalent. As described above, with household-specific energy use we apply emissions intensities and various carbon price levels to obtain household carbon pricing costs, detailed in the next section.

[17]Equation (7) differs from the expression in West and Williams (2004); there is an error in the published version of the paper confirmed by correspondence with the authors.

Figure 5: Imputed Energy Use by Province and Income Decile

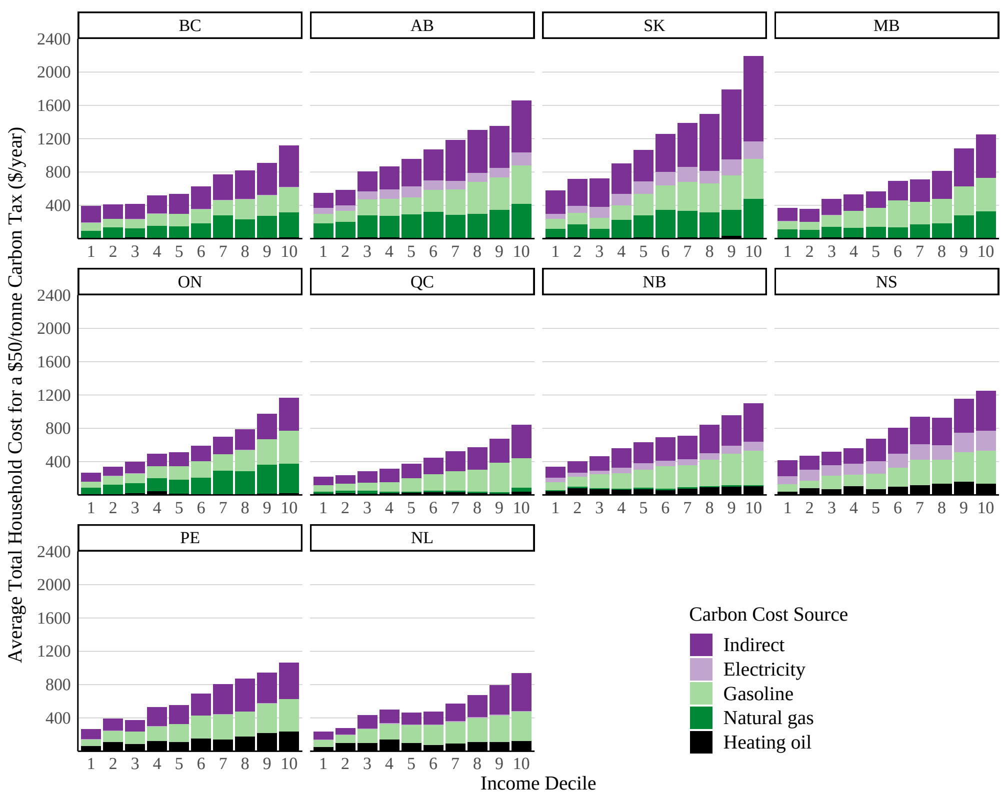


Note: Presents imputed within-decile average energy use for each province based on SPSD/M v. 28.0 energy expenditure and 2017 energy prices. BC expenditure adjusted to remove BC carbon tax prior to imputing energy use. Quebec expenditure adjusted to remove cost of cap and trade system prior to imputing energy use. Includes adjustments through federal OBPS.

4.2 Household Carbon Costs

Household carbon costs vary by province and across the income distribution. Figure 6 and Table 3 present average costs by cost source, province and income decile, at \$50 per tonne of CO_2e (see Appendix D for cost estimates by province and decile at \$110 and \$170 per tonne, and section 4.6 for costs with and without the OBPS). Our results are not normalized by household size. On average, higher income households are larger and have more earners that households in lower income deciles (see Table C3 in Appendix C). See Appendix D for cost estimates by province and decile for urban and rural households and by household size. Costs range from \$215 in Quebec to a high of \$574 in Saskatchewan for the lowest income decile. Quebec again has the lowest costs at \$839 for the highest income decile, and Saskatchewan is again the highest-cost province at $2,194 for the top earning households. Households in Alberta and Saskatchewan have higher carbon costs than households in other provinces. Much of the difference comes from the relatively high greenhouse gas emissions intensity of electricity in the two provinces. This high emissions-intensity leads to higher direct electricity carbon costs and much higher indirect carbon costs, as businesses pass along higher electricity-related carbon costs throughout the supply chain.[18] A second cause of higher costs in Alberta and Saskatchewan is households' higher transportation fuel use and natural gas use (Figure 5). A third reason is Alberta and Saskatchewan are high-income provinces. On average, higher income households use more gasoline, natural gas and electricity than households in lower income deciles. They also use their higher incomes to purchase more goods and services, which increases their indirect household carbon costs.

Figure 6: Household Carbon Tax Costs by Source, Province and Income Decile



Note: Presents within-decile average costs, based on SPSD/M v. 28.0 energy expenditure and imputed energy use. Assumes carbon price of $50 per tonne. BC expenditure adjusted to remove BC carbon tax prior to imputing energy use. Quebec expenditure adjusted to remove cost of cap and trade system prior to imputing energy use. Includes adjustments through federal OBPS. Income decile 1 corresponds to the lowest decile, while decile 10 corresponds to the highest income decile. Household counts and decile income thresholds differ by province.

[18] This is a direct result of our assumption of full cost pass-through by businesses.

Table 3: Average Carbon Tax Costs by Province and Income Decile (2020 dollars)

Province	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	Mean	Median
BC	394	409	418	517	534	627	773	817	910	1,121	652	538
AB	548	580	805	863	953	1,070	1,183	1,304	1,351	1,661	1,032	882
SK	574	712	720	904	1,065	1,255	1,390	1,497	1,790	2,194	1,210	1,005
MB	365	353	473	532	565	691	710	812	1,080	1,252	683	562
ON	266	337	398	494	511	591	699	792	972	1,161	622	522
QC	215	235	281	312	377	445	523	571	676	839	447	375
NB	335	406	462	558	628	689	708	842	956	1,100	669	600
NS	419	467	519	562	671	802	934	924	1,155	1,252	771	678
PE	263	389	371	530	555	692	808	874	946	1,060	649	591
NL	237	281	433	502	460	471	572	676	796	936	536	459

Note: Presents within-decile average costs, and provincial mean and median costs, based on SPSD/M v. 28.0 energy expenditure and imputed energy use. BC expenditure adjusted to remove BC carbon tax prior to imputing energy use. Quebec expenditure adjusted to remove cost of cap and trade system prior to imputing energy use. Shows average within-decile carbon costs, at \$50 CO_2e CAD per tonne. Income decile 1 corresponds to the lowest decile, while decile 10 corresponds to the highest income decile. Household counts and decile income thresholds differ by province.

4.3 Available Carbon Pricing Revenues

We report our available revenue estimates in Table 4. Provinces with available revenues higher than aggregate household costs include Alberta, Saskatchewan, New Brunswick and Nova Scotia. These provinces are net exporters of embodied emissions, with some of these costs exported (passed through) to consumers and businesses in other provinces. British Columbia is the province with the closest match between available revenues and aggregate household costs (97 percent), while Prince Edward Island has available carbon pricing revenues that are only 84.2 percent of aggregate household costs. This is due in large part to PEI importing 60 percent of its electricity from New Brunswick, which in turn receives the carbon pricing revenues paid by PEI residents. Provinces with available revenues greater than aggregate household costs have more capacity to restore the purchasing power of households through revenue recycling policies.

4.4 Revenue Recycling Scenarios

Using the available revenues outlined in Table 4, we compare different revenue recycling scenarios across provinces. As each province has different household energy use patterns (Figure 5), carbon tax costs and revenues differ across provinces (Table 3 and Table 4), meaning household rebates

Table 4: Available Revenues vs Aggregate Household Cost, 2020 dollars (millions)

	$50 per tonne			$110 per tonne			$170 per tonne		
	Household Cost	Revenue	$\frac{\text{Revenue}}{\text{Cost}}$%	Household Cost	Revenue	$\frac{\text{Revenue}}{\text{Cost}}$%	Household Cost	Revenue	$\frac{\text{Revenue}}{\text{Cost}}$%
BC	1280.6	1242.3	97.0	2817.3	2734.0	97.0	4354.0	4226.9	97.1
AB	1658.1	1987.9	119.9	3759.7	4481.7	119.2	5983.1	7093.9	118.6
SK	541.0	579.0	107.0	1215.5	1298.4	106.8	1917.5	2044.6	106.6
MB	344.2	323.3	93.9	757.4	711.6	94.0	1170.5	1100.2	94.0
ON	3413.8	3225.6	94.5	7510.4	7099.1	94.5	11606.9	10975.4	94.6
QC	1672.0	1508.8	90.2	3678.4	3320.6	90.3	5684.8	5133.8	90.3
NB	220.0	249.0	113.2	495.8	559.4	112.8	784.7	882.4	112.5
NS	317.8	346.4	109.0	728.8	790.6	108.5	1172.0	1265.9	108.0
PE	40.8	34.3	84.2	89.7	75.6	84.3	138.6	116.9	84.3
NL	120.2	111.9	93.1	264.4	246.3	93.2	408.6	380.7	93.2

Note: Presents aggregate household cost and available revenue, and revenue as a percentage of cost, by province under three carbon pricing scenarios. Calculations based on SPSD/M v. 28.0 energy expenditure and imputed energy use. BC expenditure adjusted to remove BC carbon tax prior to imputing energy use. Quebec expenditure adjusted to remove cost of cap and trade system prior to imputing energy use. Assumes presence of federal OBPS. Household counts differ by province.

and net returns (rebates less costs) also differ across provinces. We compare four scenarios: (1) a means-tested sales tax credit[19] increase; (2) a lump sum dividend; (3) a reduction in the provincial portion of the sales tax rate; and (4) a personal income tax basic exemption increase.

Table 5 presents current and counterfactual policy parameters for a single tax-filer 'before' and 'after' revenue-recycling at $50 CAD per tonne; the "actual" parameters are those programmed in SPSD/M v. 28.0 and reflect actual policy at the time of version release. Table C5 in Appendix C reports policy parameters by tax family composition for the GST credit and lump sum dividend. Counterfactual "modelled" policy parameters are set at a level that uses all available carbon pricing revenue in each province.[20] In the lump sum dividend scenarios, we reduce existing lump sum rebates to zero and adjust the parameters to use all available carbon pricing revenue for rebates. As a caveat, our analysis is static, and these results are based on current levels of imputed energy use and estimated emissions. Our available revenues do not account for reductions in emissions that will occur as households and firms respond to carbon pricing. These policy parameters are

[19] The goods and services tax (GST) or harmonized sales tax (HST) credit is a quarterly payment to lower-income households to offset GST/HST these households pay. The credit amount is a function of marital status, family size and family income.

[20] The exception is a sales tax cut in Saskatchewan at $170/tonne (Appendix D). Available revenues in that scenario exceed the revenue from Saskatchewan's provincial sales tax and so after cutting the provincial sales tax to 0%, $661 million (approximately 36% of available revenue for Saskatchewan at $170/tonne) in revenue remains.

upper bounds on the level of possible revenue recycling. Governments will need to fine-tune these policy settings based on updated estimates of available revenue. Similarly, we do not model non-revenue-recycling uses of carbon pricing revenues — such as Alberta's use of its large emitter system revenues to fund emissions-reduction technologies — which have their own opportunity costs.

Table 5: Revenue Recycling Policy Scenarios for a Single Tax-Filer at $50 per tonne (2020 CAD)

	GST Credit Increase		**Lump Sum Dividend**		**Sales Tax Decrease**		**Increased PIT Basic Exemption**	
	Actual	Modelled	Actual	Modelled	Actual	Modelled	Actual	Modelled
BC	$296	$869	$190	$357	7%	4.97%	$10,886	$22,290
AB	$296	$1,356	$589	$642	-	-	$19,369	$29,952
SK	$296	$1,424	$717	$745	6%	3.3%	$16,065	$27,235
MB	$296	$868	$394	$363	7%	5.1%	$9,809	$14,155
ON	$296	$794	$353	$326	8%	6.7%	$10,782	$20,189
QC	$296	$669	-	$234	9.975%	8.8%	$15,532	$17,828
NB	$296	$967	$297	$458	10%	7.9%	$10,459	$17,460
NS	$296	$1,026	-	$1097	10%	7.5%	$8,481	$17,085
PE	$296	$777	-	$303	10%	8.6%	$10,000	$14,374
NL	$296	$761	-	$278	10%	8.8%	$9,595	$14,532

The GST credit columns report the federal sales tax credit within SPSD/M received by a single tax-filer for the 2019 tax year (payments between July 2020 and June 2021); Table C5 presents parameters by tax family. These differ very little from the 2020 tax-year payments (see Table C6 in Appendix C). The GST credit is means-tested; thresholds are reported in Table C7, Appendix C. We do not adjust the income thresholds for the GST credit, mirroring the current GST credit system: spouses or single parents' first child under 18 receive the same payment as the tax filer, and children under 18 receive a credit approximately half that of the tax filer.

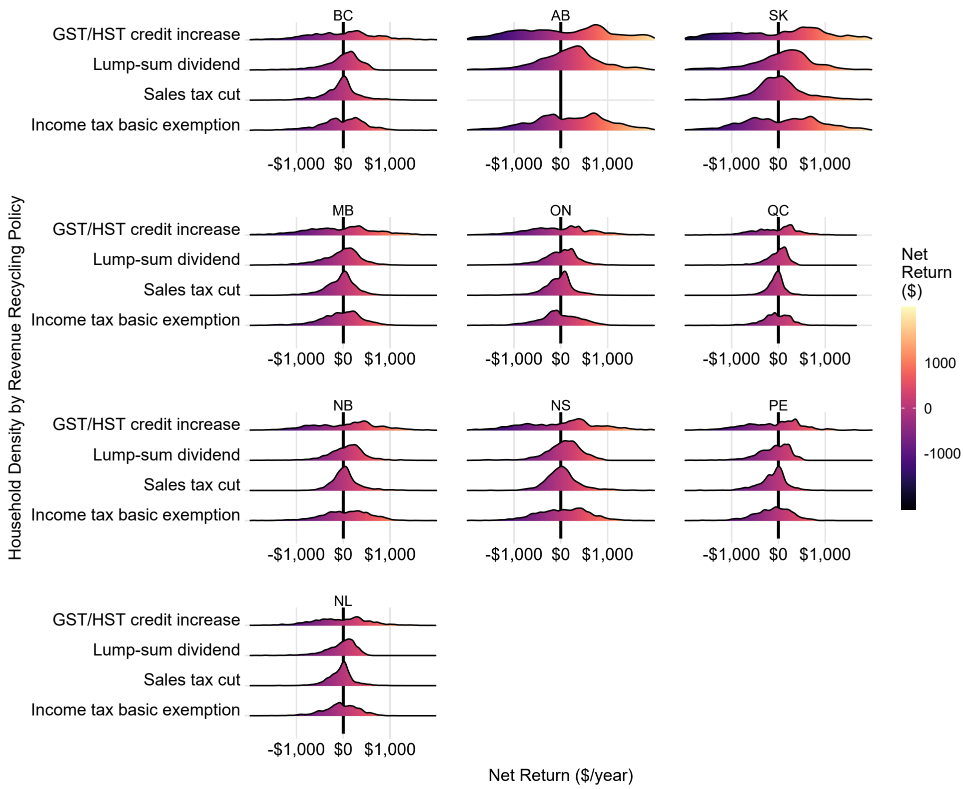
The lump sum dividend values in Table 5 (and Table C5 in Appendix C) reflect current policy. For the backstop provinces (Alberta, Saskatchewan, Manitoba, Ontario and New Brunswick), the 'actual' lump sum dividend values are SPSD/M estimates of the federal Climate Action Incentive (CAI) for the 2021 tax year. For BC, SPSD/M includes the announced 2021 tax-year Climate

Action Tax Credit (CATC). We use the 2021 tax year as both BC and the Government of Canada use the 2021 tax year to determine rebates in 2022 (payments between July 2022 and June 2023), and Canada's carbon tax is $50 per tonne in 2022. Quebec, Nova Scotia, PEI, and Newfoundland and Labrador earmark carbon pricing revenues for other purposes, and do not have household revenue-recycling systems (Environment and Climate Change Canada, 2021a), so there is no current lump sum rebate. Both Table 5 and Table C5 present dividend payments to urban households. Mirroring the federal Climate Action Incentive (CAI), we scale dividends for rural households to be ten percent higher than the default payments (not reported). Similarly, we follow the CAI in making dividend payments for the spouse or single parents' first child under 18 half of the value of the dividend for the first adult in a household, and the dividend for each child in the household is one-quarter of the first adult value. The lump sum dividend policy parameters are not a true before-and-after comparison for several reasons, but we include them for illustrative purposes. Specifically, BC's CATC is means-tested and does not use all available revenue, and the federal CAI uses only 90 percent of available revenue from the fuel charge. The sales tax values in Table 5 report the provincial portion of the sales tax before and after revenue recycling, net of the 5% federal sales tax. The increased basic exemption values show the SPSD/M estimates of provincial personal income tax basic exemptions for the 2020 tax year and the counterfactual values using all available revenues.

With these policy parameters in mind, we can turn to the distributional consequences of the four revenue-recycling scenarios. The distributions of net returns (rebates less costs) by province for each scenario are plotted in Figure 7. We show net returns by province and income quintile for each scenario in Figures 8, 9, 10, and 11. Table 6 presents average within-quintile costs, rebates and net returns for each revenue-recycling scenario and by province.

Figure 7 compares net returns across revenue-recycling policies and illustrates the trends across all provinces. The means-tested GST credit has a relatively flat distribution, with a small peak to the right of a $0 net return. The distributions of net returns are approximately normal bell curves for the sales tax rate cut and the lump sum dividend. The lump sum dividend distribution is right-

Figure 7: Household Net Returns by Province under Different Revenue-Recycling Scenarios

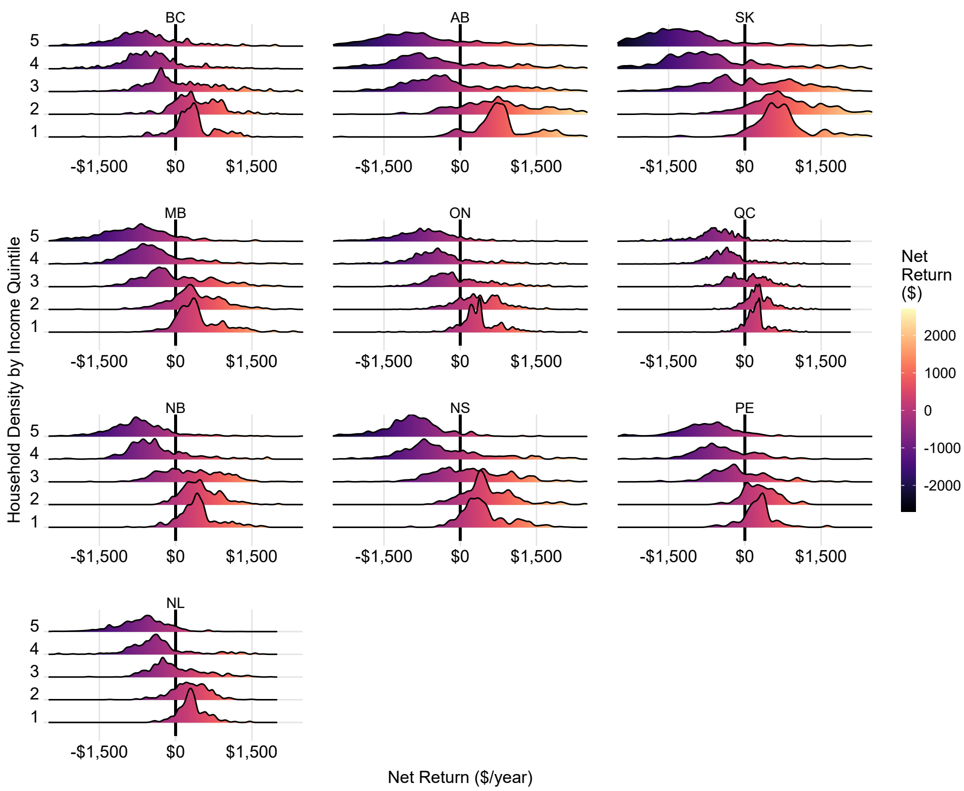


Note: Presents the distribution of household net returns (rebate less costs) by province, based on SPSD/M v. 28.0 energy expenditure and imputed energy use. Positive value implies rebate greater than costs; negative value implies cost greater than rebate. Assumes carbon price of $50 per tonne. Federal backstop modelled, including output-based pricing system. The height of each plot indicates the relative frequency of households obtaining a specific net return value. Alberta does not have a provincial sales tax, so that distribution is omitted.

skewed, showing that most households have a positive net return (rebate greater than costs). The sales tax cut has the tightest distribution. The increase to the personal income tax basic exemption is a bimodal distribution for most provinces, with varying dispersion.

Figure 8 shows the distribution of net returns by quintile and province for the GST credit. For all provinces, the majority of households in the bottom two income quintiles receive a positive net return (see Table 6). Correspondingly, the majority of households in the top two income quintiles have a negative net return. The distribution for the middle income quintile is mixed across provinces. Six provinces (BC, Alberta, Manitoba, Ontario, PEI, and Newfoundland and Labrador) have the majority of households with a negative net return and the other four provinces have the majority of middle-quintile households with a positive net return. As a means-tested use of revenue, this pattern is not surprising. Average net returns are always negative for the top two income quintiles, and always positive for the bottom two quintiles, regardless of province. Interestingly, average within-quintile net returns for the second quintile are often higher than for the first quintile; the exceptions are Manitoba, Ontario, and Newfoundland and Labrador where the reverse is true. As we note above, higher available revenue in some provinces, notably Alberta and Saskatchewan, translates into higher average rebates across the income distribution.

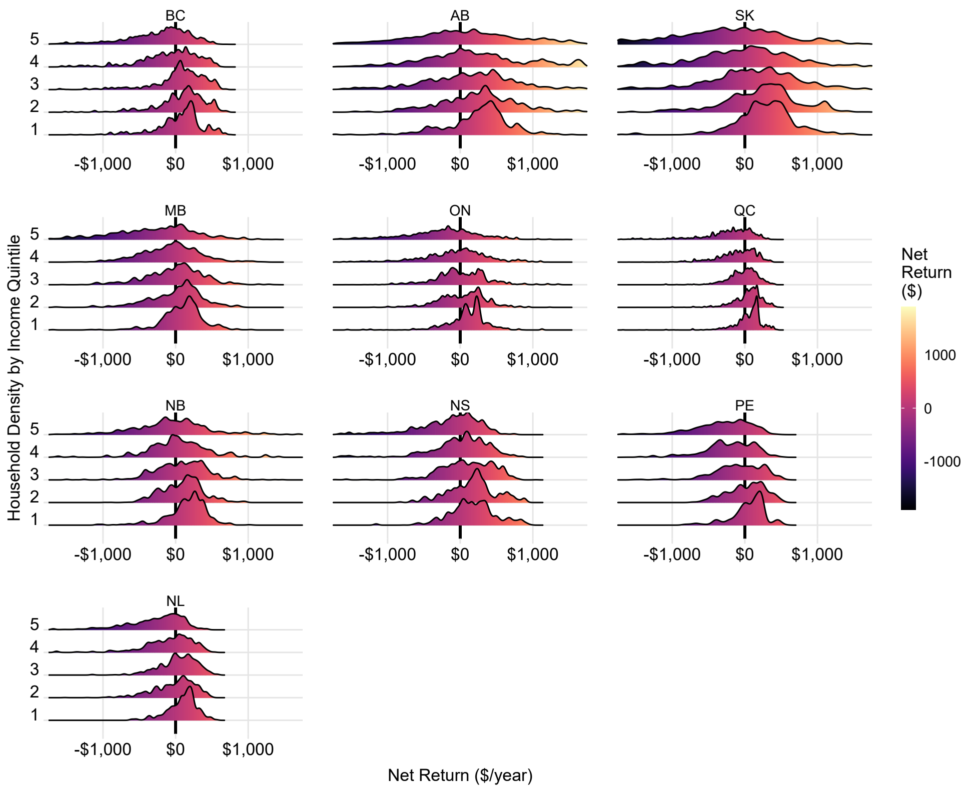
Figure 8: Household Net Returns by Province and Income Quintile When Carbon Pricing Revenues Are Used to Increase the GST/HST Credit



Note: Presents the distribution of household net returns (rebate less costs) by quintile and province, based on SPSD/M v. 28.0 energy expenditure and imputed energy use. Positive value implies rebate greater than costs; negative value implies cost greater than rebate. Assumes carbon price of $50 per tonne. Federal backstop modelled, including output-based pricing system. Income quintile 1 corresponds to the lowest quintile, while quintile 5 corresponds to the highest income quintile. The height of each plot indicates the relative frequency of households obtaining a specific net return value.

In contrast to the means-tested rebate, the lump-sum dividend rebates are a function of household size rather than income. The result is that a lump-sum dividend policy provides lower rebates and hence lower net returns for low-income households than the means-tested approach. The lump sum dividend benefits the majority of households in all but the top income quintile in most provinces (Figure 9). This translates to a flatter distribution for all provinces. The share of households with a positive net return in the bottom income quintile ranges from 66% (BC and PEI) to 79% (Saskatchewan and New Brunswick). In the top income quintile, that share ranges from 22% (PEI) to 51% (Alberta).

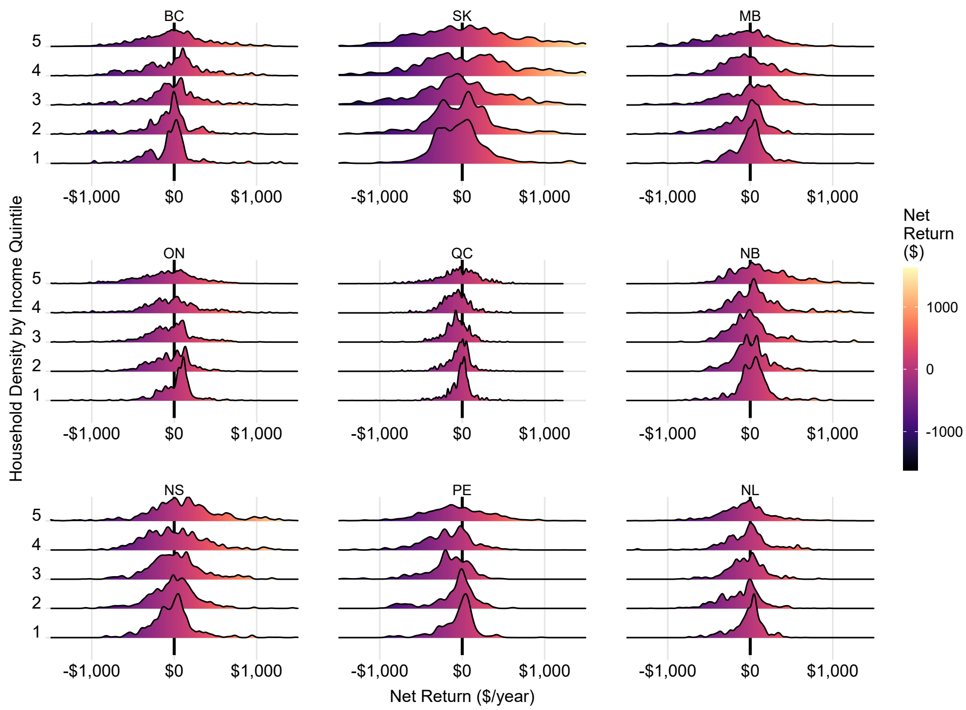
Figure 9: Household Net Returns by Province and Income Quintile When Carbon Pricing Revenues Are Used to Provide a Lump-Sum Dividend



Note: Presents the distribution of household net returns (rebate less costs) by quintile and province, based on SPSD/M v. 28.0 energy expenditure and imputed energy use. Positive value implies rebate greater than costs; negative value implies cost greater than rebate. Assumes carbon price of $50 per tonne. Federal backstop modelled, including output-based pricing system. Income quintile 1 corresponds to the lowest quintile, while quintile 5 corresponds to the highest income quintile. The height of each plot indicates the relative frequency of households obtaining a specific net return value.

The provincial average net return is negative (though small) for six provinces and positive for the other four, ranging from -$125 (PEI) to $159 (Alberta). As the province with lowest available revenue compared to aggregate household costs (Table 4), PEI is most affected by a proportional revenue-return policy: it is the only province to have the majority of quintile 3 households with costs greater than the modelled rebate, and the only province with the majority (57%) of households with a negative net return. In contrast, provinces with available revenues greater than aggregate household costs — Alberta, Saskatchewan, New Brunswick and Nova Scotia — have positive net returns for the majority of households in quintiles 1 through 4, and Alberta even has positive net returns for a slim majority (51 percent) of households in quintile 5. This is demonstrated by the tight distributions of net returns for the lower income quintiles in Figure 9 and the relatively flatter distributions for quintiles 4 and 5.

Figure 10: Household Net Returns by Province and Income Quintile When Carbon Pricing Revenues Are Used to Reduce the Provincial Sales Tax



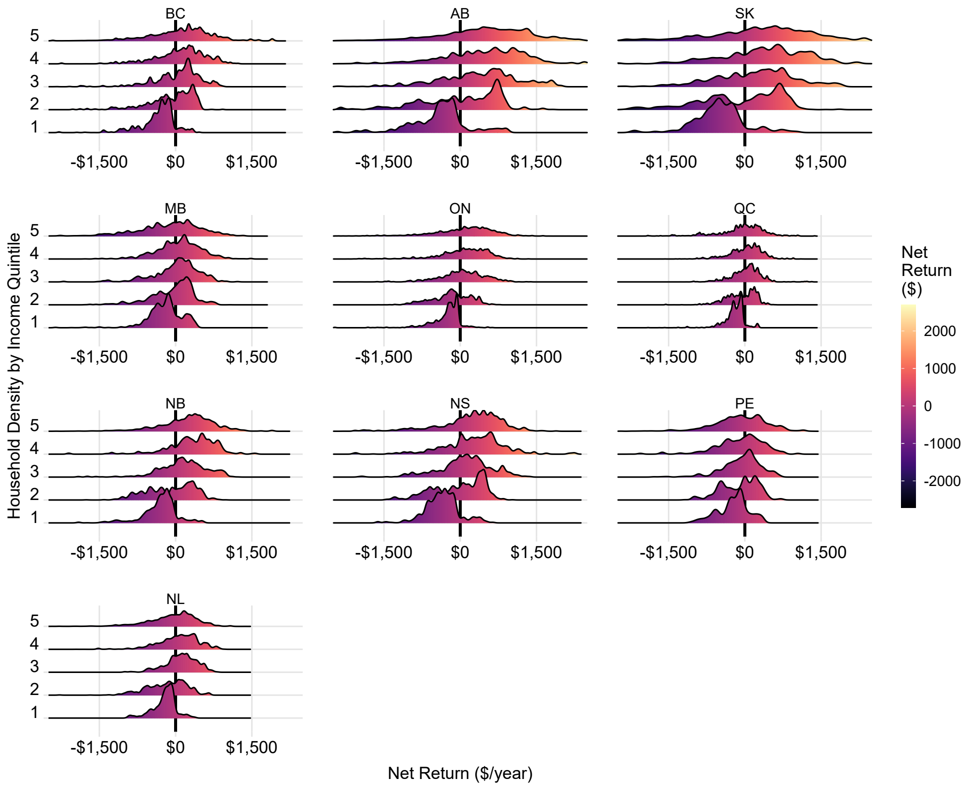
Note: Presents the distribution of household net returns (rebate less costs) by quintile and province, based on SPSD/M v. 28.0 energy expenditure and imputed energy use. Positive value implies rebate greater than costs; negative value implies cost greater than rebate. Assumes carbon price of $50 per tonne. Federal backstop modelled, including output-based pricing system. Income quintile 1 corresponds to the lowest quintile, while quintile 5 corresponds to the highest income quintile. The height of each plot indicates the relative frequency of households obtaining a specific net return value. Alberta does not have a provincial sales tax, so is not shown.

Figure 10 shows the distribution of net returns by province and income quintile when carbon pricing revenues are used to cut the provincial sales tax.[21] When revenues are used to reduce provincial sales taxes, the distribution of net returns is centered on zero. A consumption-based sales tax has a similar effect as carbon pricing and creates a relatively equal burden across income quintiles. The shares of households within each quintile that have a positive net return reflects this. Both Quebec and PEI have visibly left-skewed distributions for all income quintiles. The sales tax

[21] Alberta is excluded from this analysis as it does not have a provincial sales tax.

cut is the revenue-recycling policy that leads to the smallest redistribution of income to either low- or high-income households.

Figure 11: Household Net Returns by Province and Income Quintile When Carbon Pricing Revenues Are Used to Increase the Provincial Personal Income Tax Basic Exemption



Note: Presents the distribution of household net returns (rebate less costs) by quintile and province, based on SPSD/M v. 28.0 energy expenditure and imputed energy use. Positive value implies rebate greater than costs; negative value implies cost greater than rebate. Assumes carbon price of $50 per tonne. Federal backstop modelled, including output-based pricing system. Income quintile 1 corresponds to the lowest quintile, while quintile 5 corresponds to the highest income quintile. The height of each plot indicates the relative frequency of households obtaining a specific net return value.

Finally, the change to the personal income tax basic exemption generally benefits higher-income households. For all provinces, the 2020 tax-year provincial basic exemption is below the upper income bound for the bottom income decile (Table C4 in Appendix C). Revenue recycling to increase the basic exemption moves the basic exemption value above the bottom decile's upper income bound for BC, Alberta, Saskatchewan, Quebec, Nova Scotia, PEI, and Newfoundland and Labrador. Rebates to households range from $23 (Quebec) to $144 (Manitoba) in quintile 1, and from $694 (Quebec) to $2,240 (Saskatchewan) in the top quintile.

Across all provinces, a very small proportion of households in quintile 1 have a positive net return. Four provinces, Alberta, Saskatchewan, New Brunswick, and Nova Scotia have positive net returns on average. These are also the provinces that are net exporters of embodied carbon and have available carbon pricing revenues higher than domestic aggregate household cost (see Table 4). The provinces that are net importers of embodied carbon, and therefore have household carbon costs lower than provincial carbon pricing revenues have negative net returns on average: BC, Manitoba, Ontario, Quebec, Newfoundland and Labrador, and PEI. In some of the higher income quintiles in these provinces, carbon costs exceed the tax savings from the income tax basic exemption and net returns are negative. In general, a policy of cutting income taxes redistributes carbon pricing costs and associated revenues from low- to high-income households.

Table 6: Carbon Tax Costs ($50 per tonne), Rebates and Net Returns by Province and Income Quintile

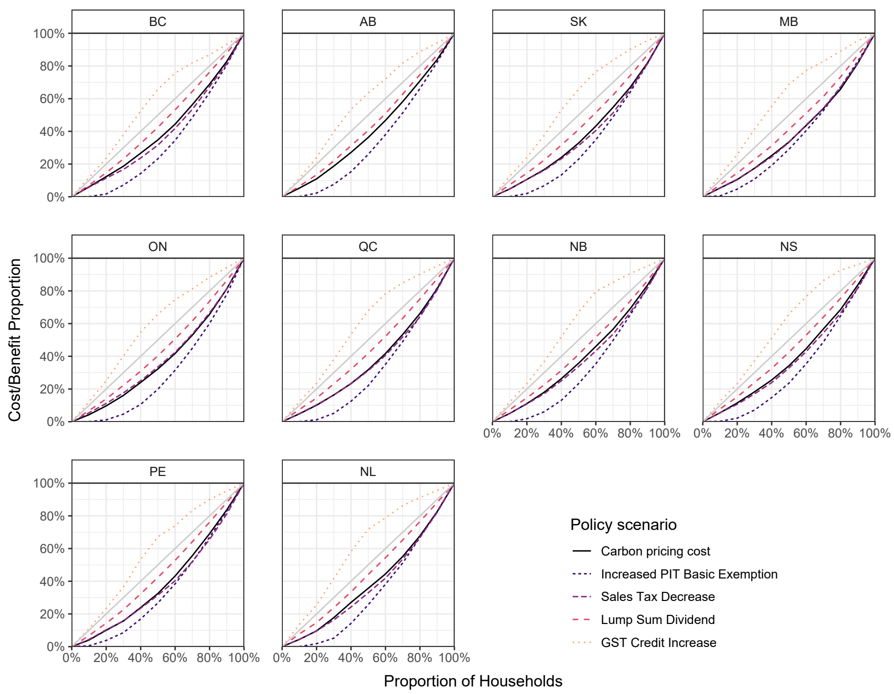
				Revenue Recycling Scenarios: GST Rebate			Lump Sum Dividend			Sales Tax Rate Decrease			Increased Basic Exemption		
	q-tile	Avg. Income	Costs	Rebate	Net Ret.	$\% R > C$	Rebate	Net Ret.	$\% R > C$	Rebate	Net Ret.	$\% R > C$	Rebate	Net Ret.	$\% R > C$
BC	1	19,189	402	714	312	85	447	45	66	347	-55	44	52	-350	9
	2	46,233	468	866	398	82	542	74	66	373	-95	39	382	-85	53
	3	76,845	581	701	120	47	629	48	68	552	-29	48	619	38	63
	4	117,136	795	334	-461	17	697	-98	48	771	-24	53	891	96	63
	5	240,681	1016	398	-618	17	723	-293	32	991	-25	48	1103	88	61
	Avg.	100,052	652	602	-50	50	608	-45	56	607	-46	46	610	-43	50
AB	1	26,129	564	1457	892	91	801	237	78	-	-	-	133	-431	13
	2	60,340	834	1780	945	84	1058	223	69	-	-	-	780	-55	55
	3	100,060	1012	1119	107	38	1167	155	63	-	-	-	1356	345	71
	4	143,236	1244	1009	-235	32	1422	178	59	-	-	-	1682	438	73
	5	286,617	1506	682	-824	22	1506	0	51	-	-	-	2017	511	74
	Avg.	123,303	1032	1209	177	54	1191	159	64	-	-	-	1194	162	57
SK	1	20,287	643	1476	832	94	901	258	79	659	16	45	123	-520	10
	2	49,178	812	1775	963	89	1075	262	71	785	-27	51	708	-104	53
	3	82,445	1160	1433	273	56	1239	79	59	1071	-89	43	1345	185	63
	4	125,303	1443	849	-594	25	1420	-23	52	1571	128	53	1829	386	72
	5	231,741	1991	593	-1399	11	1606	-385	38	2126	135	54	2240	248	66
	Avg.	101,871	1210	1225	14	55	1248	38	60	1243	32	49	1249	39	53
MB	1	19,676	359	786	427	89	448	89	69	331	-28	52	144	-215	24
	2	46,491	502	895	393	80	514	11	60	419	-83	46	448	-54	54
	3	75,423	628	664	36	44	615	-13	54	600	-28	53	656	28	61
	4	111,347	761	358	-403	21	688	-73	44	712	-48	42	827	66	59
	5	214,707	1166	334	-833	11	823	-344	33	1012	-155	37	1015	-151	46
	Avg.	93,547	683	607	-76	49	617	-66	52	615	-69	46	618	-65	49
ON	1	18,856	301	682	381	88	395	94	74	315	14	63	32	-269	5
	2	46,802	446	813	366	78	480	34	57	390	-56	46	268	-178	32
	3	79,354	551	542	-9	40	558	8	50	491	-59	44	593	43	57
	4	121,433	745	373	-372	22	653	-92	47	681	-65	45	814	69	63
	5	257,661	1067	318	-749	12	745	-322	30	942	-125	41	1131	64	62
	Avg.	104,842	622	545	-77	48	566	-56	52	564	-58	48	568	-54	44
QC	1	16,909	225	440	214	86	280	55	71	200	-25	47	23	-203	6
	2	37,637	297	566	270	87	342	45	69	250	-47	42	221	-76	45
	3	62,450	411	465	54	54	389	-21	51	337	-74	31	441	30	59
	4	98,573	547	226	-321	17	443	-104	40	457	-90	29	572	25	59
	5	199,144	758	183	-574	9	484	-274	26	696	-61	43	694	-64	50
	Avg.	82,951	447	376	-71	51	388	-60	51	388	-60	38	390	-57	44
NB	1	19,033	371	810	439	89	529	159	79	392	22	58	66	-305	10
	2	40,037	510	996	486	92	608	98	65	513	3	48	410	-100	48
	3	65,658	658	962	303	65	739	81	60	658	-1	45	812	153	68
	4	99,452	775	381	-394	21	803	28	53	853	77	58	1092	317	80
	5	181,881	1028	323	-705	11	946	-82	45	1195	167	64	1258	230	72
	Avg.	81,275	669	694	26	55	725	57	61	722	54	55	728	59	56
NS	1	17,897	443	903	460	89	611	168	74	427	-15	47	88	-355	11
	2	40,592	540	1080	539	88	703	162	70	532	-9	50	507	-33	55
	3	66,822	736	978	241	59	820	84	61	758	22	50	833	96	61
	4	103,046	929	629	-300	29	915	-14	56	947	18	48	1192	263	74
	5	200,811	1204	284	-920	8	983	-220	40	1339	135	61	1415	211	72
	Avg.	85,950	771	774	4	55	807	36	60	801	30	51	807	37	55
PE	1	21,111	326	588	262	87	376	50	66	270	-56	49	100	-226	19
	2	42,648	451	756	305	85	472	21	54	344	-107	39	345	-106	46
	3	69,606	624	513	-110	35	535	-89	44	437	-187	25	563	-61	49
	4	101,779	841	403	-437	23	613	-228	29	660	-181	26	750	-91	47
	5	186,249	1003	251	-752	10	625	-378	22	898	-105	40	868	-135	44
	Avg.	84,319	649	502	-147	48	524	-125	43	522	-127	36	525	-124	41
NL	1	18,661	259	579	321	91	353	94	73	228	-31	52	44	-215	9
	2	44,201	467	744	277	79	450	-17	56	350	-117	34	298	-169	39
	3	75,241	466	466	0	41	501	35	60	418	-47	44	574	108	67
	4	116,016	624	283	-341	18	530	-93	47	594	-30	46	684	61	61
	5	213,282	866	200	-666	8	564	-302	25	791	-75	38	799	-67	51
	Avg.	93,523	536	454	-82	47	480	-57	52	476	-60	43	480	-56	45

Note: Presents within-quintile average costs, rebates, net return (rebate less costs), and share of households with a positive net return by revenue recycling scenario, based on SPSD/M v. 28.0 energy expenditure and imputed energy use. Positive value implies rebate greater than costs; negative value implies cost greater than rebate. Sales tax decreases modelled as reducing provincial portion of sales tax. Assumes carbon price of $50 per tonne. BC expenditure adjusted to remove BC carbon tax prior to imputing energy use. Quebec expenditure adjusted to remove cost of cap and trade system prior to imputing energy use. Federal backstop modelled, including output-based pricing system. Numbers may differ due to rounding.

4.5 Progressivity of Policy Changes

The Lorenz curve in Figure 12 indicates that carbon pricing costs are slightly progressive; the solid black carbon pricing line is located beneath the 45 degree light grey line which indicates perfect proportionality. Figure 12 also demonstrates that the benefits of the sales tax credit increase are enjoyed mainly by lower income deciles, while the benefits of the increase to the personal income tax basic exemption are enjoyed by the higher income deciles. The sales tax cut is the closest match to the distribution of carbon pricing costs.

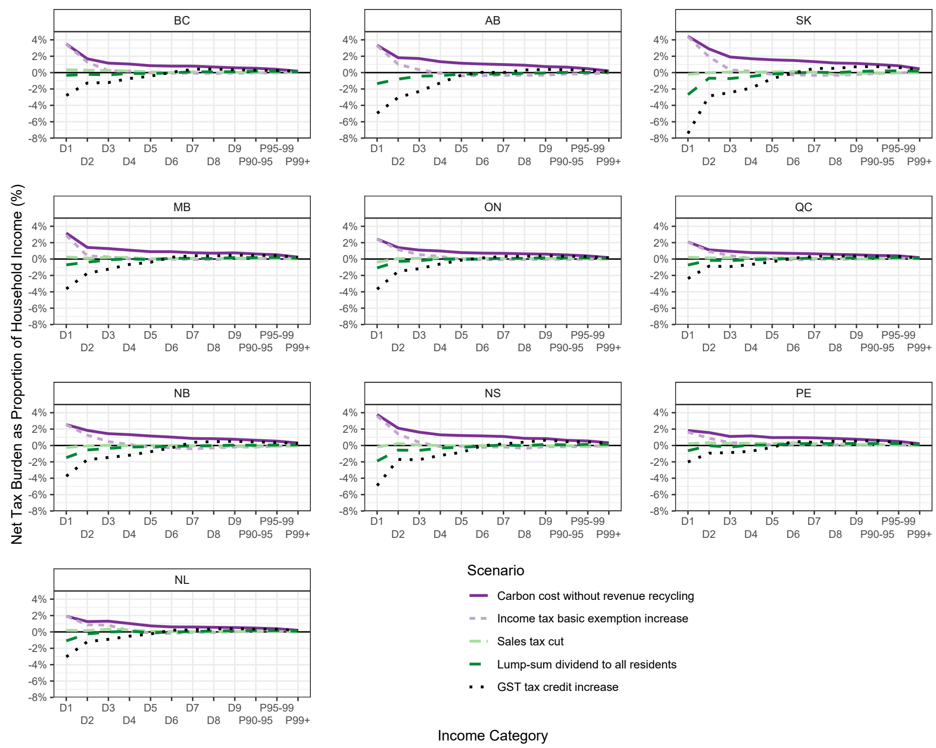
Figure 12: Lorenz Curves of Carbon Pricing and Revenue Recycling Options



Note: Presents cumulative distribution of carbon pricing costs and revenue recycling benefits using a Lorenz curve structure. The grey line in the figure is the 45-degree line.

The burden of carbon pricing can be assessed relative to household income or household expenditure. Poterba (1989) argues that household expenditure may provide a better representation of lifetime income since annual incomes are variable, and households can move up and down on the income distribution. For example, in a year when a child is born, a parent may experience a drop in income, but spend out of savings to maintain expenditure levels at historic levels. We plot tax burden of the carbon tax, with and without revenue recycling, as a share of total income in Figure 13 and as a share of total expenditure in Figure 14. When compared to income, carbon pricing appears highly regressive, imposing a greater burden on lower income households. When we compare carbon pricing burden against household expenditure we see that it is fairly even across the income distribution.

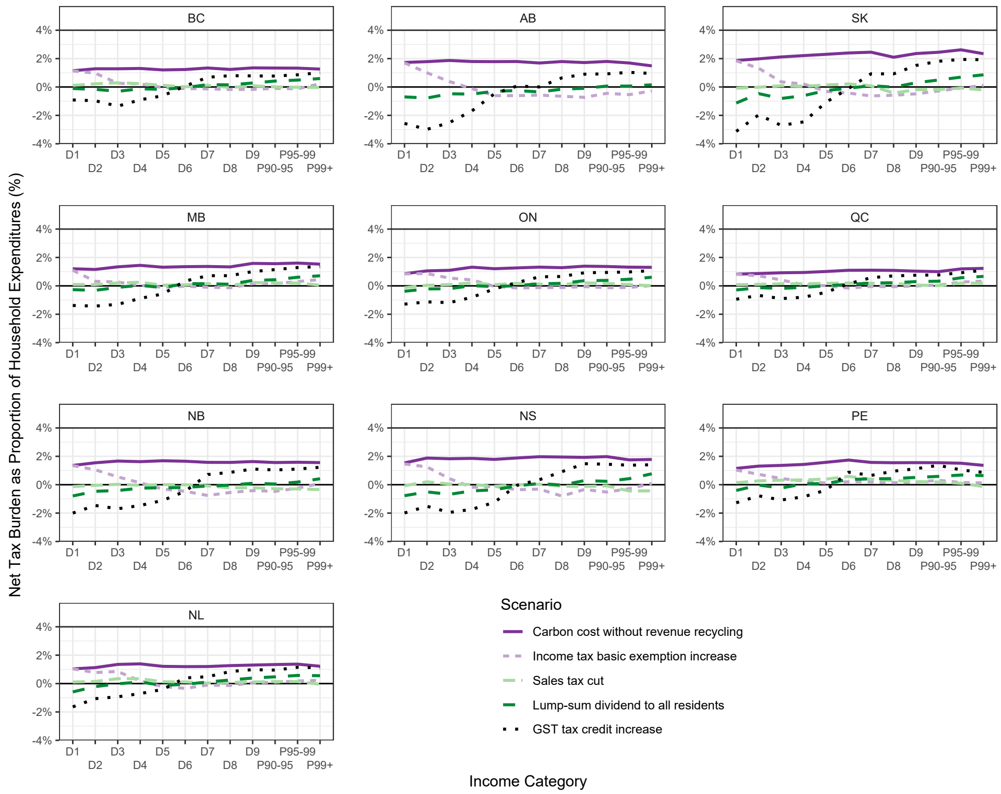
Figure 13: Mean Household Tax Burden as a Proportion of Total Household Income by Province and Income Category



Note: Presents mean household tax burden resulting from the carbon tax on its own, and with four counterfactual revenue recycling policies. Negative values indicate a positive net return. Income deciles include the lowest income decile (D1) to the second highest decile (D9), with three additional income categories containing the 90th - 95th percentile of households (P90-95), 95th - 99th percentile of households (P95-P99), and top 1% of income earners (P99+).

We calculate the West and Williams (2004) progressivity index using household expenditure data (Table 7). A positive value indicates a progressive policy, a value of zero indicates a neutral or equal tax burden, where carbon pricing is proportional to expenditure, and a negative value indicates a regressive policy. We find that carbon pricing is nearly neutral, and is mildly progressive in all provinces except Alberta. Echoing Figure 14, this means carbon pricing is proportional to total household expenditure. The upper panel of Table 7 presents the progressivity of each of

Figure 14: Mean Household Tax Burden as a Proportion of Total Household Expenditure by Province and Income Category



Note: Presents mean household tax burden resulting from the carbon tax on its own, and with four counterfactual revenue recycling policies. Negative values indicate a positive net return. Income deciles include the lowest income decile (D1) to the second highest decile (D9), with three additional income categories containing the 90th - 95th percentile of households (P90-95), 95th - 99th percentile of households (P95-P99), and top 1% of income earners (P99+).

the four revenue recycling options independent of carbon tax costs. The means-tested GST credit and the lump-sum dividend are both progressive revenue uses (as expected), as indicated by their positive West-Williams index values. The sales tax is mildly regressive, while the increase to the income tax basic exemption is significantly regressive.

Summing the West-Williams index value for the carbon tax without revenue recycling with each of the revenue recycling index values generates the progressivity of the net effect of carbon pricing after revenue recycling measures. The lower panel in Table 7 presents these results. The means-tested GST credit policy remains highly progressive, and the lump-sum dividend policy is also progressive. The sales tax cut is closer to neutral, and is mildly progressive for Manitoba and Ontario. The income tax change remains highly regressive.

Table 7: West-Williams Index Progressivity Estimates (%)

	Carbon Tax	GST Credit Increase	Lump Sum Dividend	Sales Tax Rate Decrease	PIT Basic Exemption Increase
			Panel A: Independent Policies		
BC	0.02	0.39	0.10	-0.06	-0.19
AB	-0.02	0.71	0.14	-	-0.24
SK	0.08	0.84	0.18	-0.13	-0.34
MB	0.06	0.46	0.07	-0.05	-0.11
ON	0.06	0.39	0.07	-0.04	-0.22
QC	0.04	0.33	0.08	-0.05	-0.12
NB	0.01	0.62	0.12	-0.06	-0.24
NS	0.03	0.69	0.18	-0.08	-0.27
PE	0.04	0.41	0.11	-0.07	-0.12
NL	0.02	0.43	0.12	-0.05	-0.13
			Panel B: Net Effect		
BC	-	0.41	0.12	-0.04	-0.17
AB	-	0.69	0.12	-	-0.26
SK	-	0.92	0.26	-0.05	-0.26
MB	-	0.52	0.13	0.01	-0.05
ON	-	0.45	0.13	0.02	-0.16
QC	-	0.37	0.12	-0.01	-0.08
NB	-	0.63	0.13	-0.05	-0.23
NS	-	0.72	0.21	-0.05	-0.24
PE	-	0.45	0.15	-0.03	-0.08
NL	-	0.45	0.14	-0.03	-0.11

Note: The West and Williams (2004) index calculates overall progressivity or regressivity of tax changes by scaling the tax burden on a given income group *i* by all other income groups' tax burden and group *i*'s share of total expenditure. Tax burden is measured as a share of total expenditure. Positive (negative) values indicate a progressive (regressive) change and a flat tax generates a value of zero.

4.6 The Effect of the OBPS on Household Carbon Costs

With the OBPS and a carbon price of $50 per tonne, over half of households in most provinces have carbon tax costs below $700 (Table 8). The exception is Alberta and Saskatchewan, with much flatter distributions and higher carbon costs. BC, Ontario and Quebec have concentrated distributions, with most households' costs below $600. Alberta and Saskatchewan have very flat distributions with long right tails. The other provinces have relatively flat distributions, but with costs more concentrated than Alberta and Saskatchewan. The presence of an output-based pricing system significantly reduces estimated indirect costs to households. Without the OBPS, average household carbon costs are between 35% and 93% higher (Table 8).

Though the intent of the OBPS is to mitigate cost impacts from emissions pricing for emissions-intensive and trade-exposed industrial facilities, this policy also has the effect of reducing the indirect carbon costs paid by households. The distribution of costs changes, in some cases quite drastically. Removing the OBPS flattens the distribution for all provinces, but the change is particularly apparent for Alberta and Saskatchewan, and to a lesser extent New Brunswick, Nova Scotia and PEI. Average household costs within each decile increase between 35 and 93 percent, shown in Panel C of Table 8. Provinces with a more emissions-intensive electricity grid (Alberta, Saskatchewan, New Brunswick, and Nova Scotia) see the largest increases. For Alberta and Saskatchewan, the change in the distribution has two primary causes. First, the high emissions-intensity of electricity production and second, relatively high overall consumption of emissions-intensive goods and services (as seen in Figure 6). New Brunswick and Nova Scotia also have higher emissions-intensities in electricity, and PEI imports significant amounts of electricity from New Brunswick (60 percent) in 2018), which translates to higher indirect costs and a flattened cost distribution in the absence of the OBPS.

Though we do not present it here, a corollary of higher household costs where there is no OBPS is much higher available revenue. Specifically, the OBPS is an output subsidy to firms; absence of the OBPS means the government collects the full cost of emissions from these firms at the prevailing emissions price, granting it more revenue. While this revenue increase would be offset by behavioural changes on the part of firms to avoid the emissions price and potential decreased or lost output, a hypothetical government could feasibly offset the additional household costs with this additional revenue. These results raise two important points. First, the OBPS dampens indirect

Table 8: Average Carbon Tax Costs by Province, Income Decile and OBPS Scenario (2020 dollars)

Province	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	Mean	Median
						Panel A: Average Costs with OBPS						
BC	394	409	418	517	534	627	773	817	910	1,121	652	538
AB	548	580	805	863	953	1,070	1,183	1,304	1,351	1,661	1,032	882
SK	574	712	720	904	1,065	1,255	1,390	1,497	1,790	2,194	1,210	1,005
MB	365	353	473	532	565	691	710	812	1,080	1,252	683	562
ON	266	337	398	494	511	591	699	792	972	1,161	622	522
QC	215	235	281	312	377	445	523	571	676	839	447	375
NB	335	406	462	558	628	689	708	842	956	1,100	669	600
NS	419	467	519	562	671	802	934	924	1,155	1,252	771	678
PE	263	389	371	530	555	692	808	874	946	1,060	649	591
NL	237	281	433	502	460	471	572	676	796	936	536	459
						Panel B: Average Costs without OBPS						
BC	543	566	563	709	742	883	1,070	1,145	1,255	1,539	902	770
AB	1,015	1,073	1,462	1,603	1,837	2,010	2,252	2,406	2,481	3,030	1,917	1,691
SK	954	1,183	1,238	1,521	1,773	2,047	2,307	2,551	3,037	3,620	2,024	1,698
MB	510	499	665	730	791	978	996	1,157	1,501	1,743	957	793
ON	384	471	551	681	711	806	960	1,098	1,323	1,586	857	727
QC	318	338	405	449	541	633	738	804	970	1,216	641	535
NB	600	670	756	961	1,068	1,148	1,203	1,430	1,621	1,864	1,133	1,036
NS	768	873	944	1,011	1,214	1,429	1,654	1,639	2,052	2,226	1,382	1,249
PE	451	670	612	846	878	1,077	1,299	1,395	1,499	1,697	1,043	952
NL	352	404	610	699	660	684	838	970	1,158	1,349	773	656
						Panel C: Percentage Increase in Costs without OBPS						
BC	38	38	35	37	39	41	38	40	38	37	38	43
AB	85	85	82	86	93	88	90	85	84	82	86	92
SK	66	66	72	68	66	63	66	70	70	65	67	69
MB	40	41	41	37	40	42	40	42	39	39	40	41
ON	44	40	38	38	39	36	37	39	36	37	38	39
QC	48	44	44	44	44	42	41	41	43	45	43	43
NB	79	65	64	72	70	67	70	70	70	69	69	73
NS	83	87	82	80	81	78	77	77	78	78	79	84
PE	71	72	65	60	58	56	61	60	58	60	61	61
NL	49	44	41	39	43	45	47	43	45	44	44	43

Note: Presents within-decile average costs, and provincial mean and median costs, based on SPSD/M v. 28.0 energy expenditure and imputed energy use. BC expenditure adjusted to remove BC carbon tax prior to imputing energy use. Quebec expenditure adjusted to remove cost of cap and trade system prior to imputing energy use. Panels A and B show average within-decile carbon costs, at \$50 CO_2e CAD per tonne. Panel C shows the percentage increase in within-decile average costs without the OBPS. Income decile 1 corresponds to the lowest decile, while decile 10 corresponds to the highest income decile. Household counts and decile income thresholds differ by province.

costs to households, relative to economy-wide carbon pricing with full pass-through. Similar to other forms of revenue-recycling, behavioural change and emissions-reductions will be lower than without the presence of cost-mitigating policy. Second, increases to the stringency of the OBPS will correspondingly increase indirect costs for households, which policymakers may wish to be mindful of in designing revenue-recycling policies moving forward.

5 CONCLUSION

We find that the "use-side" impacts of carbon pricing on the costs of energy and the prices of goods and services is progressive without revenue recycling. The revenue raised by carbon pricing creates opportunities to change the progressivity of the policy by recycling revenues. Our simulations show that increasing the personal income tax basic exemptions within each province increases net consumable income for the average household in the highest income quintiles, and makes carbon pricing highly regressive. Cuts to provincial sales taxes are well matched to offset the impact of carbon pricing when the OBPS is in place, and achieve an outcome that is closest to neutral. The means-tested federal GST credit leave households in the lowest income quintile(s) with higher levels of consumable income than without carbon pricing, and are a highly progressive means of recycling revenues. Lump-sum rebates, similar to the federal Climate Action Incentive, are also progressive and can lead to small gains in consumable income for the the majority of households in the lowest income quintiles, while largely offsetting carbon pricing costs for the middle income quintile and second highest income quintile.

We also find that the presence of an output-based pricing system (OBPS) significantly dampens the burden of carbon pricing on households. This occurs through two channels: reducing estimated indirect costs to households and reducing electricity costs for provinces with emissions-intensive electricity sectors. Without the OBPS, revenue recycling options could be more generous, but it magnifies the regressive or progressive nature of each policy.

Our research can inform the design of provincial carbon pricing systems in Canada. Provinces subject to the federal backstop are increasingly looking to design their own pricing systems. A key aspect of that design will be deciding how to use the revenues. Progressivity is one aspect of revenue recycling that provincial governments can consider in making this decision. Our results suggest that means-tested rebates and lump-sum dividends address one critique of carbon pricing by making nearly all low-income households better off. Governments that choose to use the revenue to cut provincial sales tax or income taxes may want to allocate a portion of revenues to means-tested rebates that restore the spending power of low-income households. In future work, we can consider hybrid policy design of this nature. Relatedly, we do not measure costs under actual policy; future work could involve comparisons of actual revenue-recycling choices to our hypothetical scenarios.

Our research design is limited in two important ways. First, we do not model behavioural responses to carbon pricing. This means household emissions remain fixed in each of our scenarios. The richness of the expenditure data we use — 315 consumption and expenditure categories differing by province and quintile — means finding elasticity estimates is challenging and would decrease the transparency of our results. Future work could consider how households will change consumption in response to carbon pricing. Second, we do not consider the impact of carbon pricing on the growth rate of incomes. The Canadian Parliamentary Budget Office 2022 produced an analysis of these broader "economic" impacts, and by Beck et al. (2015) for BC specifically. An analysis that considers the effect of carbon pricing on the growth rates of income and returns to capital would be useful as a comparative exercise, comparing the economic impacts of carbon pricing against alternative policies to achieve the same level of GHG emissions reductions. We leave that to future work.

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A APPENDIX: AVERAGE AND MARGINAL CARBON TAX RATES UNDER AN OUTPUT-BASED PRICING SYSTEM

Under an output based pricing system, covered (typically large) emitters are required to achieve an industry-specific performance standard. Facilities can purchase credits as a compliance option to offset any excess emissions and are rewarded with credits for exceeding the standard. Economically, this is identical to a structure in which facilities pay a carbon price on all emissions and receive an offsetting subsidy based on their total output and can be modelled as such. The carbon tax payment is a cost per tonne of CO_2e (τ) multiplied by the firm's GHG emissions (G), while the output-based subsidy is a fixed subsidy rate common to an industry (a) multiplied by the firm's output (Q). The net carbon tax paid by a firm can be represented as:

$$T = \tau G - aQ \tag{A1}$$

The subsidy rate is generally determined by multiplying the carbon tax rate by a proportion of an industry's average emissions intensity. Specifically: $a = \alpha \tau \widetilde{\gamma}$, where the output-based allocation rate is $\alpha \in [0,1)$ and the industry's average emissions intensity is represented by $\widetilde{\gamma}$. In determining the average and marginal effective carbon tax rates it is useful to rewrite equation (A1) as:

$$T = \tau (G - \alpha \widetilde{\gamma} Q) \tag{A2}$$

It is straightforward to verify that, the offsetting subsidy notwithstanding, the marginal effective carbon tax rate is equal to the mandated cost per tonne γ. Specifically, taking the derivitive of equation (A2) with respect to total firm emissions G:

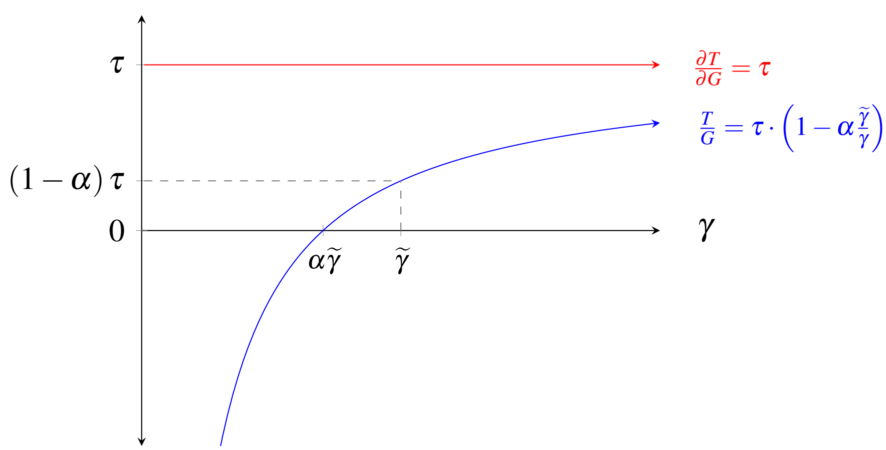
$$\frac{\partial T}{\partial G} = \tau \tag{A3}$$

Dividing equation (A2) by G and recognizing that firm-level emissions can be defined as the product of intensity and output $G = \gamma Q$, the average carbon tax rate for a given firm's emissions intensity γ can be written as:

$$\frac{T}{G} = \tau\left(1 - \alpha\frac{\widetilde{\gamma}}{\gamma}\right) \tag{A4}$$

We show equations (A3) and (A4) graphically in Figure A1. The marginal effective carbon tax rate per tonne of CO_2e is constant and equal to τ whereas the average carbon tax rate per tonne of CO_2e asymptotically approaches $-\infty$ as a firm's emissions intensity approaches zero and asymptotically approaches τ as a firm's emissions intensity approaches $+\infty$. Firms with a sufficiently low emissions intensity ($\gamma < \alpha\widetilde{\gamma}$) receive a net subsidy (that is, $aQ > \tau G$) and therefore exhibit a negative average tax rate.

Figure A1: Average and Marginal Carbon Tax Rates as a Function of Intensity (γ)



Substituting the identity for firm level emissions ($G = \gamma Q$) into equation (A2) and indexing firms in a given industry by i yields a set of equations for taxes paid by firms in any given industry as: $T_i = \tau\left(\gamma_i Q_i - \alpha\widetilde{\gamma}Q_i\right)\ \forall i$. From this, the industry average carbon tax cost per unit of output is:

$$\frac{\sum_i T_i}{\sum_i Q_i} = (1-\alpha)\,\tau\widetilde{\gamma} \tag{A5}$$

Assuming full cost pass through the implication is that the direct effect of an output-based pricing system will lead to an average price increase consistent with equation (A5) at the industry level while maintaining a marginal effective carbon tax rate of τ (or $\tau\gamma$ measured per unit of output rather than per tonne of CO_2e). As described elsewhere, this direct effect on industry prices will be augmented through the input-output system by the indirect effects of carbon pricing on the prices of industry inputs.

B TECHNICAL APPENDIX: INDIRECT INTENSITY CALCULATION

The Fellows and Dobson (2017) model, which is the base for our calculation of indirect emissions, uses expenditure and revenue flows from provincial-level symmetric input-output tables (Statistics Canada, 2015b) to allocate GHG emissions across sectors and regions in a manner that reflects the emissions “embodied" in the output of each sector. In this application, the term “embodied" implies that the emissions being accounted for are all of the upstream emissions that occur as a result of output in every sector. The concept is similar to the development of a conventional Input-Output multiplier, except that in this application the multiplier is constructed for emissions rather than an input factor (like labour employment) or a macroeconomic metric (like GDP).

In this appendix, we provide a mathematical description of the Fellows and Dobson (2017) model and describe modifications to it such that it can be applied to the calculation of indirect cost of emissions pricing to households by quintile and region in Canada. We proceed in two steps, first describing our modified version of the Fellows and Dobson (2017) model, then describing how the results of that model are mapped to the survey of household spending (Statistics Canada, 2018) in order to produce quintile level projections of indirect costs.

B.1 A Modified Version of Fellows and Dobson (2017) to Calculate Household Costs

As with the original Fellows and Dobson (2017) model, this modified version specifies 29 production sectors and 13 regions (10 provinces, Nunavut, a region representing the Yukon and Northwest Territories and a region representing Canadian production abroad).[22] Sectors in the model are rep-

[22]Fellows and Dobson (2017) calculate the model for the years 2004 to 2011 with the exact number of sectors varying due to changes in the aggregation of data from Statistics Canada. However, we are only calculating the intensities for a 2011 base year as this is the most recent year possible using this model.

resented by the subscripts i, j and k such that $i \in \mathscr{S}$ and $\{j,k\} \in \{\mathscr{S} \cup \mathscr{C}\}$ where $\mathscr{S}$ is the set of 29 production sectors and $\mathscr{C}$ is the set of final consumption sectors (Consumption, Investment and Government Spending). Regions are represented by the subscripts $\{r,q\} \in \mathscr{R}$ where $\mathscr{R}$ is the total set of 13 regions. Known parameter values are represented in lower case letters while endogenous variables are represented in upper case.

Equation (B1) gives the total emissions embodied in the output from each sector/region pairing:

$$Y_{i,r} = d_{i,r} + \sum_{j \in \mathscr{S}} \left[B_{j,i,r}\right] + \sum_{q \in \mathscr{R}} \left[W_{i,q,r}\right] \tag{B1}$$

where: $Y_{i,r}$ is a variable representing the total embodied emissions in sector i and region r; $B_{j,i,r}$ is a variable representing the flow of embodied emissions from sector j to sector i in region r; $W_{i,q,r}$ is a variable representing the embodied emissions flowing from sector i in region q to sector i in region r; and $d_{i,r}$ is a parameter representing the direct emissions (in tonnes of CO_2e) produced in sector i in region r.

This equation differs from the one in Fellows and Dobson (2017) in that the term representing emissions embodied in international imports is omitted. We omit imported emissions since these are assumed to be unpriced or that any price on them is not part of the Canadian framework (and therefore excluded from our assessment).

Equation (B2) defines the value shares and provides an explicit value of $B_{i,j,r}$:

$$B_{i,j,r} = Y_{i,r} \cdot \left(\frac{b_{i,j,r}}{\sum_{k \in \{\mathscr{S} \cup \mathscr{C}\}} \left[b_{i,k,r}\right] + \sum_{q \in \mathscr{R}} \left[w_{i,r,q}\right] + x_{i,r}} \right) \tag{B2}$$

This equation is identical to the value share equation in Fellows and Dobson (2017). The bracketed term in equation (B2) represents the value share of sector j's input into sector i in region r. The numerator of this term ($b_{j,i,r}$) is the expenditure/revenue associated with of inputs flowing from sector j to sector i in region r. The denominator sums to the total gross output from sector j. Specifically $w_{j,r,q}$ is the expenditure or revenue (depending of the perspective of a consumer vs a producer) associated with inter-provincial flows of output in sector j inputs from region r to region

q. $x_{j,r}$ is the revenue from international exports by sector j in region r.[23]

Also following directly from Fellows and Dobson (2017), equation (B3) determines the values of the inter-regional flows (from region q to region r) of GHG emissions for each sector:

$$W_{i,q,r} = Y_{i,r} \cdot \left(\frac{w_{i,q,r}}{\sum_{k \in \{\mathscr{S} \cup \mathscr{C}\}} \left[b_{i,k,r}\right] + \sum_{q \in \mathscr{R}} \left[w_{i,r,q}\right] + x_{i,r}} \right) \tag{B3}$$

The model developed in Fellows and Dobson (2017) includes an additional equation which calculates emissions embodied in international exports. However we have no reason to calculate this value in our current application, so it is omitted.

Equations (B1) through (B3) form a closed system of equations with a unique solution for the endogenous variables ($Y_{i,r}$, $B_{i,j,r}$ and $W_{i,q,r}$).[24]

Calibration values for the financial value parameters ($b_{i,k,r}$, $w_{i,r,q}$ and $x_{i,r}$) are identical to those used by Fellows and Dobson (2017). However, since we are interested in the embodied emissions subject to a carbon price (rather than all embodied emissions) the parameter values for $d_{i,r}$ require some modification in this application.

Specifically, we scale the Fellows and Dobson (2017) values for $d_{i,r}$ to account for the Output Based Pricing System (OBPS) used to address competitiveness concerns for large emitters in emissions intensive and trade exposed industries. Under this system, firms receive an "Output Based Allocation" (OBA) which is a per unit transfer related to the level of emissions in a firm's industry, but not directly related to the firm's own emissions. The overall effect is to lower the average emissions tax rate on an industry while preserving the marginal tax rate (intended to provide an incentive not to emit and therefore to change behavior).[25] We identify the sectors and rates associated with the OBPS (Dobson et al., 2019)'s assessment of emissions coverage.

The Provincial Symmetric Input Output Tables (Statistics Canada, 2015b) include industry data at a "Summary" level aggregation, which is roughly equivalent to a 2 or 3 digit North American

[23] All parameter values in this model are based on "basic price" measures from Statistics Canada (2015b).

[24] In total, the system includes 16,211 equations and 16,211 endogenous variables. For equation (B1) and $Y_{i,r}$: 29 sectors $\times$ 13 regions $=$ 377. For equation (B2) and $B_{i,j,r}$: 29 sectors^2 $\times$ 13 regions $=$ 10,933. For equation (B3) and $w_{i,q,r}$: 29 sectors $\times$ 13 regions ^{2} $=$ 4,901

[25] For more detail and background on the OBPS see Dobson et al. (2017).

Table B1: Weighted Average Effective OBA Rates to Match Statistics Canada's Summary Level Industry Classifications

Sector	Industry Code	Effective OBA Rate (%)
Forestry and Logging	BS113	80
Fishing, Hunting and Trapping	BS114	80
Support Activities for Agriculture and Forestry	BS115	80
Crop and Animal Production	BS11A0	80
Manufacturing	BS3A0	81.34
Transportation and Warehousing	BS4B0	8.97
Coal Mining	BS210*	80
Crude Oil Extraction	BS210*	80
Natural Gas Extraction	BS210*	80
Other Mining	BS210*	85.69
Mining Support Services	BS210*	80
All Other Sectors Except Utilities		0

* The "Mining and Oil and Gas Extraction" sector (BS210) appears as a single sector in the original Statistics Canada Symmetric Provincial input output tables, however Fellows and Dobson (2017) disaggregate this into 5 sub-sectors: Coal Mining, Crude Oil Extraction, Natural Gas Extraction, Other Mining, and Mining Support Services.

Industrial Classification System (NAICS) code. However, the government's guidelines (and by extension the assessment in Dobson et al. 2019) are more targeted than that, often mentioning specific sub-sectors which would be better represented at the 4-digit NAICS level. In order to account for this we calculate a weighted average OBA for each of these sectors to account for the sub-sector emissions that are covered by OBAs (at either an 80% or 90% rate) as a percentage of total sector emissions. These "effective OBA rates" are given in Table B1.

Additionally, electricity generation is treated somewhat differently than other sectors subject to the OBPS. In a standard application, the output subsidy rate is set at 80% or 90% of a sector's average emissions intensity. That is, for an 80% rate, firms receive an output subsidy that is equal to $\left\{0.8 \times \frac{\text{Total Industry}\text{CO}_2\text{e}}{\text{Total Industry revenue}} \times \text{ Firm's Revenue}\right\}$. However the output subsidy rate for electricity generation is to set technology-specific intensity standards. Given this, the *effective* OBA rate (or, more accurately, the carbon tax charges less the output based subsidies at the sector level) is a function of the electricity generation profile in that region. As an additional complication, the industry categories in Fellows and Dobson (2017) group electricity generation into a broader sector including other utilities (such as water and sewer services). Therefore, we calculate the effective OBA rates for this sector using equation (B4).

$$\Theta_{\text{Utilities},r} = \left(\frac{\text{Electricity emissions}}{\text{Utilities emissions}}\right) \times \left[1 - \frac{\sum\limits_{g=\{\text{Coal,Petroleum}\}} \Big((Intensity_g - Benchmark_g) \times (\text{Share of Generation})_g\Big)}{\sum\limits_{g=\{\text{Coal,Petroleum}\}} \Big(Intensity_g \times (\text{Share of Generation})_g\Big)}\right] \tag{B4}$$

where the first right hand side term $\left(\text{Electricity emissions}/\text{Utilities emissions}\right)$ is informed by data from Statistics Canada (2015a) (Physical flow account for greenhouse gas emissions); emissions intensities for petroleum and coal generation are taken from Environment and Climate Change Canada (2018) and the share of generation for each fuel (coal and petroleum) are taken from Natural Resources Canada (2018).

To account for the effect of the OBPS and the electricity generation standard on *priced* emissions, we take the direct province by sector emissions from Fellows and Dobson (2017) and scale them using the OBA rates from Table B1 and the analogous parameter for the utilities produced using Equation B4. Equation B5 relates our measure of priced emissions by sector and province to the total province and sector level emissions provided by Fellows and Dobson (2017):

$$d_{i,r} = \widehat{d_{i,r}} \cdot (1 - \Theta_{i,r}) \tag{B5}$$

where $\widehat{d_{i,r}}$ is the original total sector by province emission level as applied in Fellows and Dobson (2017) and $\Theta_{i,r}$ is the effective OBA rate or analogous electricity parameter for the sector and region from Table B1 or equation B4.

It follows that substituting the value for $d_{i,r}$ from equation (B5) into equation (B1) and solving the system of equations (B1) through (B3) will produce an account of the embodied priced emissions (including indirect emissions) that flow between the modeled 13 regions and 29 sectors (plus final consumption categories C,I and G).

B.1.1 A Further Modification of Fellows and Dobson (2017) to Project Revenue Raised from Households Within a Region

We have an interest in knowing what proportion of a household's indirect emissions costs will translate into revenue that stays within their home region. The ratio is not 100% due to inter-regional pass-through of costs.

Consider that consumers in a specific region will end up bearing costs associated with pricing within their region (intra-region pass-through of emissions taxes) as well as costs associated with pricing in other regions (inter-region pass-through of emissions taxes). The latter occurs when a consumer in one region directly purchases a good from another region or when a consumer in one region purchases a good that has an input (at any stage in the value chain) sourced from another region.

In the preceding section, the endogenous variable of interest ($B_{i,j,r}$) reflects the priced emissions embodied in the output of each sector i flowing to each sector j (where $j \in \mathscr{S} \cup \mathscr{C}$ reflecting that the target sectors denoted by j include final household consumption). To determine the domestic revenues, we net out inter-provincial leakage associated with end costs to households. This is a simple modification.

Starting with the already calculated values for $B_{i,j,r}$, we make the following adjustment to determine emissions that will be associated with domestic revenues associated with household consumption:[26]

$$B^{Rev}_{i,j,r} = B_{i,j,r} + \sum_{q} \left(W_{i,r,q} - W_{i,q,r} \right) \times \frac{b_{i,\text{consumption},r}}{\sum\limits_{j \in \mathscr{C}} b_{i,j,r}} \tag{B6}$$

The resulting alternative values for $B_{i,j,r}$ (reflecting embodied priced emissions net of leakage) are distinct from the values produced by the larger model described in section B.1 (reflecting total embodied priced emissions). However, both sets of values for the endogenous will map on to the survey of household spending in exactly the same way as described in section B.2 below. The

[26]Note that this calculation is not exact, given data limitations, but should be a close proxy.

distinction is that mapping the values of $B^{Rev}_{i,j,r}$ generated by the model in this section will produce a projection of the indirect or upstream domestic revenue associated with household consumption whereas mapping the values of $B_{i,j,r}$ generated by the model in the previous section will produce a projection of the indirect cost associated with household consumption (by province and quintile).

B.2 Mapping Emissions to the Survey of Household Spending

Solving for the endogenous variables in the above model (and specifically solving for the values of $B_{i,\text{consumption},r}$) provides an account of the priced emissions embodied in final household consumption across the 29 industries ($i \in \mathscr{S}$) and 13 regions (r) modeled. However, in order to determine the costs per household and the distribution of these costs across household income levels, it is necessary to map these emissions onto household spending patterns. To do this, we convert the aggregate embodied emissions values into emissions intensities. We then develop a concordance in order to map these 29 intensities onto 213 spending categories itemized in Statistics Canada's Survey of Household Spending (Statistics Canada, 2018).[27]

We calculate emissions intensities in household consumption expenditure across industries using expenditure data valued at the Purchaser Price from the same input-output tables we use to calibrate our version of the Fellows and Dobson (2017) model (specifically, Statistics Canada 2015b).[28]

Equation B7 illustrates the calculation of emissions intensities based on purchaser price valuations:

[27] Statistics Canada (2018) itemizes 318 categories of household spending, however; 84 of these are aggregates of more detailed spending. We explain our approach to aggregation below. Further, 21 of the categories are associated with expenditures that have no associated emissions (such as "Forfeit of deposits, fines, and money lost or stolen") and therefore do not require mapping.

[28] In calibrating the model we made use of valuations based on "basic price", rather than valuations based on "purchaser price." The basic price valuation nets out subsidies, taxes and various margins on exchange. It represents the closest measure of the economic value of a product so it is used in defining the parameter values of the model outlined in section B.1 above. The purchase price valuation is more analogous to the measures of spending represented in the survey of household spending as it reflects a measure of expenditure on industry output, rather than the value of that output.

$$\gamma_{i,r} = \frac{B_{i,\text{consumption},r}}{\widetilde{b}_{i,\text{consumption},r}} \tag{B7}$$

where the values of $\gamma_{i,r}$ are emissions intensities (tonnes of CO_2e per dollar of household purchase expenditures by sector i and region r) and the values of $\widetilde{b}_{i,\text{consumption},r}$ are total dollars of household purchase expenditures by sector i and region r.[29]

These intensities are then mapped to the expenditure categories in Statistics Canada's Survey of Household Spending (Statistics Canada, 2018). We define these categories using the subscript $n \in \mathscr{N}$ and $m \in \{\mathscr{N} \cup \mathscr{A}\}$ where $\mathscr{N}$ is the set of expenditure categories at the lowest level of aggregation and $\mathscr{A}$ represents expenditure categories that are themselves aggregates of the categories in set $\mathscr{N}$.

Statistics Canada uses different data collection methodologies in Statistics Canada (2018) as compared to Statistics Canada (2015b) so there is no direct concordance to ensure consistency. Because of this, we are forced to develop our own concordance. We do this by comparing the category descriptions of the elements of $\mathscr{N}$ and $\mathscr{S}$ and defining a best match. The mapping only goes in one direction, such that each element of $\mathscr{N}$ is matched to exactly one element of $\mathscr{S}$ but an element from $\mathscr{S}$ could be matched to zero or more elements of $\mathscr{N}$.

As indicated in section B.1 we calculate intensities based on 2011, as this is the most recent year to which the Fellows and Dobson (2017) model has been applied. Because these intensities are based on a nominal value base, in order to apply them to different years they must be adjusted for inflation. To maintain the highest level of accuracy in our projections as possible, we deflate these intensities using individual price indices for each element of $\mathscr{N}$.

With the mapping in place we redefine $\gamma_{i,r}$ over the set $\mathscr{N}$ instead of $\mathscr{S}$ and add a time dimension $t \in \{2010, 2011, 2012, 2013, 2014, 2015, 2016\}$ as well. Formally:

$$\left\{ \gamma_{n,r,t} = \frac{\gamma_{i,r}}{p_{n,t}} \;\mid n \mapsto i \right\} \forall n \in \mathscr{N}$$

[29]Note that $\tilde{b}_{i,\text{consumption},r}$ is directly analogous to the values of $b_{i,j,r}$ (indicating a financial revenue/expenditure flow) wherein $j \equiv$ consumption and with $\tilde{}$ indicating the use of a purchaser price valuation rather than the basic price valuation.

where the values of $p_{n,t}$ are price indices with a base year of 2011 for each spending category n and time period t. The values for $p_{n,t}$ are calculated using data from Statistics Canada (nda).[30]

We then calculate the emissions embodied in household consumption by spending category $\mathscr{N}$ and income quintiles for each region. Income quintiles are denoted by the subscript $h \in \{1,2,3,4,5\}$:

$$\Omega_{n,h,r,t} = E_{n,h,r,t} \cdot \gamma_{n,r,t} \;\; \forall n \in \mathscr{N} \tag{B8}$$

where $E_{n,h,r,t}$ is a parameter representing the level of household expenditure by spending category, income quintile, region and year (as taken from Statistics Canada 2018) and $\Omega_{n,h,r,t}$ is our calculated value for embodied priced emissions in household expenditure by spending category, quintile, region and year.

Unfortunately, statistics Canada suppresses certain values in the survey of household expenditure (Statistics Canada, 2018) for data quality reasons. The values ($E_{n,h,r,t}$) are therefore missing for some elements of set $\mathscr{N}$, however they are accounted for in the more aggregated spending categories in set $\mathscr{A}$. To address this issue, we calculate weighted average emissions intensities using data for the observable sub-sectors for each element of the set $\mathscr{A}$ and apply them to that element. Since some elements of the set $\mathscr{A}$ are aggregates which encompass other elements that are themselves also aggregates (and therefore in set $\mathscr{A}$) we do this calculation in steps, working from the lowest level of aggregation to the highest. The calculation in each step takes the form:

$$\Omega_{m,h,r,t} = E_{m,h,r,t} \cdot \frac{\sum_{\{n|n\mapsto m\}} \left[\gamma_{n,r,t} \cdot E_{n,h,r,t}\right]}{\sum_{\{n|n\mapsto m\}} \left[E_{n,h,r,t}\right]} \tag{B9}$$

where the summations on the top and bottom of the fraction indicate a sum over all of the values of n such that n maps to (or is a sub-category of) the element $m \in \mathscr{A}$. Exact notation becomes excessive as we move to subsequent steps, however it is sufficient to describe the process as follows; in the first step (which directly corresponds to equation B9) the calculation is performed for all elements $m \in \mathscr{A}$ wherein the subcategories of m (specifically, all n such that $n \mapsto m$) all belong to set

[30] Specifically, we convert the monthly CPI numbers from Statistics Canada (nda) into simple annual average and then re-base the index to a 2011 base year to match our 2011 intensity calculations.

$\mathscr{N}$. In subsequent rounds, we add any element for which a value of $\Omega_{m,h,r,t}$ has been calculated to the set $\mathscr{N}$ and remove it from the set $\mathscr{A}$. We then calculate a value $\gamma_{n,r,t} = \frac{\Omega_{m,h,r,t}}{E_{m,h,r,t}}$ for that element and recalculate equation (B9) using the same process as before. This works because, as we move elements from set $\mathscr{S}$ to set $\mathscr{A}$ a new portion of the elements $m \in \mathscr{A}$ satisfy the requirement that the subcategories of m all belong to set $\mathscr{N}$.

The entire set of spending categories ($\mathscr{N} \cup \mathscr{A}$) represent six levels of aggregation. As such, we perform the above described step 6 times in order to reach the most aggregated spending category ("Total expenditure").

To calculate the indirect costs associated with each spending category, quintile, region and year, we multiply an assumed carbon price (\$ per tonne of CO_2e) in each year denoted τ_t by the measure of embodied priced emissions in household spending $\Omega_{m,h,r,t}$:

$$C_{m,h,r,t} = \tau_t \cdot \Omega_{m,h,r,t} \tag{B10}$$

where $C_{m,h,r,t}$ is the indirect cost of emissions pricing for each spending category, quintile, region and year. The total cost to each household is then found within this set. Specifically a value for $n \equiv$ Total expenditure:

$$C_{\text{Total expenditure},h,r,t} = \tau_t \cdot \Omega_{\text{Total expenditure},h,r,t} \tag{B11}$$

If, instead of using the values for $B_{i,\text{consumption},r}$ from the model described in section B.1, we instead use the values from the restricted model described in section B.1.1, the result is that the calculated values for $C_{\text{Total expenditure},h,r,t}$ would describe the indirect or upstream domestic revenue associated with household consumption (rather than the household costs).

C APPENDIX: SUPPLEMENTARY TABLES AND POLICY PARAMETERS

Table C1: 2017 Weighted-Average Electricity and Natural Gas Prices

	Electricity			Natural Gas		
	Commodity Charge ($/kWh)	Second-tier Charge ($/kWh)	Monthly Fee ($)	Commodity Charge ($/GJ)	Distribution Charge ($/GJ)	Monthly Fee ($)
BC	0.079	0.118	5.31	5.61	0	0
AB	0.110	-	29.51	2.30	3.13	41.81
SK	0.126	-	23.41	2.39	3.65	22.58
MB	0.075	-	7.40	2.64	3.83	14.00
ON	0.137	-	18.00	3.55	4.33	20.38
QC	0.057	0.088	12.24	3.83	8.18	15.93
NB	0.104	-	21.53	8.79	9.45	18.00
NS	0.149	-	10.83	-	-	-
PE	0.130	-	25.51	-	-	-
NL	0.102	-	17.00	-	-	-

Note: For British Columbia, Alberta and Ontario, prices presented are weighted averages based on utility providers' share of sales. For Manitoba and Saskatchewan, natural gas prices are weighted to reflect rate changes that occurred in 2017. Quebec allows for 30 kWh per day (equivalent to 10,950 kWh per year) at the first rate, and remaining consumption is charged at the second-tier rate. British Columbia also operates with this two-tier system, allowing consumption of 22.1918 kWh per day (8100 kWh per year) at an initial lower rate, and charging a higher rate for electricity usages above that threshold.
Source: Various and authors' calculations. Price data available upon request.

Table C2: 2017 Average Transportation Fuel and Heating Oil Prices Exclusive of Tax

	Gasoline		Heating Oil	
	Simple Average (¢/litre)	Weighted Average (¢/litre)	Simple Average (¢/litre)	Weighted Average (¢/litre)
BC	119.57	130.64	113.01	111.31
AB	101.11	100.42	86.31	-
SK	99.30	98.87	86.31	-
MB	99.06	97.88	87.62	-
ON	112.79	112.07	109.05	108.52
QC	114.64	114.50	95.02	95.02
NB	109.79	109.22	78.28	78.28
NS	109.15	108.64	94.35	94.03
PE	108.78	108.78	81.93	81.93
NL	129.10	126.16	91.40	89.38

Note: All prices are exclusive of taxes. Gasoline price is regular unleaded. Provincial simple average is the Kent Group Ltd.'s average price. Weighted average is the population-weighted average of cities' prices. Heating oil prices for AB, SK, and MB are imputed from Statistics Canada (ndd), and are the simple average only.
Source: Kent Group Ltd. and authors' calculations.

Table C3: Household Characteristics by Province and Income Decile

Province	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
	Panel A: Household Mean Size									
BC	1.51	1.46	1.73	2.00	2.34	2.54	2.61	2.90	3.24	3.49
AB	1.50	1.69	2.23	2.45	2.57	2.76	3.22	3.24	3.23	3.45
SK	1.66	1.47	1.70	2.19	2.34	2.58	2.66	3.06	3.33	3.33
MB	1.70	1.70	1.99	1.95	2.47	2.60	2.58	3.06	3.40	3.36
ON	1.67	1.73	2.04	2.13	2.37	2.67	2.85	3.09	3.34	3.49
QC	1.53	1.31	1.77	1.87	2.04	2.23	2.44	2.71	3.09	3.33
NB	1.63	1.43	1.65	1.92	2.15	2.42	2.29	2.75	2.91	3.26
NS	1.63	1.37	1.80	1.83	2.15	2.19	2.65	2.69	2.96	3.17
PE	1.48	1.58	1.63	2.16	2.29	2.30	2.96	3.20	3.13	3.12
NL	1.63	1.40	1.90	2.15	2.46	2.23	2.65	2.70	3.07	3.20
	Panel B: Household Mean Number of Adults									
BC	1.20	1.28	1.56	1.65	1.89	2.07	2.16	2.34	2.65	2.90
AB	1.22	1.45	1.74	1.93	1.91	2.13	2.53	2.50	2.51	2.78
SK	1.23	1.26	1.51	1.75	1.84	2.02	2.09	2.36	2.44	2.56
MB	1.26	1.32	1.57	1.61	1.94	1.98	2.06	2.39	2.66	2.68
ON	1.25	1.39	1.70	1.81	1.95	2.12	2.32	2.53	2.66	2.82
QC	1.24	1.16	1.55	1.53	1.70	1.88	2.02	2.22	2.38	2.58
NB	1.17	1.23	1.52	1.62	1.80	2.04	2.03	2.28	2.34	2.56
NS	1.29	1.23	1.56	1.56	1.85	1.90	2.18	2.31	2.30	2.48
PE	1.12	1.30	1.48	1.88	1.95	1.91	2.31	2.42	2.42	2.54
NL	1.27	1.25	1.70	1.83	1.97	1.97	2.19	2.26	2.38	2.51
	Panel C: Household Mean Number of Earners									
BC	0.41	0.52	0.81	1.04	1.36	1.45	1.59	1.88	2.08	2.37
AB	0.40	0.62	0.99	1.36	1.45	1.72	1.91	2.06	2.18	2.40
SK	0.34	0.56	0.81	1.05	1.28	1.53	1.63	2.00	2.18	2.27
MB	0.33	0.56	0.81	1.04	1.33	1.43	1.54	1.97	2.35	2.46
ON	0.36	0.51	0.82	0.99	1.26	1.50	1.71	1.99	2.19	2.44
QC	0.35	0.31	0.64	0.89	1.06	1.24	1.40	1.67	1.98	2.22
NB	0.33	0.44	0.52	0.86	1.26	1.40	1.28	1.83	2.07	2.31
NS	0.46	0.43	0.66	0.89	1.08	1.26	1.51	1.75	1.89	2.07
PE	0.32	0.58	0.77	1.30	1.31	1.37	1.71	2.13	2.11	2.33
NL	0.22	0.27	0.53	1.03	1.35	1.42	1.67	1.79	1.92	2.31

Note: Presents within-decile households characteristics based on SPSD/M v. 28.0. Income decile 1 (D1) corresponds to the lowest decile, while decile 10 (D10) corresponds to the highest income decile.

Table C4: Household Income Category Upper Bounds by Province (2020 CAD)

Income Cut-point	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
10%	20,669	26,816	22,017	21,633	20,398	19,764	20,504	20,003	21,646	20,138
20%	31,730	42,217	33,193	33,332	32,549	26,566	28,584	29,283	31,316	29,945
30%	46,447	60,029	49,795	46,843	46,161	37,365	39,517	40,151	41,879	44,564
40%	61,231	80,099	65,899	60,089	62,520	48,746	51,251	52,538	55,697	60,712
50%	76,308	100,584	82,186	75,518	79,285	62,262	65,891	66,718	68,779	74,932
60%	95,937	119,569	101,471	90,755	98,422	79,263	80,827	82,340	85,516	91,101
70%	115,844	142,662	123,806	109,920	119,906	97,473	97,847	101,634	101,666	116,544
80%	143,570	172,041	154,361	137,096	150,223	122,471	121,207	128,113	120,245	142,128
90%	194,063	235,123	196,295	178,701	204,879	164,752	156,715	173,371	152,638	185,454
95%	247,083	303,875	249,062	228,509	264,209	201,831	195,336	210,630	193,950	228,161
99%	440,673	517,233	414,073	378,219	492,422	381,294	313,946	352,797	323,863	365,959

Note: Cut-off points at the household level calculated using microdata from SPSD/M v. 28.0.

Table C5: Revenue Recycling Policy Scenarios at $50 per tonne (2020 CAD)

	Adult		**Spouse or Child**		**Child**	
	Actual	Modelled	Actual	Modelled	Actual	Modelled
			Panel A: GST Credit Increase			
BC	$296	$869	$296	$869	$156	$430
AB	$296	$1,356	$296	$1,356	$156	$671
SK	$296	$1,424	$296	$1,424	$156	$747
MB	$296	$868	$296	$868	$156	$429
ON	$296	$794	$296	$794	$156	$418
QC	$296	$669	$296	$669	$156	$327
NB	$296	$967	$296	$967	$156	$480
NS	$296	$1,026	$296	$1,026	$156	$508
PE	$296	$777	$296	$777	$156	$386
NL	$296	$761	$296	$761	$156	$377
			Panel B: Lump Sum Dividend			
BC	$190	$357	$190	$179	$55	$89
AB	$589	$642	$294	$321	$147	$160
SK	$717	$745	$357	$371	$179	$186
MB	$394	$363	$197	$181	$97	$91
ON	$353	$326	$177	$163	$87	$80
QC	-	$234	-	$117	-	$59
NB	$297	$458	$148	$229	$74	$115
NS	-	$1097	-	$549	-	$274
PE	-	$303	-	$152	-	$76
NL	-	$278	-	$139	-	$70

Note: Actual and counterfactual policy parameters using all available carbon tax revenues. The GST credit columns report the federal sales tax credit within SPSD/M received by tax-filers by family composition for the 2019 tax year (payments between July 2020 and June 2021). These differ very little from the 2020 tax-year payments (see Table C6. The GST credit is means-tested; thresholds are reported in Table C7. The lump sum dividend columns report the payment to urban tax-filers by family composition. BC's actual policy is the means-tested BC Climate Action Tax Credit for the 2021 tax year. For Alberta, Saskatchewan, Manitoba, Ontario and New Brunswick, the actual column for the lump sum dividend is the federal Climate Action Incentive for the 2021 tax year estimated within SPSD/M. Modelled dividends to rural households are also scaled to be 10% higher (not shown).

Table C6: GST/HST Credit Payment Amounts (nominal CAD)

	2019 base year (July 2020-June 2021)	2020 base year (July 2021-June 2022)
Credit for eligible adult	$296	$299
Credit for each qualified child under 19	$155	$157
Equivalent to spouse amount for single parents	$296	$299
Supplement for single adults	$155	$157
Phase-in threshold for single-adults (without children) supplement	$9,950	$9.686
Phase-out threshold	$38,507	$38,892

Source: Canada Revenue Agency (ndc,n).

Table C7: GST/HST Credit Payment Amounts by Income and Family Type, 2020 base year (nominal CAD)

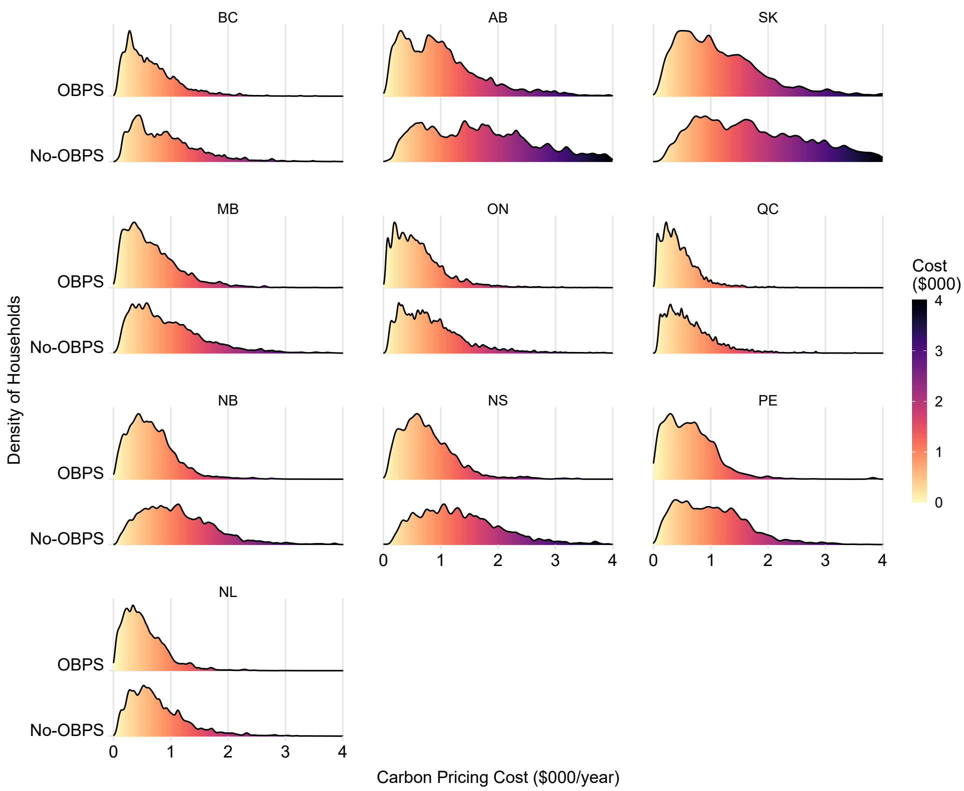
Adjusted family net income ($)	No children ($/year)	1 child ($/year)	2 children ($/year)	3 children ($/year)	4 children ($/year)
	Panel A: Single				
Under $9,686	$299.00	$755.00	$912.00	$1,069.00	$1,226.00
$12,000	$345.28	$755.00	$912.00	$1,069.00	$1,226.00
$15,000	$405.28	$755.00	$912.00	$1,069.00	$1,226.00
$20,000	$456.00	$755.00	$912.00	$1,069.00	$1,226.00
$25,000	$456.00	$755.00	$912.00	$1,069.00	$1,226.00
$30,000	$456.00	$755.00	$912.00	$1,069.00	$1,226.00
$35,000	$456.00	$755.00	$912.00	$1,069.00	$1,226.00
$40,000	$400.60	$699.60	$856.60	$1,013.60	$1,170.60
$45,000	$150.60	$449.60	$606.60	$763.60	$920.60
$50,000	$0.00	$199.60	$356.60	$513.60	$670.60
$55,000	$0.00	$0.00	$106.60	$263.60	$420.60
$60,000	$0.00	$0.00	$0.00	$13.60	$170.60
$65,000	$0.00	$0.00	$0.00	$0.00	$0.00
	Panel B: Married or Common-law				
Under $38,892	$598.00	$755.00	$912.00	$1,069.00	$1,226.00
$40,000	$542.60	$699.60	$856.60	$1,013.60	$1,170.60
$45,000	$292.60	$449.60	$606.60	$763.60	$920.60
$50,000	$42.60	$199.60	$356.60	$513.60	$670.60
$55,000	$0.00	$0.00	$106.60	$263.60	$420.60
$60,000	$0.00	$0.00	$0.00	$13.60	$170.60
$65,000	$0.00	$0.00	$0.00	$0.00	$0.00

Note: We use the 2019 base year from SPSD/M v.28.0, but per Table C6 these payments are not appreciably different. We do not adjust the income thresholds.
Source: Canada Revenue Agency (nda).

D APPENDIX: SUPPLEMENTARY DISTRIBUTIONAL RESULTS

Here we present additional distributional results; the distribution of costs with and without an OBPS (Figure D1), rural and urban household costs by province at \$50 per tonne (Table D1), household costs normalized by household size at \$50 per tonne (Table D2), and replicate our main results at \$110 and \$170 per tonne. As we assume 100% pass-through by firms and no behavioural change by households, these results largely scale from the results presented in section 4. The exceptions to this linear scaling are the costs related to electricity sector emissions. As the carbon price increases in Canada, the free allocations to natural gas and coal-fired power plants also decline (Environment and Climate Change Canada, 2020d).

Figure D1: Household Carbon Tax Costs With and Without the OBPS at \$50 per tonne



Note: Presents distribution of household costs, based on SPSD/M v. 28.0 energy expenditure and imputed energy use. The height of each curve represents the density or relative frequency of households paying a carbon cost of the magnitude shown at that point on the x-axis. BC expenditure adjusted to remove BC carbon tax prior to imputing energy use. Quebec expenditure adjusted to remove cost of cap and trade system prior to imputing energy use. Results are shown for \$50/tonne both with and without the OBPS.

Table D1: Mean Carbon Pricing Costs by Geography ($50/tonne)

Province	Geography	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
BC	Urban	414	411	406	514	535	617	775	807	912	1,117
	Rural	313	400	465	532	531	671	759	869	899	1,154
AB	Urban	520	536	798	811	917	1,077	1,181	1,301	1,349	1,661
	Rural	769	837	852	1,297	1,213	1,012	1,211	1,338	1,377	1,654
SK	Urban	573	710	659	820	1,048	1,243	1,371	1,486	1,821	2,160
	Rural	580	718	895	1,219	1,123	1,304	1,452	1,545	1,647	2,405
MB	Urban	354	324	459	529	537	674	702	797	1,087	1,243
	Rural	445	540	561	544	710	766	745	882	1,039	1,310
ON	Urban	261	336	398	494	510	589	693	787	978	1,163
	Rural	438	371	399	501	522	602	762	843	899	1,139
QC	Urban	212	238	277	302	366	433	523	565	677	842
	Rural	255	210	316	407	455	527	520	609	672	811
NB	Urban	316	408	419	544	597	665	698	852	936	1,100
	Rural	381	401	558	607	699	791	730	812	1,030	1,101
NS	Urban	404	444	465	516	639	807	880	878	1,165	1,297
	Rural	480	530	671	701	751	790	1,109	1,043	1,109	1,070
PE	All	263	389	371	530	555	692	808	874	946	1,060
NL	Urban	210	274	356	440	463	460	542	682	809	950
	Rural	301	299	554	584	455	497	625	660	745	891

Note: Presents within-decile average costs differentiated by geography, based on SPSD/M v. 28.0 energy expenditure and imputed energy use. BC expenditure adjusted to remove BC carbon tax prior to imputing energy use. Quebec expenditure adjusted to remove cost of cap and trade system prior to imputing energy use. Shows average within-decile carbon costs, at $50 CO_2e CAD per tonne. Income decile 1 corresponds to the lowest decile, while decile 10 corresponds to the highest income decile. Household counts and decile income thresholds differ by province.

Table D2: Mean Carbon Pricing Costs by Household Size ($50/tonne)

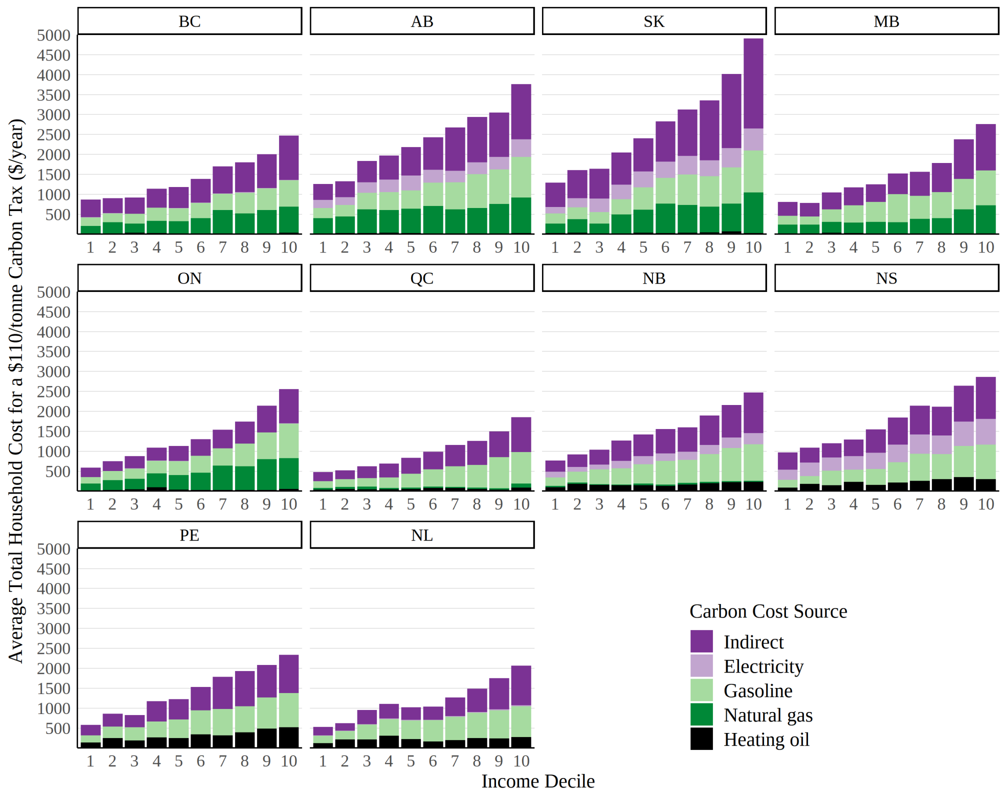
Province	Quintile	Household Size						
		1	2	3	4	5	6	7
BC	1	370	508	290	555	570	746	93
	2	338	533	644	694	665	471	568
	3	365	615	653	741	815	644	504
	4	531	830	814	810	830	936	865
	5	617	886	993	1,151	1,075	1,279	1,198
AB	1	433	754	779	1,046	564	1,446	1,029
	2	505	744	1,076	1,320	1,390	1,732	1,846
	3	602	881	963	1,529	1,736	1,492	1,418
	4	676	1,157	1,237	1,381	1,432	1,554	1,652
	5	873	1,336	1,552	1,658	1,795	1,720	1,356
SK	1	579	768	839	719	939	1,118	900
	2	591	919	1,036	979	1,420	1,660	1,002
	3	739	1,210	1,229	1,449	1,472	1,255	1,235
	4	866	1,308	1,564	1,782	1,640	1,794	2,048
	5	1,113	1,692	1,894	2,267	2,593	2,072	1,952
MB	1	317	392	382	543	581	808	447
	2	425	496	614	680	749	721	949
	3	387	593	686	767	1,009	952	1,330
	4	568	695	768	870	1,038	968	560
	5	698	1,007	1,096	1,349	1,267	1,493	1,284
ON	1	248	378	397	425	524	436	438
	2	398	416	463	684	577	756	582
	3	441	524	579	700	691	605	710
	4	475	726	798	793	754	894	1,375
	5	539	889	997	1,247	1,220	1,315	1,256
QC	1	202	285	239	313	434	639	533
	2	224	346	378	420	482	513	582
	3	299	431	464	570	562	605	790
	4	380	505	608	689	759	629	692
	5	471	613	744	894	919	1,014	919
NB	1	300	490	434	554	820	930	1,147
	2	344	605	643	827	659	1,121	-
	3	443	654	761	844	700	-	-
	4	448	730	796	943	1,299	783	1,178
	5	548	876	1,068	1,217	1,188	1,027	1,073
NS	1	415	484	498	613	472	-	-
	2	412	620	592	968	913	706	-
	3	531	780	811	947	846	950	-
	4	525	886	1,019	1,067	1,239	849	1,397
	5	652	1,071	1,311	1,362	1,308	1,567	1,108
PE	1	265	450	366	568	-	-	611
	2	276	530	539	850	759	486	-
	3	429	615	652	974	946	897	-
	4	405	763	847	988	891	1,214	1,153
	5	502	892	921	1,101	1,414	1,175	-
NL	1	221	295	388	480	-	395	-
	2	318	521	498	616	471	521	926
	3	323	503	449	522	587	715	-
	4	345	597	650	803	698	854	-
	5	432	753	891	1,009	1005	794	819

Note: Presents within-quintile average costs differentiated by household size, based on SPSD/M v. 28.0 energy expenditure and imputed energy use. BC expenditure adjusted to remove BC carbon tax prior to imputing energy use. Quebec expenditure adjusted to remove cost of cap and trade system prior to imputing energy use. Shows average within-quintile carbon costs, at $50 CO_2e CAD per tonne. Income quintile 1 corresponds to the lowest quintile, while quintile 5 corresponds to the highest income quintile. Household counts and quintile income thresholds differ by province.

D.1 Results with $110 per Tonne Carbon Tax

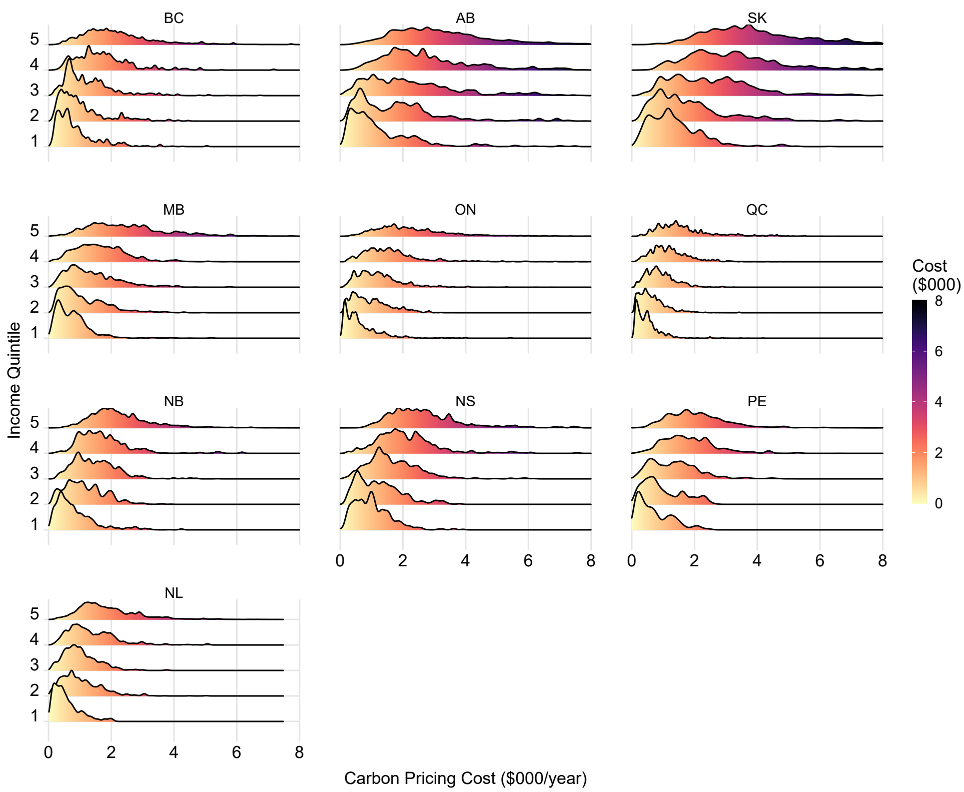
Household Carbon Costs at $110/tonne

Figure D2: Household Carbon Tax Costs by Source, Province and Income Decile



Note: Presents within-decile average costs, based on SPSD/M energy expenditure and imputed energy use. Assumes carbon price of $110 per tonne. BC expenditure adjusted to remove BC carbon tax prior to imputing energy use. Quebec expenditure adjusted to remove cost of cap and trade system prior to imputing energy use. Includes adjustments through federal OBPS. Income decile 1 corresponds to the lowest decile, while decile 10 corresponds to the highest income decile. Household counts and decile income thresholds differ by province.

Figure D3: Distribution of Household Carbon Tax Costs by Province and Income Quintile



Note: Presents the distribution of household carbon costs by income quintile, based on SPSD/M energy expenditure and imputed energy use. Assumes carbon price of $110 per tonne, and includes adjustments through federal OBPS. Income quintile 1 corresponds to the lowest quintile, while quintile 5 corresponds to the highest income quintile. Household counts and quintile income thresholds differ by province. The height of each plot indicates the relative frequency of households obtaining a specific net return value.

Revenue Recycling Policy Parameters at $110 per tonne

Table D3: Revenue Recycling Policy Scenarios for a Single Tax-Filer at $110 per tonne (2020 CAD)

	GST Credit Increase		Lump Sum Dividend		Sales Tax Decrease		Increased PIT Basic Exemption	
	Actual	Modelled	Actual	Modelled	Actual	Modelled	Actual	Modelled
BC	$296	$1,415	$190	$786	7%	2.6%	$10,886	$40,100
AB	$296	$2,290	$589	$1,148	-	-	$19,369	$47,862
SK	$296	$2,387	$717	$1,670	6%	.1%	$16,065	$47,004
MB	$296	$1,396	$394	$799	7%	3%	$9,809	$19,919
ON	$296	$1,275	$353	$718	8%	5.2%	$10,782	$33,966
QC	$296	$1,051	-	$516	9.975%	7.5%	$15,532	$20,780
NB	$296	$1,597	$297	$814	10%	5.3%	$10,459	$28,086
NS	$296	$1,747	-	$1,097	10%	4.5%	$8,481	$30,510
PE	$296	$1,215	-	$667	10%	7.1%	$10,000	$20,220
NL	$296	$1,221	-	$611	10%	7.3%	$9,595	$21,088

Note: Actual and counterfactual policy parameters using all available carbon tax revenues. The GST credit columns report the federal sales tax credit within SPSD/M received by a single tax-filer for the 2019 tax year (payments between July 2020 and June 2021); Table C5 presents parameters by tax family. These differ very little from the 2020 tax-year payments (see Table C6 in Appendix C). The GST credit is means-tested; thresholds are reported in Table C7, Appendix C. The lump sum dividend columns report the payment to a single adult living in an urban area. BC's current policy is the means-tested BC Climate Action Tax Credit for the 2021 tax year. For Alberta, Saskatchewan, Manitoba, Ontario and New Brunswick, the lump-sum-dividend actual column is the federal Climate Action Incentive for the 2021 tax year estimated within SPSD/M. Counterfactual dividend payments are scaled according to household composition (see Table C5). Dividends to rural households are also scaled to be 10% higher (not reported). The sales tax columns report the provincial portion of the sales tax, net of 5% federal GST. The increased basic exemption actual column shows SPSD/M estimates of 2020 tax year provincial personal income tax basic exemption.

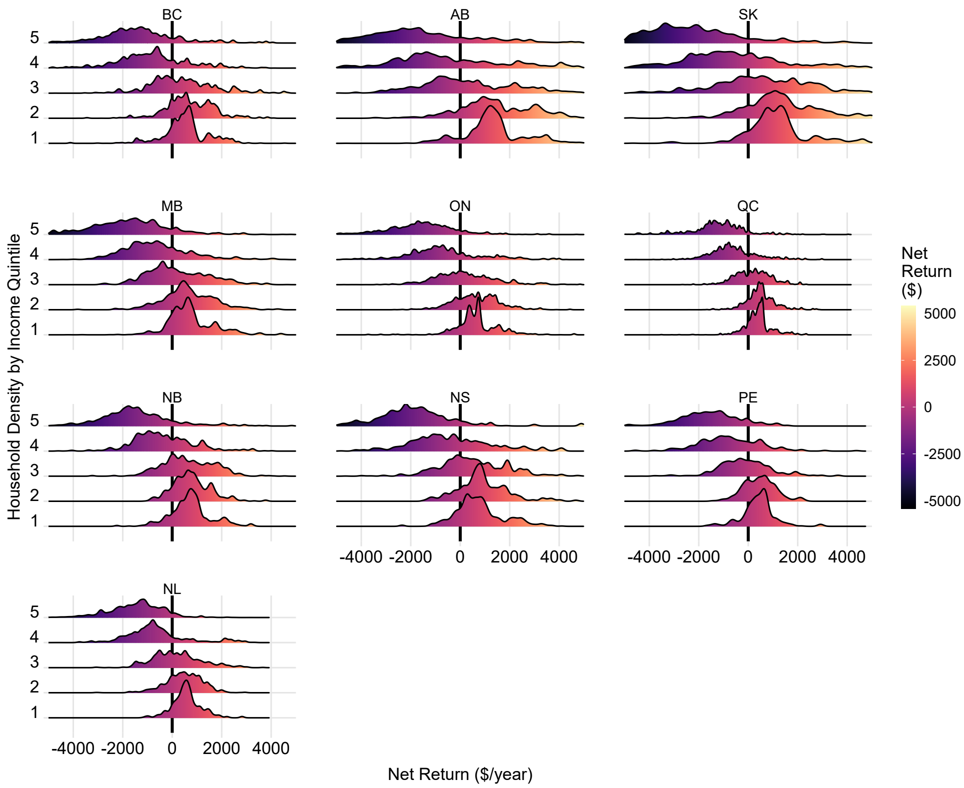
Table D4: Revenue Recycling Policy Scenarios at $110 per tonne (2020 CAD)

	Adult		**Spouse or Child**		**Child**	
	Actual	Modelled	Actual	Modelled	Actual	Modelled
			Panel A: GST Credit Increase			
BC	$296	$1,415	$296	$1,415	$156	$689
AB	$296	$2,290	$296	$2,290	$156	$1,127
SK	$296	$2,387	$296	$2,387	$156	$1,241
MB	$296	$1,396	$296	$1,396	$156	$677
ON	$296	$1,275	$296	$1,275	$156	$671
QC	$296	$1,051	$296	$1,051	$156	$502
NB	$296	$1,597	$296	$1,597	$156	$781
NS	$296	$1,747	$296	$1,747	$156	$850
PEI	$296	$1,215	$296	$1,215	$156	$595
NL	$296	$1,221	$296	$1,221	$156	$593
			Panel B: Lump Sum Dividend			
BC	$190	$786	$190	$393	$55	$196
AB	$589	$1,148	$294	$574	$147	$287
SK	$717	$1,670	$357	$832	$179	$416
MB	$394	$799	$197	$399	$97	$200
ON	$353	$718	$177	$359	$87	$177
QC	-	$516	-	$258	-	$129
NB	$297	$814	$149	$515	$74	$257
NS	-	$1,097	-	$549	-	$274
PE	-	$667	-	$334	-	$167
NL	-	$611	-	$306	-	$153

Note: Actual and counterfactual policy parameters using all available carbon tax revenues. The GST credit columns report the federal sales tax credit within SPSD/M received by tax-filers by family composition for the 2019 tax year (payments between July 2020 and June 2021). These differ very little from the 2020 tax-year payments (see Table C6 in Appendix C). The GST credit is means-tested; thresholds are reported in Table C7, Appendix C. The lump sum dividend columns report the payment to urban tax-filers by family composition. BC's actual policy is the means-tested BC Climate Action Tax Credit for the 2021 tax year. For Alberta, Saskatchewan, Manitoba, Ontario and New Brunswick, the actual column for the lump sum dividend is the federal Climate Action Incentive for the 2021 tax year estimated within SPSD/M. Modelled dividends to rural households are also scaled to be 10% higher (not shown).

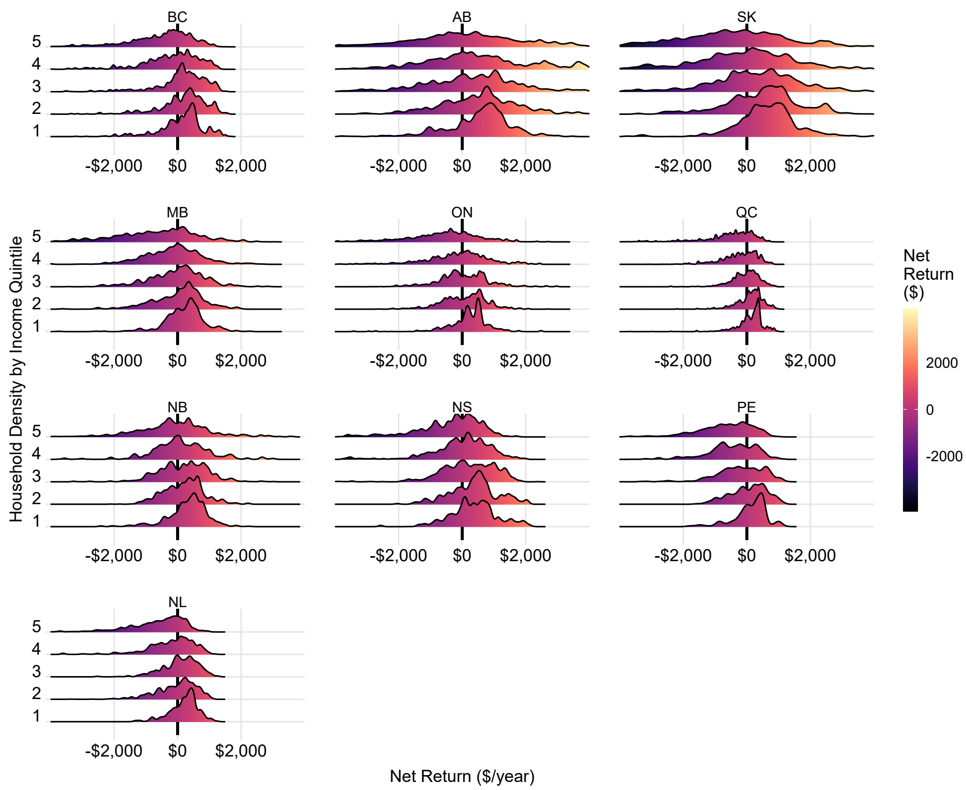
Revenue Recycling at $110/tonne

Figure D4: Net Household Rebates by Province and Income Quintile When Carbon Pricing Revenues Are Used to Provide An Increase to the GST/HST Credit



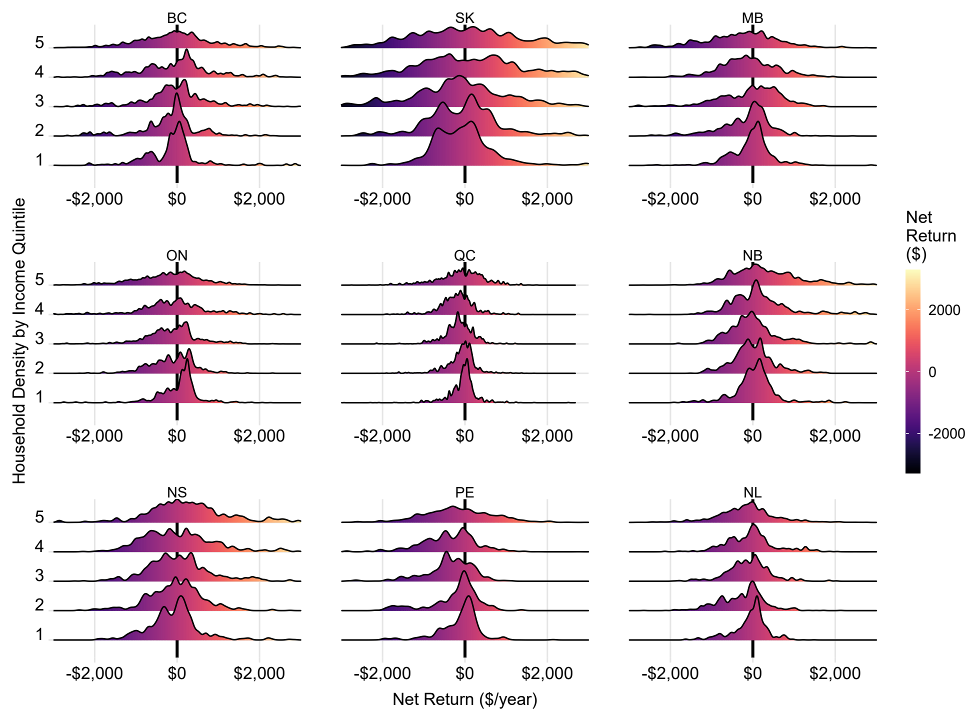
Note: Presents the distribution of household net returns (rebate less costs) by quintile and province, based on SPSD/M energy expenditure and imputed energy use. Positive value implies rebate greater than costs; negative value implies cost greater than rebate. Assumes carbon price of $110 per tonne. Federal backstop modelled, including output-based pricing system. Income quintile 1 corresponds to the lowest quintile, while quintile 5 corresponds to the highest income quintile. The height of each plot indicates the relative frequency of households obtaining a specific net return value.

Figure D5: Net Household Rebates by Province and Income Quintile When Carbon Pricing Revenues Are Used to Provide a Lump-sum Dividend



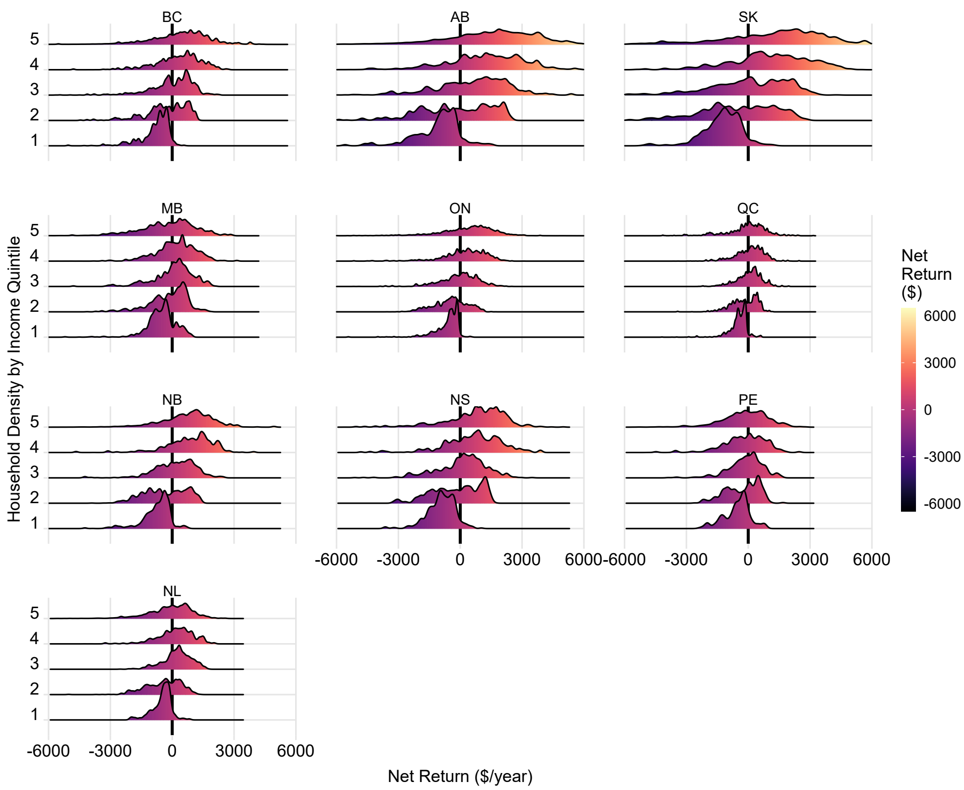
Note: Presents the distribution of household net returns (rebate less costs) by quintile and province, based on SPSD/M energy expenditure and imputed energy use. Positive value implies rebate greater than costs; negative value implies cost greater than rebate. Assumes carbon price of \$110 per tonne. Federal backstop modelled, including output-based pricing system. Income quintile 1 corresponds to the lowest quintile, while quintile 5 corresponds to the highest income quintile. The height of each plot indicates the relative frequency of households obtaining a specific net return value.

Figure D6: Net Household Rebates by Province and Income Quintile When Carbon Pricing Revenues Are Used to Reduce Provincial Sales Tax



Note: Presents the distribution of household net returns (rebate less costs) by quintile and province, based on SPSD/M energy expenditure and imputed energy use. Positive value implies rebate greater than costs; negative value implies cost greater than rebate. Assumes carbon price of $110 per tonne. Federal backstop modelled, including output-based pricing system. Income quintile 1 corresponds to the lowest quintile, while quintile 5 corresponds to the highest income quintile. The height of each plot indicates the relative frequency of households obtaining a specific net return value.

Figure D7: Net Household Rebates by Province and Income Quintile When Carbon Pricing Revenues Are Used to Increase the Basic Income Tax Exemption



Note: Presents the distribution of household net returns (rebate less costs) by quintile and province, based on SPSD/M energy expenditure and imputed energy use. Positive value implies rebate greater than costs; negative value implies cost greater than rebate. Assumes carbon price of $110 per tonne. Federal backstop modelled, including output-based pricing system. Income quintile 1 corresponds to the lowest quintile, while quintile 5 corresponds to the highest income quintile. The height of each plot indicates the relative frequency of households obtaining a specific net return value.

Table D5: Carbon Tax Costs ($110 per tonne) and Average Net Returns by Province and Income Quintile

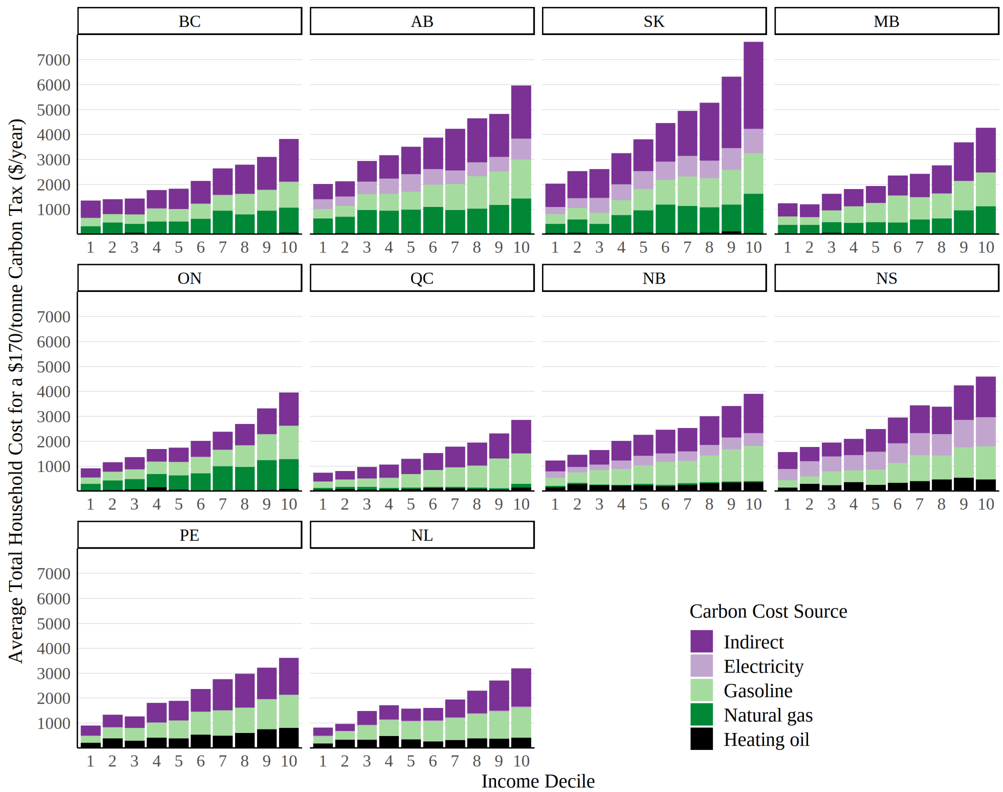
				Revenue Recycling Scenarios											
				GST Rebate			Lump Sum Dividend			Sales Tax Rate Decrease			Increased Basic Exemption		
province	q-tile	Avg. Income	Total Costs	Rebate	Net Ret.	% $R > C$	Rebate	Net Ret.	% $R > C$	Rebate	Net Ret.	% $R > C$	Rebate	Net Ret.	% $R > C$
BC	1	19,189	884	1395	511	81	983	99	66	764	-119	44	59	-825	3
	2	46,233	1029	1731	703	78	1193	164	66	820	-209	39	748	-281	45
	3	76,845	1278	1690	412	58	1385	107	68	1216	-62	48	1277	-1	56
	4	117,136	1749	942	-807	25	1534	-215	48	1698	-51	52	2029	280	65
	5	240,681	2235	872	-1363	17	1590	-645	32	2177	-58	48	2601	366	66
	Avg.	100,052	1435	1326	-110	52	1337	-98	56	1335	-100	46	1344	-92	47
AB	1	26,129	1288	2741	1453	88	1807	519	77	NA	NA	NA	157	-1131	8
	2	60,340	1902	3586	1684	86	2385	482	68	NA	NA	NA	1476	-426	47
	3	100,060	2306	2955	648	53	2631	325	62	NA	NA	NA	2873	566	66
	4	143,236	2804	2798	-6	41	3207	403	59	NA	NA	NA	3938	1135	77
	5	286,617	3400	1557	-1843	21	3396	-4	51	NA	NA	NA	5023	1623	79
	Avg.	123,303	2340	2727	387	58	2685	345	64	NA	NA	NA	2694	354	56
SK	1	20,287	1444	2731	1288	88	2020	576	79	1478	35	46	130	-1314	5
	2	49,178	1838	3351	1513	84	2410	571	71	1760	-79	50	1264	-575	42
	3	82,445	2613	3322	709	63	2779	166	59	2399	-214	43	2642	29	54
	4	125,303	3239	2663	-576	35	3185	-53	52	3526	288	54	4266	1028	75
	5	231,741	4459	1667	-2792	12	3603	-856	38	4759	301	54	5710	1252	74
	Avg.	101,871	2719	2746	27	56	2800	80	60	2786	66	49	2804	84	50
MB	1	19,676	789	1510	721	84	986	196	69	729	-60	52	249	-540	21
	2	46,491	1105	1755	649	76	1131	26	60	922	-183	46	938	-168	51
	3	75,423	1381	1619	238	51	1353	-28	54	1321	-61	53	1458	77	62
	4	111,347	1674	1045	-628	28	1513	-160	44	1568	-106	42	1854	180	60
	5	214,707	2566	756	-1810	12	1810	-756	33	2224	-342	37	2302	-265	48
	Avg.	93,547	1503	1337	-166	50	1359	-145	52	1353	-150	46	1361	-143	48
ON	1	18,856	663	1339	676	85	870	207	74	695	31	63	32	-631	2
	2	46,802	981	1636	655	75	1056	75	57	860	-121	46	511	-470	28
	3	79,354	1212	1404	192	53	1229	18	50	1082	-130	44	1179	-32	53
	4	121,433	1639	957	-683	26	1437	-203	47	1498	-141	45	1840	201	63
	5	257,661	2347	674	-1673	10	1639	-708	30	2071	-277	41	2685	338	66
	Avg.	104,842	1369	1202	-167	50	1246	-122	52	1241	-128	48	1250	-119	43
QC	1	16,909	496	889	394	83	617	121	71	440	-55	46	36	-460	5
	2	37,637	652	1146	494	83	752	99	69	550	-103	42	458	-195	44
	3	62,450	904	1090	186	60	857	-47	51	741	-162	31	945	42	58
	4	98,573	1203	615	-588	22	975	-228	40	1005	-198	29	1286	82	61
	5	199,144	1667	398	-1269	9	1065	-602	26	1532	-135	43	1568	-98	54
	Avg.	82,951	984	828	-157	51	853	-131	51	854	-131	38	859	-126	44
NB	1	19,033	840	1569	729	84	1157	317	77	883	43	56	82	-759	5
	2	40,037	1150	1931	781	86	1349	199	64	1154	4	48	812	-338	43
	3	65,658	1485	2127	643	72	1664	179	60	1478	-7	44	1648	164	60
	4	99,452	1746	1379	-366	34	1821	76	53	1915	170	58	2594	848	81
	5	181,881	2311	807	-1505	13	2151	-160	47	2680	368	63	3033	722	77
	Avg.	81,275	1507	1562	55	58	1629	122	60	1623	116	54	1634	128	53
NS	1	17,897	1024	1794	771	82	1395	371	73	977	-46	47	110	-914	6
	2	40,592	1244	2150	905	84	1604	360	71	1215	-29	48	1047	-197	49
	3	66,822	1690	2251	562	64	1872	182	60	1733	43	50	1785	95	60
	4	103,046	2123	1850	-273	37	2088	-36	55	2161	37	47	2763	640	71
	5	200,811	2752	808	-1945	9	2244	-508	40	3050	298	59	3503	751	77
	Avg.	85,950	1768	1770	2	55	1841	73	60	1828	61	50	1843	76	53
PE	1	21,111	717	1122	405	81	829	112	66	594	-123	49	175	-542	14
	2	42,648	993	1454	461	74	1041	48	54	758	-235	39	705	-288	46
	3	69,606	1372	1264	-108	44	1179	-193	44	962	-411	25	1256	-116	48
	4	101,779	1850	1109	-741	27	1351	-499	29	1454	-396	26	1682	-167	49
	5	186,249	2206	582	-1625	10	1377	-829	22	1974	-232	40	1960	-246	47
	Avg.	84,319	1428	1106	-322	47	1156	-273	43	1149	-280	36	1157	-272	41
NL	1	18,661	569	1151	582	87	776	207	73	503	-67	52	71	-498	7
	2	44,201	1028	1503	475	75	990	-38	56	772	-256	34	597	-431	36
	3	75,241	1025	1217	192	54	1103	78	60	921	-104	44	1267	242	69
	4	116,016	1372	711	-661	20	1168	-205	47	1308	-65	46	1540	167	63
	5	213,282	1905	420	-1485	7	1240	-664	25	1738	-167	38	1805	-100	51
	Avg.	93,523	1180	1000	-180	48	1056	-125	52	1049	-132	43	1057	-123	45

Note: Presents within-quintile average costs, rebates, and net returns (rebate less costs) by revenue recycling scenario, based on SPSD/M energy expenditure and imputed energy use. Positive value implies rebate greater than costs; negative value implies cost greater than rebate. Sales tax decreases modelled as reducing provincial portion of sales tax. Assumes carbon price of $110 per tonne. BC expenditure adjusted to remove BC carbon tax prior to imputing energy use. Quebec expenditure adjusted to remove cost of cap and trade system prior to imputing energy use. Federal backstop modelled, including output-based pricing system. Numbers may differ due to rounding.

D.2 Results with $170 per Tonne Carbon Tax

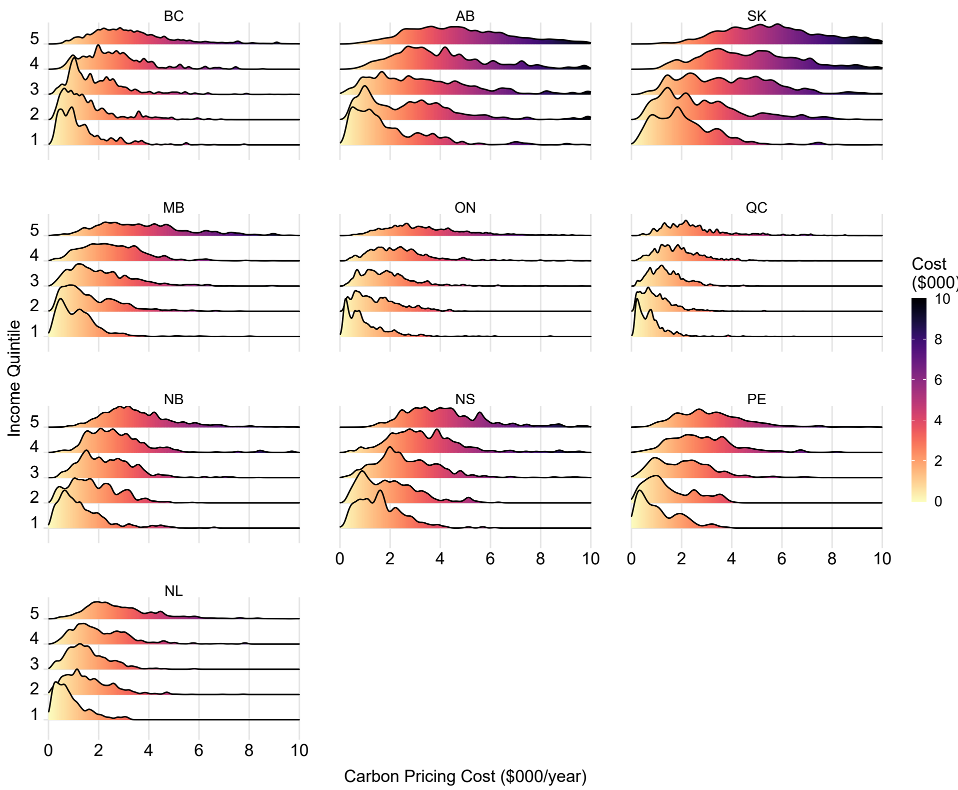
Household Carbon Costs at $170/tonne

Figure D8: Household Carbon Tax Costs by Source, Province and Income Decile



Note: Presents within-decile average costs, based on SPSD/M energy expenditure and imputed energy use. Assumes carbon price of $170 per tonne. BC expenditure adjusted to remove BC carbon tax prior to imputing energy use. Quebec expenditure adjusted to remove cost of cap and trade system prior to imputing energy use. Includes adjustments through federal OBPS. Income decile 1 corresponds to the lowest decile, while decile 10 corresponds to the highest income decile. Household counts and decile income thresholds differ by province.

Figure D9: Distribution of Household Carbon Tax Costs by Province and Income Quintile



Note: Presents the distribution of household carbon costs by income quintile, based on SPSD/M energy expenditure and imputed energy use. Assumes carbon price of $170 per tonne, and includes adjustments through the federal OBPS. Income quintile 1 corresponds to the lowest quintile, while quintile 5 corresponds to the highest income quintile. Household counts and quintile income thresholds differ by province.

Revenue Recycling Policy Parameters at $170 per tonne

Table D6: Revenue Recycling Policy Scenarios for a Single Tax-Filer at $170 per tonne (2020 CAD)

	GST Credit Increase		**Lump Sum Dividend**		**Sales Tax Decrease**		**Increased PIT Basic Exemption**	
	Actual	Modelled	Actual	Modelled	Actual	Modelled	Actual	Modelled
BC	$296	$1,879	$190	$1,214	7%	.3%	$10,886	$70,200
AB	$296	$3,172	$589	$2,290	-	-	$19,369	$81,194
SK	$296	$3,264	$717	$2,630	6%	0%*	$16,065	$90,692
MB	$296	$1,848	$394	$1,235	7%	.8%	$9,809	$26,479
ON	$296	$1,696	$353	$1,110	8%	3.8%	$10,782	$53,114
QC	$296	$1,385	-	$797	9.975%	6.2%	$15,532	$23,975
NB	$296	$2,179	$297	$1,625	10%	2.7%	$10,459	$44,400
NS	$296	$2,437	-	$1,757	10%	1.3%	$8,481	$49,575
PE	$296	$1,600	-	$1,032	10%	5.5%	$10,000	$26,978
NL	$296	$1,627	-	$945	10%	5.9%	$9,595	$28,606

Note: Actual and counterfactual policy parameters using all available carbon tax revenues. The GST credit columns report the federal sales tax credit within SPSD/M received by a single tax-filer for the 2019 tax year (payments between July 2020 and June 2021); Table C5 presents parameters by tax family. These differ very little from the 2020 tax-year payments (see Table C6 in Appendix C). The GST credit is means-tested; thresholds are reported in Table C7, Appendix C. The lump sum dividend columns report the payment to a single adult living in an urban area. BC's current policy is the means-tested BC Climate Action Tax Credit for the 2021 tax year. For Alberta, Saskatchewan, Manitoba, Ontario and New Brunswick, the lump-sum-dividend actual column is the federal Climate Action Incentive for the 2021 tax year estimated within SPSD/M. Counterfactual dividend payments are scaled according to household composition (see Table C5). Dividends to rural households are also scaled to be 10% higher (not reported). The sales tax columns report the provincial portion of the sales tax, net of 5% federal GST. The increased basic exemption actual column shows SPSD/M estimates of 2020 tax year provincial personal income tax basic exemption. *Note that the PST cut in Saskatchewan uses all available revenue and leaves $661 million in carbon pricing revenue available (approximately 36% of available revenue for Saskatchewan at $170/tonne).

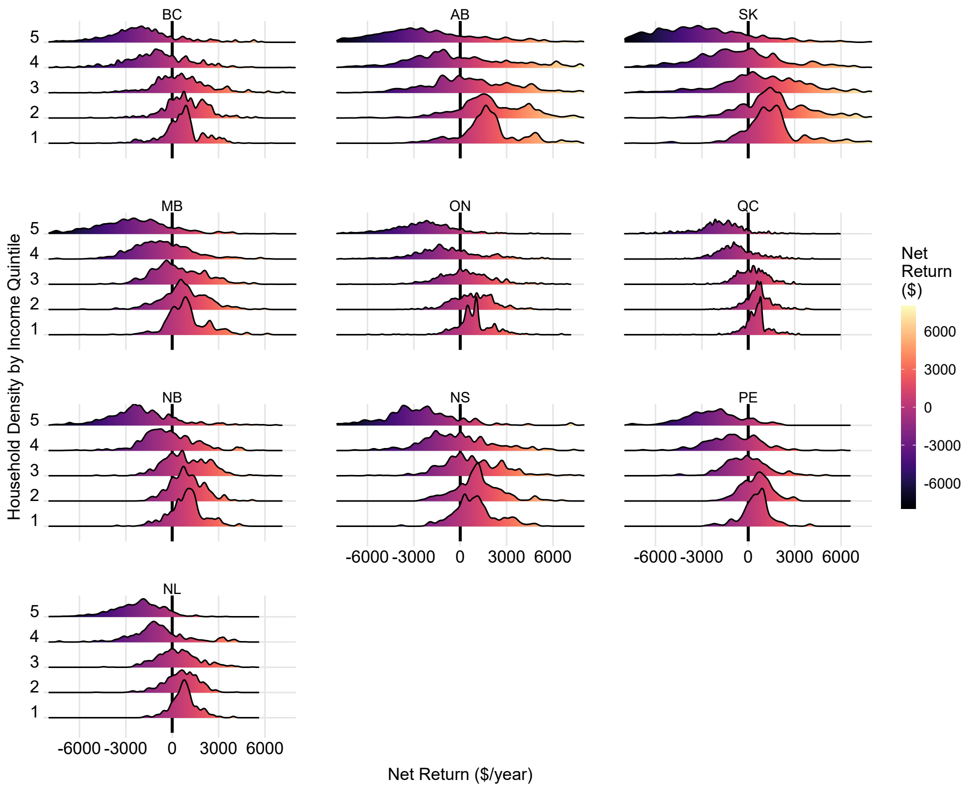
Table D7: Revenue Recycling Policy Scenarios at $170 per tonne (2020 CAD)

	Adult		**Spouse or Child**		**Child**	
	Actual	Modelled	Actual	Modelled	Actual	Modelled
	Panel A: GST Credit Increase					
BC	$296	$1,879	$296	$1,879	$156	$910
AB	$296	$3,172	$296	$3,172	$156	$1,394
SK	$296	$3,264	$296	$3,264	$156	$1,709
MB	$296	$1,848	$296	$1,848	$156	$891
ON	$296	$1,696	$296	$1,696	$156	$893
QC	$296	$1,385	$296	$1,385	$156	$658
NB	$296	$2,179	$296	$2,179	$156	$973
NS	$296	$2,437	$296	$2,437	$156	$1,056
PE	$296	$1,600	$296	$1,600	$156	$780
NL	$296	$1,627	$296	$1,627	$156	$776
	Panel B: Lump Sum Dividend					
BC	$190	$1,214	$190	$607	$55	$304
AB	$589	$2,290	$294	$1,145	$147	$573
SK	$717	$2,630	$357	$1,310	$179	$654
MB	$394	$1,235	$197	$617	$97	$309
ON	$353	$1,110	$177	$555	$87	$274
QC	-	$797	-	$399	-	$199
NB	$297	$1,625	$149	$812	$74	$406
NS	-	$1,757	-	$878	-	$439
PE	-	$1,032	-	$516	-	$258
NL	-	$945	-	$472	-	$236

Note: Actual and counterfactual policy parameters using all available carbon tax revenues. The GST credit columns report the federal sales tax credit within SPSD/M received by tax-filers by family composition for the 2019 tax year (payments between July 2020 and June 2021). These differ very little from the 2020 tax-year payments (see Table C6 in Appendix C). The GST credit is means-tested; thresholds are reported in Table C7, Appendix C. The lump sum dividend columns report the payment to urban tax-filers by family composition. BC's actual policy is the means-tested BC Climate Action Tax Credit for the 2021 tax year. For Alberta, Saskatchewan, Manitoba, Ontario and New Brunswick, the actual column for the lump sum dividend is the federal Climate Action Incentive for the 2021 tax year estimated within SPSD/M. Modelled dividends to rural households are also scaled to be 10% higher (not shown).

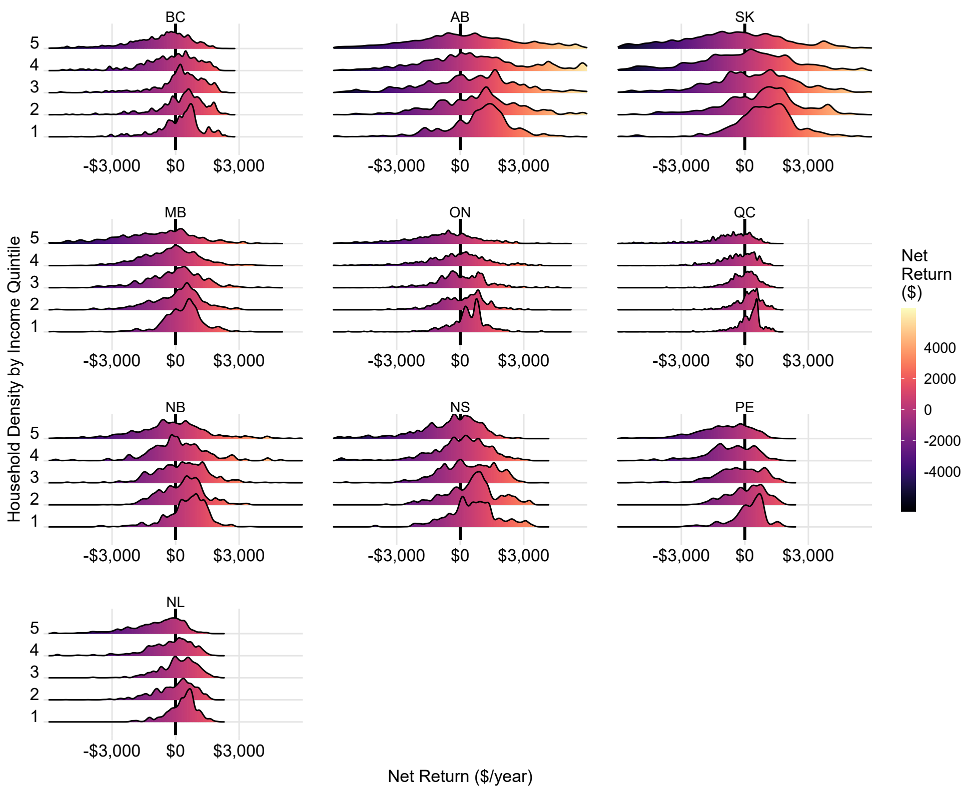
Revenue Recycling at $170/tonne

Figure D10: Net Household Rebates by Province and Income Quintile When Carbon Pricing Revenues Are Used to Provide An Increase to the GST/HST Credit



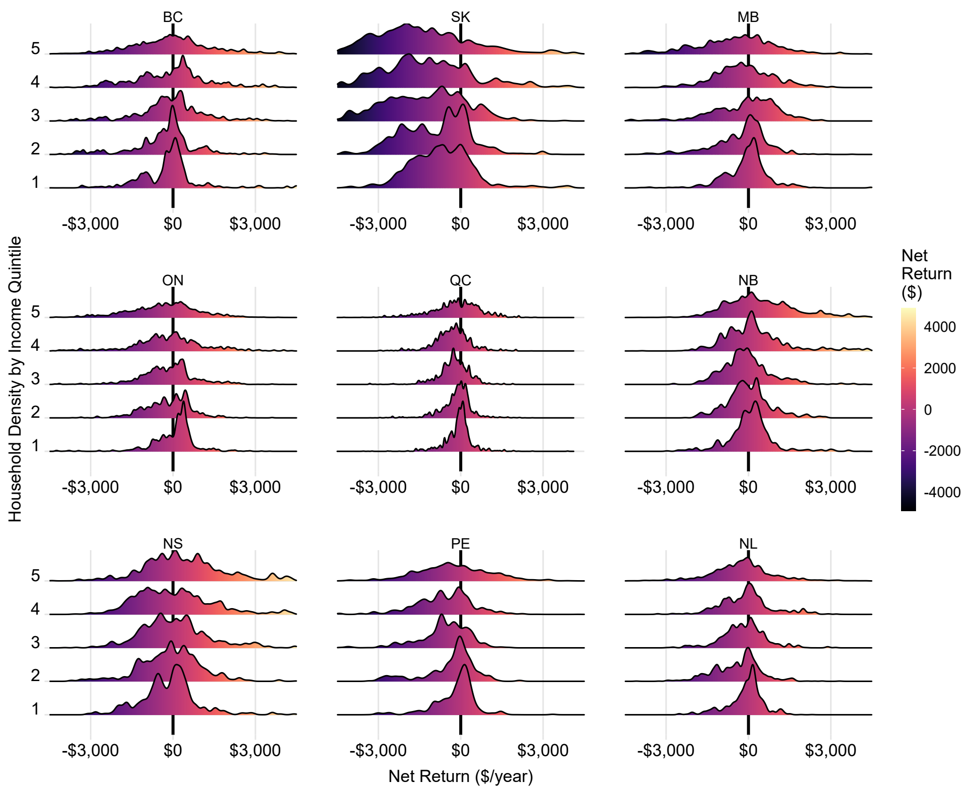
Note: Presents the distribution of household net returns (rebate less costs) by quintile and province, based on SPSD/M energy expenditure and imputed energy use. Positive value implies rebate greater than costs; negative value implies cost greater than rebate. Assumes carbon price of $170 per tonne. Federal backstop modelled, including output-based pricing system. Income quintile 1 corresponds to the lowest quintile, while quintile 5 corresponds to the highest income quintile. The height of each plot indicates the relative frequency of households obtaining a specific net return value.

Figure D11: Net Household Rebates by Province and Income Quintile When Carbon Pricing Revenues Are Used to Provide a Lump-sum Dividend



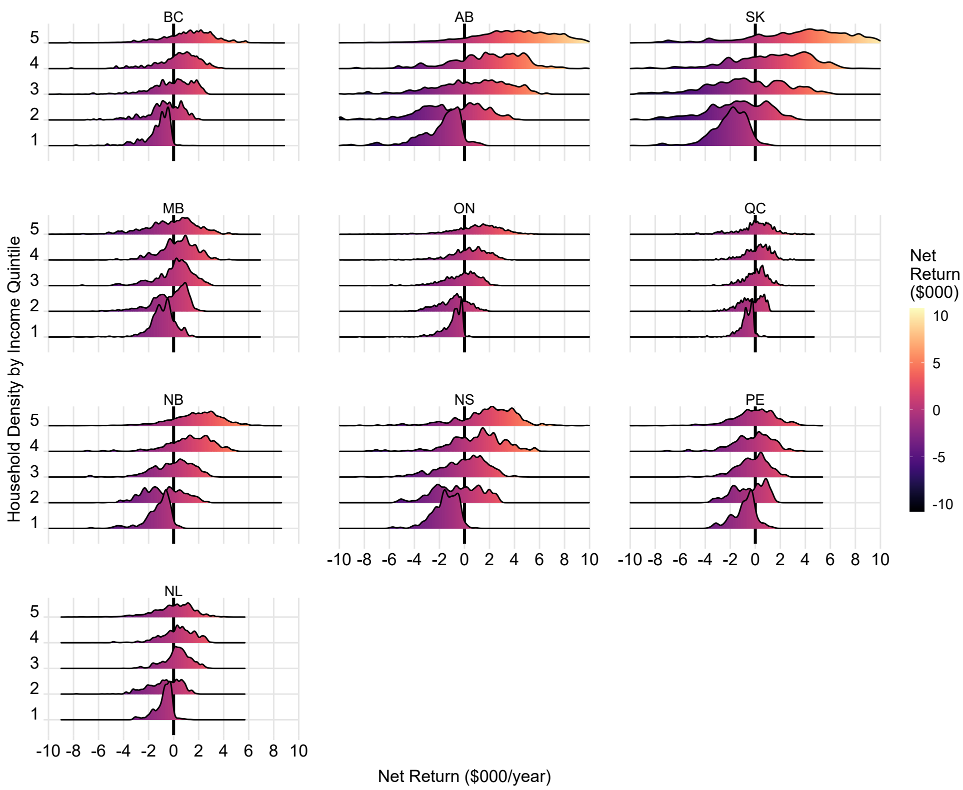
Note: Presents the distribution of household net returns (rebate less costs) by quintile and province, based on SPSD/M energy expenditure and imputed energy use. Positive value implies rebate greater than costs; negative value implies cost greater than rebate. Assumes carbon price of $170 per tonne. Federal backstop modelled, including output-based pricing system. Income quintile 1 corresponds to the lowest quintile, while quintile 5 corresponds to the highest income quintile. The height of each plot indicates the relative frequency of households obtaining a specific net return value.

Figure D12: Net Household Rebates by Province and Income Quintile When Carbon Pricing Revenues Are Used to Reduce Provincial Sales Tax



Note: Presents the distribution of household net returns (rebate less costs) by quintile and province, based on SPSD/M energy expenditure and imputed energy use. Positive value implies rebate greater than costs; negative value implies cost greater than rebate. Assumes carbon price of $170 per tonne. Federal backstop modelled, including output-based pricing system. Income quintile 1 corresponds to the lowest quintile, while quintile 5 corresponds to the highest income quintile. The height of each plot indicates the relative frequency of households obtaining a specific net return value. Note that the provincial sales tax is reduced to 0% in Saskatchewan, but 36% of available carbon pricing revenues remain unused. This is why the Saskatchewan distribution appears skewed to the left.

Figure D13: Net Household Rebates by Province and Income Quintile When Carbon Pricing Revenues Are Used to Increase the Basic Income Tax Exemption



Note: Presents the distribution of household net returns (rebate less costs) by quintile and province, based on SPSD/M energy expenditure and imputed energy use. Positive value implies rebate greater than costs; negative value implies cost greater than rebate. Assumes carbon price of $170 per tonne. Federal backstop modelled, including output-based pricing system. Income quintile 1 corresponds to the lowest quintile, while quintile 5 corresponds to the highest income quintile. The height of each plot indicates the relative frequency of households obtaining a specific net return value.

Table D8: Carbon Tax Costs ($170 per tonne) and Average Net Returns by Province and Income Quintile

				Revenue Recycling Scenarios											
				GST Rebate			Lump Sum Dividend			Sales Tax Rate Decrease			Increased Basic Exemption		
province	q-tile	Avg. Income	Total Costs	Rebate	Net Ret.	$\% R > C$	Rebate	Net Ret.	$\% R > C$	Rebate	Net Ret.	$\% R > C$	Rebate	Net Reb.	$\% R > C$
BC	1	19,189	1366	1977	611	76	1520	154	66	1184	-182	44	65	-1301	1
	2	46,233	1590	2467	877	75	1844	254	66	1268	-322	39	863	-727	34
	3	76,845	1975	2607	632	63	2141	166	68	1881	-94	48	1857	-118	53
	4	117,136	2703	1779	-924	30	2372	-331	48	2627	-76	52	3077	374	67
	5	240,681	3454	1422	-2032	16	2459	-995	32	3360	-94	48	4528	1074	73
	Avg.	100,052	2218	2050	-168	52	2067	-151	56	2064	-154	46	2079	-139	46
AB	1	26,129	2062	3920	1858	87	2860	798	76	NA	NA	NA	157	-1905	5
	2	60,340	3044	5220	2177	84	3775	731	67	NA	NA	NA	1671	-1372	39
	3	100,060	3688	4758	1070	59	4165	476	60	NA	NA	NA	4081	393	59
	4	143,236	4437	4897	460	47	5076	639	60	NA	NA	NA	6161	1724	76
	5	286,617	5389	2796	-2593	23	5376	-14	51	NA	NA	NA	9265	3876	86
	Avg.	123,303	3724	4318	594	60	4250	526	63	NA	NA	NA	4268	544	53
SK	1	20,287	2276	3880	1605	85	3181	906	79	1516	-759	25	130	-2146	3
	2	49,178	2921	4793	1872	79	3795	873	70	1805	-1116	24	1344	-1577	31
	3	82,445	4131	5097	966	64	4376	245	57	2460	-1671	17	3433	-698	42
	4	125,303	5104	4625	-480	41	5016	-89	51	3616	-1488	20	6449	1345	69
	5	231,741	7010	3235	-3776	16	5673	-1337	38	4880	-2130	17	10723	3713	82
	Avg.	101,871	4290	4325	35	57	4409	119	59	2857	-1433	21	4419	129	45
MB	1	19,676	1220	2129	909	80	1524	304	69	1129	-91	52	302	-918	17
	2	46,491	1708	2490	782	73	1748	40	60	1427	-281	46	1365	-343	50
	3	75,423	2135	2509	374	54	2093	-42	54	2044	-91	53	2241	106	63
	4	111,347	2587	1908	-678	33	2340	-247	44	2424	-163	42	2922	335	61
	5	214,707	3966	1303	-2663	13	2799	-1167	33	3436	-530	37	3685	-280	51
	Avg.	93,547	2323	2068	-255	51	2101	-223	52	2092	-231	46	2104	-220	48
ON	1	18,856	1025	1913	888	83	1345	320	74	1075	51	63	32	-993	1
	2	46,802	1517	2359	842	73	1633	117	57	1331	-186	46	624	-893	23
	3	79,354	1872	2247	375	58	1900	28	50	1673	-200	44	1648	-225	49
	4	121,433	2534	1710	-823	31	2221	-312	47	2318	-216	44	2812	279	63
	5	257,661	3628	1072	-2556	11	2534	-1093	30	3197	-430	41	4553	926	72
	Avg.	104,842	2115	1860	-255	51	1927	-188	52	1919	-196	48	1934	-181	42
QC	1	16,909	766	1283	517	81	954	187	71	681	-85	47	40	-727	4
	2	37,637	1008	1654	645	81	1162	154	69	850	-158	42	656	-353	42
	3	62,450	1397	1667	270	61	1325	-72	51	1146	-251	31	1418	21	57
	4	98,573	1859	1139	-720	25	1507	-352	40	1554	-305	29	2035	176	62
	5	199,144	2576	656	-1920	9	1647	-929	26	2367	-209	43	2489	-87	55
	Avg.	82,951	1521	1280	-242	51	1319	-202	51	1320	-202	38	1328	-194	44
NB	1	19,033	1337	2252	915	81	1875	538	78	1396	59	56	82	-1255	3
	2	40,037	1822	2783	961	82	2154	332	65	1824	2	47	1014	-808	32
	3	65,658	2351	3200	849	70	2619	268	59	2333	-18	42	2342	-9	55
	4	99,452	2760	2512	-248	40	2845	85	52	3020	260	56	4068	1308	79
	5	181,881	3650	1592	-2059	15	3353	-297	45	4220	570	62	5391	1741	83
	Avg.	81,275	2385	2467	83	58	2570	185	60	2559	175	52	2581	196	50
NS	1	17,897	1658	2630	972	78	2234	576	73	1568	-90	47	110	-1548	2
	2	40,592	2009	3150	1142	80	2568	559	69	1950	-59	46	1413	-596	40
	3	66,822	2719	3470	751	62	2997	278	60	2779	60	49	2630	-90	53
	4	103,046	3405	3273	-132	44	3343	-62	55	3460	55	47	4394	989	69
	5	200,811	4415	1667	-2748	13	3593	-822	39	4874	459	59	6202	1787	81
	Avg.	85,950	2843	2837	-6	56	2947	105	59	2928	85	50	2952	110	49
PE	1	21,111	1109	1592	483	76	1282	173	66	919	-189	49	214	-895	12
	2	42,648	1534	2066	532	69	1609	75	54	1171	-363	39	1023	-511	44
	3	69,606	2121	1978	-143	44	1824	-297	44	1485	-635	25	1887	-234	48
	4	101,779	2859	1930	-929	32	2089	-770	29	2247	-612	26	2654	-204	51
	5	186,249	3410	987	-2423	12	2129	-1280	22	3049	-361	40	3158	-251	50
	Avg.	84,319	2207	1711	-496	47	1787	-420	43	1775	-432	36	1789	-419	41
NL	1	18,661	880	1655	775	85	1200	320	73	778	-102	52	77	-803	4
	2	44,201	1588	2171	582	72	1530	-58	56	1194	-394	34	848	-741	34
	3	75,241	1584	1952	368	58	1705	121	60	1425	-159	44	1896	312	67
	4	116,016	2121	1282	-839	25	1805	-316	47	2022	-99	46	2440	319	64
	5	213,282	2944	674	-2269	6	1917	-1027	25	2684	-260	38	2905	-38	54
	Avg.	93,523	1824	1547	-277	49	1632	-192	52	1621	-203	43	1634	-189	45

Note: Presents within-quintile average costs, rebates, and net returns (rebate less costs) by revenue recycling scenario, based on SPSD/M energy expenditure and imputed energy use. Positive value implies rebate greater than costs; negative value implies cost greater than rebate. Assumes carbon price of $170 per tonne. Sales tax decreases modelled as reducing provincial portion of sales tax. Note that Saskatchewan sales tax cut returns are based on eliminating the provincial sales tax, but 36% of available revenue still remains after that policy action. This revenue would be available for other revenue-recycling opportunities within Saskatchewan and explains the negative net returns for that policy and province. BC expenditure adjusted to remove BC carbon tax prior to imputing energy use. Quebec expenditure adjusted to remove cost of cap and trade system prior to imputing energy use. Federal backstop modelled, including output-based pricing system. Numbers may differ due to rounding.