

# Evaluating the Progressivity of Canada’s Federal Fuel Charge (GGPPA Part I) and the Canada Carbon Rebate (CCR), 2019–2025

Ontario, Manitoba, Saskatchewan, Alberta

Replication package generated by Python incidence model

February 10, 2026

## Abstract

This report documents a reduced-form incidence model for Canada’s federal fuel charge under Part I of the *Greenhouse Gas Pollution Pricing Act* (GGPPA) and the associated household rebate (Climate Action Incentive / Canada Carbon Rebate, CAI/CCR). The model produces province–income–quintile–year estimates of (i) *gross* household costs of the fuel charge and (ii) *net* household costs after subtracting CCR schedules, together with effective tax rates (ETRs) defined relative to total household expenditure. The scope is restricted to Ontario, Manitoba, Saskatchewan and Alberta from 2019 (policy start) through 2025 (policy wind-down convention). All intermediate quantities and component taxes are saved to the main CSV output to maximize transparency and auditability.

## 1 Policy background and scope

Part I of the GGPPA establishes a federal *fuel charge* applied to a broad set of fossil fuels in jurisdictions that do not meet the federal benchmark. The charge is legislated in Schedule 2 of the Act and administered by the Canada Revenue Agency (CRA). Rates for key fuels in backstop provinces from April 2019 to March 2025 are published by the CRA in *Fuel charge rates*.

Household proceeds are returned primarily through a rebate administered through the personal income tax system (originally the Climate Action Incentive; renamed the Canada Carbon Rebate in 2024). Department of Finance backgrounders publish annual rebate schedules by province and household composition and describe the rural supplement. Environment and Climate Change Canada (ECCC) annual reporting on the administration of the GGPPA documents, among other items, the schedule of fuel charge rates and the wind-down of the consumer fuel charge effective April 1, 2025.

This report focuses exclusively on Ontario, Manitoba, Saskatchewan, and Alberta; years 2019–2025; and the consumer fuel charge (Part I). The output-based pricing system (Part II) is outside scope except insofar as it informs external cross-validation benchmarks.

## 2 Data

### 2.1 User-provided micro-aggregation inputs (Statistics Canada)

Three Statistics Canada tables (provided as `.xlsx` extracts) are used:

- **Household spending by category:** Table 11-10-0223-01 (Survey of Household Spending) provides average annual expenditures by province and before-tax income quintile for:

$$E_{pqt}^{gas} \equiv \text{“Gas and other fuels (all vehicles and tools)”}, \quad (1)$$

$$E_{pqt}^{ng} \equiv \text{“Natural gas for principal accommodation”}, \quad (2)$$

$$E_{pqt}^{oil} \equiv \text{“Other fuel for principal accommodation”}, \quad (3)$$

$$E_{pqt}^{tot} \equiv \text{“Total expenditure”}. \quad (4)$$

- **Retail energy prices:** Table 18-10-0001-01 provides gasoline and heating-fuel retail prices. The script uses annual means of:

$$P_{pt}^{gas} \equiv \text{“Regular unleaded gasoline at self service filling stations”}, \quad (5)$$

$$P_{pt}^{oil} \equiv \text{“Household heating fuel”}. \quad (6)$$

- **Household counts:** Table 36-10-0101-01 provides the number of households by province and income quintile, used as weights  $w_{pqt}$ .

**Interpolation.** The expenditure extract includes years 2019, 2021, and 2023; the script linearly interpolates missing years within each province $\times$ quintile cell. For 2024–2025, expenditures and household counts are held at their 2023 interpolated level in the absence of additional microdata. This maintained assumption affects the level of later-year incidence estimates and is documented in the code and the data dictionary.

## 2.2 Statutory rates and rebate schedules

- **Fuel charge rates.** Statutory rates for gasoline, light fuel oil, and marketable natural gas are taken from a user-provided extract `Tax Rate Items_v2.xlsx`. The underlying primary source is the CRA *Fuel charge rates* publication, which reports historical rates (April 2019 to March 2025) by fuel and fuel-charge year.
- **CCR/CAI schedules.** Annual base rebate schedules for 2019–2024 are hard-coded in the script based on Department of Finance backgrounders for the corresponding benefit years. The rural supplement rate is parameterized as 10% through 2023 and 20% in 2024 (consistent with the announced policy change for 2024–25). The script sets rebate schedules to zero for 2025 to match its Part I wind-down convention.
- **Carbon price schedule.** For transparency and for indirect-effect calibration, the script stores a carbon price schedule in  $\$/\text{tCO}_2\text{e}$  as `carbon_price_per_tCO2e`. This is used only for interpolation of the indirect wedge; direct statutory rates are taken from the CRA schedule and are not extrapolated.

## 3 Methodology

### 3.1 Imputing fuel quantities from expenditures

The model converts expenditures into physical quantities using annual average retail prices.

**Gasoline and heating oil.** For gasoline and heating oil, quantities are imputed by dividing expenditure by the annual average retail price:

$$\hat{Q}_{pqt}^{gas} = \frac{E_{pqt}^{gas}}{P_{pt}^{gas}} \quad (\text{litres}), \quad (7)$$

$$\hat{Q}_{pqt}^{oil} = \frac{E_{pqt}^{oil}}{P_{pt}^{oil}} \quad (\text{litres}). \quad (8)$$

**Natural gas (reduced form).** The SHS extract provides natural-gas expenditures but not physical quantity. The script uses a reduced-form conversion:

$$\hat{Q}_{pqt}^{ng} = \phi_p \cdot E_{pqt}^{ng} \quad (\text{GJ}), \quad (9)$$

where  $\phi_p$  is a province-specific “GJ per dollar” factor. The coefficients are calculated from StatCan Table 25-10-0060-01:

$$\phi_{ON} = 0.0720192545, \phi_{MB} = 0.1386298932, \phi_{SK} = 0.0878257722, \phi_{AB} = 0.0858479021.$$

Interpretation:  $\phi_p \approx 1/\bar{P}_p^{ng}$ , the inverse of an assumed average residential end-user natural gas price in \$/GJ. This reduced-form step is necessary because the SHS table provides expenditures but not natural gas quantities. The script also converts the statutory natural gas rate from \$/m<sup>3</sup> to \$/GJ using a constant conversion factor:

$$r_{pt}^{ng,GJ} = r_{pt}^{ng,m^3} \cdot \kappa^{m^3/GJ}, \quad \kappa^{m^3/GJ} = 26.853. \quad (10)$$

### 3.2 Direct fuel charge incidence

Let  $r_{pt}^{gas}$  denote the statutory gasoline rate (\$/L),  $r_{pt}^{oil}$  the light fuel oil rate (\$/L), and  $r_{pt}^{ng,GJ}$  the natural gas rate (\$/GJ). Direct fuel charge paid is:

$$T_{pqt}^{gas} = \hat{Q}_{pqt}^{gas} \cdot r_{pt}^{gas}, \quad (11)$$

$$T_{pqt}^{oil} = \hat{Q}_{pqt}^{oil} \cdot r_{pt}^{oil}, \quad (12)$$

$$T_{pqt}^{ng} = \hat{Q}_{pqt}^{ng} \cdot r_{pt}^{ng,GJ}, \quad (13)$$

$$T_{pqt}^{dir} = T_{pqt}^{gas} + T_{pqt}^{oil} + T_{pqt}^{ng}. \quad (14)$$

The output CSV includes each component ( $T_{pqt}^{gas}$ ,  $T_{pqt}^{oil}$ ,  $T_{pqt}^{ng}$ ) and intermediate quantities for transparency.

### 3.3 Indirect effects: reduced-form wedge calibrated to published anchors

The model represents indirect effects (price impacts on other goods and services) using a multiplicative wedge  $\kappa_{pt}$  applied to the direct burden:

$$T_{pqt}^{gross} = T_{pqt}^{dir} \cdot (1 + \kappa_{pt}), \quad (15)$$

$$T_{pqt}^{ind} = T_{pqt}^{gross} - T_{pqt}^{dir}. \quad (16)$$

Calibration proceeds in two steps. First compute the household-weighted provincial average direct burden:

$$\bar{T}_{pt}^{dir} = \frac{\sum_q w_{pqt} T_{pqt}^{dir}}{\sum_q w_{pqt}}. \quad (17)$$

Given an external “average cost impact per household” anchor  $A_{pt}$ , the implied wedge is:

$$\kappa_{pt} = \frac{A_{pt}}{\bar{T}_{pt}^{dir}} - 1. \quad (18)$$

Second, the script interpolates  $\kappa_{pt}$  linearly as a function of the carbon price schedule. In 2025, the script sets direct statutory rates to zero and imposes  $\kappa_{pt} = 0$ .

### 3.4 CCR/CAI: net incidence under alternative household types

Let  $R_{pt}^{type}$  denote the annual CCR schedule amount for household type  $\mathbf{type} \in \{\text{single adult, couple, family of four}\}$ . Net cost is:

$$T_{pqt}^{net,type} = T_{pqt}^{gross} - R_{pt}^{type}. \quad (19)$$

A rural supplement is implemented as:

$$R_{pt}^{type,rural} = R_{pt}^{type} \cdot (1 + \tau_t), \quad (20)$$

with  $\tau_t$  the rural top-up rate.

### 3.5 Effective tax rates (ETRs)

For any incidence measure  $X_{pqt} \in \{T_{pqt}^{dir}, T_{pqt}^{gross}, T_{pqt}^{net,type}\}$ , the effective tax rate is:

$$\text{ETR}(X)_{pqt} = \frac{X_{pqt}}{E_{pqt}^{tot}}. \quad (21)$$

## 4 Results

### 4.1 Illustrative ETR patterns in 2024

Figure 1 plots the gross-cost ETR by quintile in 2024. Figure 2 shows the net ETR after subtracting the base CCR for a family of four. Negative net ETR values indicate net gains (rebate exceeds gross cost).

### 4.2 Time trend in provincial average gross costs

Figure 3 displays the household-weighted provincial average gross cost over 2019–2025. The sharp drop in 2025 reflects the script convention of setting fuel charge rates to zero.

### 4.3 Selected incidence levels (2021 and 2024)

Table 1 reports gross costs and net costs (family of four, base CCR) by quintile in 2021 and 2024 (ETRs in percent). This table is generated directly from the output CSV.

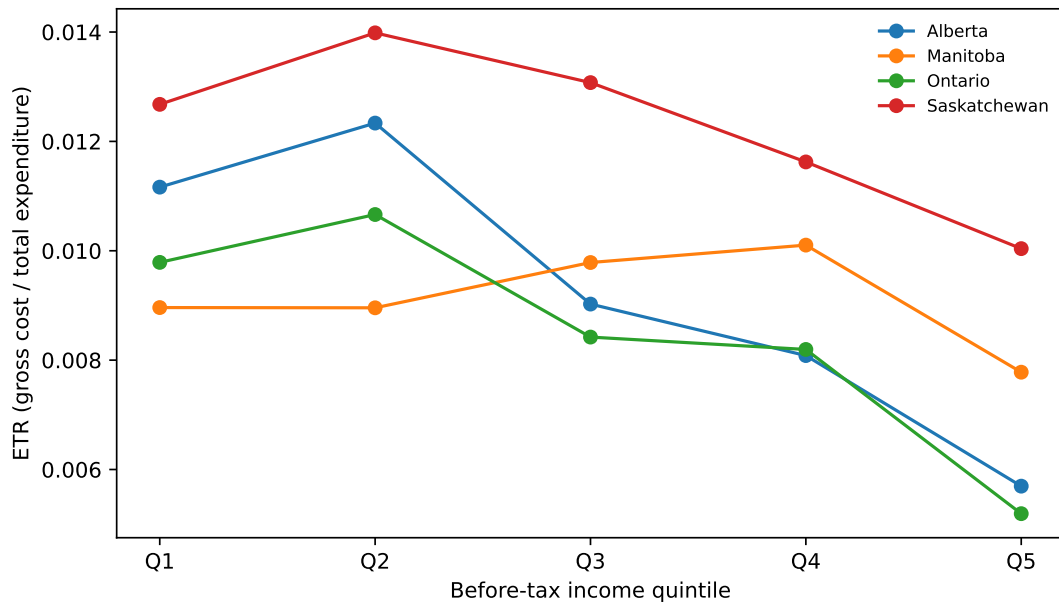


Figure 1: Gross-cost effective tax rates in 2024 (direct fuel charge plus indirect wedge), by income quintile.

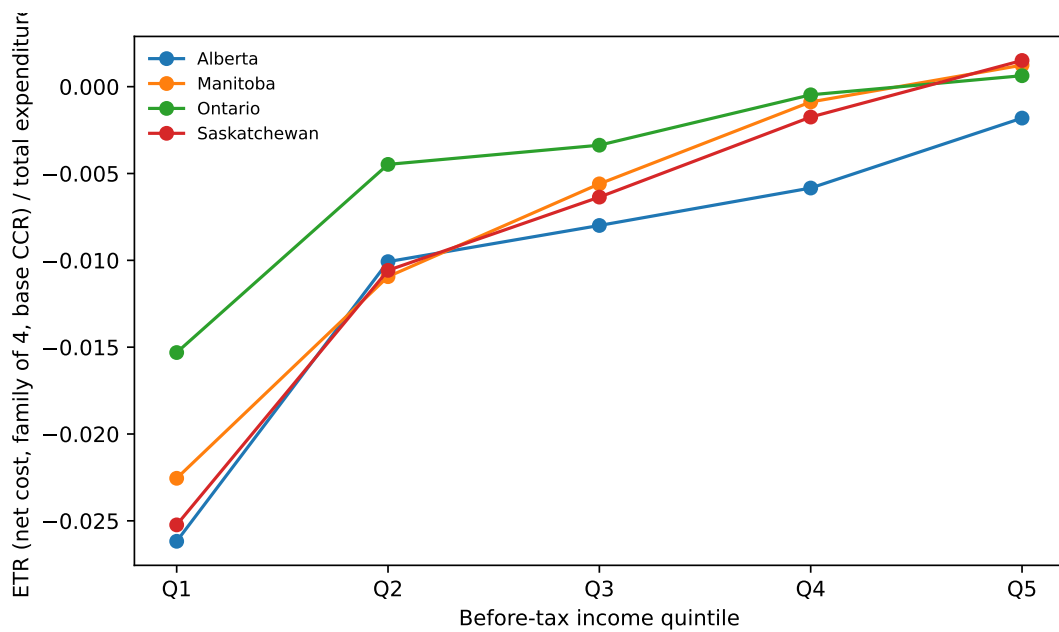


Figure 2: Net effective tax rates in 2024 for a family of four (gross cost minus base CCR), by income quintile.

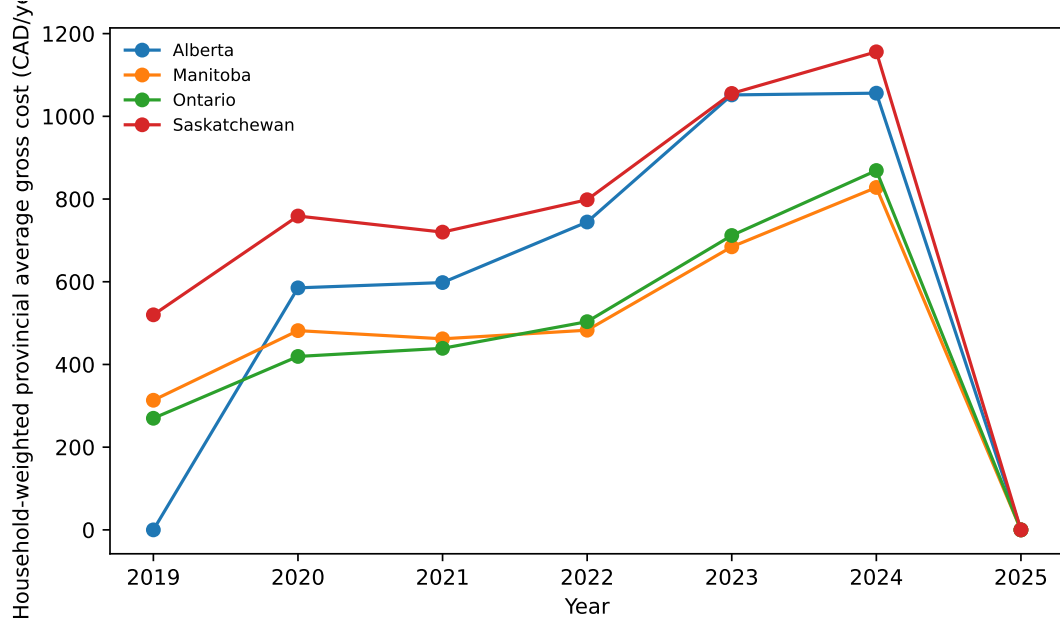


Figure 3: Household-weighted provincial average gross cost over time.

Table 1: Incidence measures by province and income quintile (selected years). ETRs are percentages of total expenditure.

Province	Year	Quintile	gross_cost	net_family4_base	etr_gross_cost	etr_net_family4_base
Alberta	2021	Fourth	682	-299	0.550000	-0.240000
Alberta	2021	Highest	761	-220	0.390000	-0.110000
Alberta	2021	Lowest	266	-715	0.620000	-1.660000
Alberta	2021	Second	480	-501	0.700000	-0.730000
Alberta	2021	Third	508	-473	0.580000	-0.540000
Alberta	2024	Fourth	1045	-755	0.810000	-0.580000
Alberta	2024	Highest	1366	-434	0.570000	-0.180000
Alberta	2024	Lowest	538	-1262	1.120000	-2.620000
Alberta	2024	Second	991	-809	1.230000	-1.010000
Alberta	2024	Third	955	-845	0.900000	-0.800000
Manitoba	2021	Fourth	542	-178	0.540000	-0.180000
Manitoba	2021	Highest	777	57	0.470000	0.030000
Manitoba	2021	Lowest	222	-498	0.570000	-1.280000
Manitoba	2021	Second	306	-414	0.550000	-0.750000
Manitoba	2021	Third	505	-215	0.630000	-0.270000
Manitoba	2024	Fourth	1104	-96	1.010000	-0.090000
Manitoba	2024	Highest	1427	227	0.780000	0.120000
Manitoba	2024	Lowest	341	-859	0.900000	-2.260000
Manitoba	2024	Second	540	-660	0.900000	-1.090000
Manitoba	2024	Third	763	-437	0.980000	-0.560000

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Table 1: Incidence measures by province and income quintile (selected years). ETRs are percentages of total expenditure.

Province	Year	Quintile	gross_cost	net_family4_base	etr_gross_cost	etr_net_family4_base
Ontario	2021	Fourth	603	3	0.520000	0.000000
Ontario	2021	Highest	641	41	0.330000	0.020000
Ontario	2021	Lowest	260	-340	0.640000	-0.840000
Ontario	2021	Second	295	-305	0.530000	-0.550000
Ontario	2021	Third	380	-220	0.470000	-0.270000
Ontario	2024	Fourth	1059	-61	0.820000	-0.050000
Ontario	2024	Highest	1275	155	0.520000	0.060000
Ontario	2024	Lowest	437	-683	0.980000	-1.530000
Ontario	2024	Second	789	-331	1.070000	-0.450000
Ontario	2024	Third	800	-320	0.840000	-0.340000
Saskatchewan	2021	Fourth	824	-176	0.760000	-0.160000
Saskatchewan	2021	Highest	1007	7	0.580000	0.000000
Saskatchewan	2021	Lowest	451	-549	1.080000	-1.320000
Saskatchewan	2021	Second	512	-488	0.870000	-0.830000
Saskatchewan	2021	Third	672	-328	0.940000	-0.460000
Saskatchewan	2024	Fourth	1307	-197	1.160000	-0.170000
Saskatchewan	2024	Highest	1770	266	1.000000	0.150000
Saskatchewan	2024	Lowest	503	-1001	1.270000	-2.520000
Saskatchewan	2024	Second	856	-648	1.400000	-1.060000
Saskatchewan	2024	Third	1012	-492	1.310000	-0.640000

## 5 Cross-validation and integrity checks

This section documents checks against published sources and built-in diagnostics. The aim is to verify schedules and magnitudes; definitions can differ across sources (calendar vs benefit years, included channels, treatment of GST, and inclusion of broader economic effects).

### 5.1 Fuel charge rates (CRA)

The model’s statutory fuel charge rates are sourced from `Tax Rate Items_v2.xlsx`, which corresponds to the CRA’s published historical fuel charge rates (April 2019 to March 2025). The CRA publication reports gasoline rates of 0.0442, 0.0663, 0.0884, 0.1105, 0.1431, and 0.1761 \$/L for successive fuel-charge years through 2024–25, and marketable natural gas rates of 0.0391 to 0.1525 \$/m<sup>3</sup> over the same period. These values are consistent with the units used in this model (direct taxes computed as rate times imputed litres or GJ).

### 5.2 CCR/CAI schedules (Department of Finance and CRA)

The script’s CCR/CAI schedule parameters match Department of Finance backgrounders for each relevant benefit year: 2019, 2020, 2021, 2022–23, 2023–24, and 2024–25. CRA program pages on the Canada Carbon Rebate summarize quarterly payment amounts for previous base years and provide an additional check that the annual totals are in the correct range.

Table 2: Calibration diagnostic: model-implied provincial average costs versus anchors used for calibration (see script dictionary FINANCE\_COST\_IMPACT).

Province	Year	Direct_model_avg	Gross_model_avg	Finance_cost_impact	Gross_minus_finance
Alberta	2021	308.700000	598.000000	598.000000	0.000000
Alberta	2024	800.700000	1056.000000	1056.000000	0.000000
Manitoba	2021	218.000000	462.000000	462.000000	0.000000
Manitoba	2024	491.600000	828.000000	828.000000	0.000000
Ontario	2021	234.400000	439.000000	439.000000	0.000000
Ontario	2024	485.900000	869.000000	869.000000	0.000000
Saskatchewan	2021	292.400000	720.000000	720.000000	-0.000000
Saskatchewan	2024	646.700000	1156.000000	1156.000000	0.000000

### 5.3 Indirect wedge calibration (government cost-impact anchors)

The file `ggppa_finance_crosswalk_v2.csv` provides a diagnostic comparison between the model’s household-weighted provincial average gross cost and the anchor values used for calibration in 2021 and 2024. Table 2 reproduces this crosswalk.

### 5.4 Independent distributional analysis (PBO)

The Parliamentary Budget Officer (PBO) provides a distributional analysis of federal carbon pricing for Ontario, Manitoba, Saskatchewan, and Alberta, reporting gross costs and net costs by income quintile and emphasizing that distributional results depend on whether broader economic channels are included. While the PBO framework is not identical to this report (it incorporates additional channels and reports fiscal-year results under a different forward policy scenario), it is a useful external benchmark. In particular, the PBO documents that gross household carbon costs vary by province and that net costs (after rebates) can change sign across the income distribution.

For completeness, Table 3 reports Kakwani indices produced by the script for selected measures (direct tax, gross cost, and net cost for a single adult under the base schedule), using total expenditure as the ranking variable. These indices summarize whether a burden is progressive or regressive relative to expenditure.

Table 3: Kakwani indices and related inequality statistics (ranking variable: total expenditure).

Province	Year	Measure	Kakwani	Gini_expenditure	Concentration	Total_net_revenue
Alberta	2019	direct_tax	NaN	0.277000	NaN	0.000000
Alberta	2019	gross_cost	NaN	0.277000	NaN	0.000000
Alberta	2019	net_single_base	NaN	0.277000	NaN	0.000000
Alberta	2020	direct_tax	-0.127000	0.275000	0.148000	484402246.465353
Alberta	2020	gross_cost	-0.127000	0.275000	0.148000	1013219994.386693
Alberta	2020	net_single_base	0.280000	0.275000	0.555000	244527234.386693
Alberta	2021	direct_tax	-0.105000	0.260000	0.155000	535415576.169204
Alberta	2021	gross_cost	-0.105000	0.260000	0.155000	1037167014.000000
Alberta	2021	net_single_base	0.533000	0.260000	0.793000	187314444.000000

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Table 3: Kakwani indices and related inequality statistics (ranking variable: total expenditure).

Province	Year	Measure	Kakwani	Gini_expenditure	Concentration	Total_net_revenue
Alberta	2022	direct_tax	-0.125000	0.276000	0.151000	737219306.651247
Alberta	2022	gross_cost	-0.125000	0.276000	0.151000	1314136963.074728
Alberta	2022	net_single_base	0.220000	0.276000	0.496000	362654277.074729
Alberta	2023	direct_tax	-0.142000	0.278000	0.136000	1246016829.838057
Alberta	2023	gross_cost	-0.142000	0.278000	0.136000	1932210577.291688
Alberta	2023	net_single_base	0.188000	0.278000	0.467000	513942357.291688
Alberta	2024	direct_tax	-0.140000	0.284000	0.144000	1533196983.980337
Alberta	2024	gross_cost	-0.140000	0.284000	0.144000	2022073152.000000
Alberta	2024	net_single_base	0.573000	0.284000	0.857000	298715352.000000
Alberta	2025	direct_tax	NaN	0.284000	NaN	0.000000
Alberta	2025	gross_cost	NaN	0.284000	NaN	0.000000
Alberta	2025	net_single_base	NaN	0.284000	NaN	0.000000
Manitoba	2019	direct_tax	-0.045000	0.292000	0.247000	72557188.572848
Manitoba	2019	gross_cost	-0.045000	0.292000	0.247000	169538725.301776
Manitoba	2019	net_single_base	0.210000	0.292000	0.502000	77586915.301776
Manitoba	2020	direct_tax	-0.042000	0.291000	0.248000	118072345.348980
Manitoba	2020	gross_cost	-0.042000	0.291000	0.248000	263051373.881658
Manitoba	2020	net_single_base	0.174000	0.291000	0.465000	130387224.881658
Manitoba	2021	direct_tax	-0.038000	0.275000	0.237000	119196837.865487
Manitoba	2021	gross_cost	-0.038000	0.275000	0.237000	252595266.000000
Manitoba	2021	net_single_base	0.676000	0.275000	0.950000	55767786.000000
Manitoba	2022	direct_tax	-0.032000	0.290000	0.258000	133624789.590999
Manitoba	2022	gross_cost	-0.032000	0.290000	0.258000	268639946.799843
Manitoba	2022	net_single_base	1.357000	0.290000	1.647000	37189610.799843
Manitoba	2023	direct_tax	-0.028000	0.279000	0.250000	210642320.739382
Manitoba	2023	gross_cost	-0.028000	0.279000	0.250000	389118822.602559
Manitoba	2023	net_single_base	0.750000	0.279000	1.029000	88935510.602559
Manitoba	2024	direct_tax	-0.024000	0.289000	0.265000	285349358.600911
Manitoba	2024	gross_cost	-0.024000	0.289000	0.265000	480581964.000000
Manitoba	2024	net_single_base	0.593000	0.289000	0.882000	132334164.000000
Manitoba	2025	direct_tax	NaN	0.289000	NaN	0.000000
Manitoba	2025	gross_cost	NaN	0.289000	NaN	0.000000
Manitoba	2025	net_single_base	NaN	0.289000	NaN	0.000000
Ontario	2019	direct_tax	-0.098000	0.312000	0.214000	812317674.252460
Ontario	2019	gross_cost	-0.098000	0.312000	0.214000	1555275941.747302
Ontario	2019	net_single_base	0.131000	0.312000	0.443000	667742679.747303
Ontario	2020	direct_tax	-0.097000	0.315000	0.218000	1291530322.772106
Ontario	2020	gross_cost	-0.097000	0.315000	0.218000	2445634893.887338
Ontario	2020	net_single_base	0.104000	0.315000	0.419000	1139306765.887338
Ontario	2021	direct_tax	-0.096000	0.323000	0.226000	1377739829.264906
Ontario	2021	gross_cost	-0.096000	0.323000	0.226000	2579919590.000000
Ontario	2021	net_single_base	0.289000	0.323000	0.611000	816876590.000000

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Table 3: Kakwani indices and related inequality statistics (ranking variable: total expenditure).

Province	Year	Measure	Kakwani	Gini_expenditure	Concentration	Total_net_revenue
Ontario	2022	direct_tax	-0.110000	0.336000	0.225000	1629754369.470576
Ontario	2022	gross_cost	-0.110000	0.336000	0.225000	3017576725.474115
Ontario	2022	net_single_base	0.377000	0.336000	0.713000	782011669.474115
Ontario	2023	direct_tax	-0.124000	0.342000	0.218000	2413416937.982651
Ontario	2023	gross_cost	-0.124000	0.342000	0.218000	4392471716.764915
Ontario	2023	net_single_base	0.231000	0.342000	0.573000	1381223308.764915
Ontario	2024	direct_tax	-0.125000	0.336000	0.212000	3080052208.685105
Ontario	2024	gross_cost	-0.125000	0.336000	0.212000	5508644878.000000
Ontario	2024	net_single_base	0.169000	0.336000	0.505000	1958770158.000000
Ontario	2025	direct_tax	NaN	0.336000	NaN	0.000000
Ontario	2025	gross_cost	NaN	0.336000	NaN	0.000000
Ontario	2025	net_single_base	NaN	0.336000	NaN	0.000000
Saskatchewan	2019	direct_tax	-0.069000	0.283000	0.214000	88618404.965814
Saskatchewan	2019	gross_cost	-0.069000	0.283000	0.214000	248105321.419431
Saskatchewan	2019	net_single_base	0.206000	0.283000	0.489000	102587076.419431
Saskatchewan	2020	direct_tax	-0.084000	0.275000	0.191000	138050529.962763
Saskatchewan	2020	gross_cost	-0.084000	0.275000	0.191000	363210719.507292
Saskatchewan	2020	net_single_base	0.119000	0.275000	0.394000	169380554.507292
Saskatchewan	2021	direct_tax	-0.102000	0.258000	0.156000	140082721.822203
Saskatchewan	2021	gross_cost	-0.102000	0.258000	0.156000	344924640.000000
Saskatchewan	2021	net_single_base	0.237000	0.258000	0.495000	105393640.000000
Saskatchewan	2022	direct_tax	-0.083000	0.260000	0.177000	169662590.302106
Saskatchewan	2022	gross_cost	-0.083000	0.260000	0.177000	389135859.815847
Saskatchewan	2022	net_single_base	0.288000	0.260000	0.548000	121047159.815847
Saskatchewan	2023	direct_tax	-0.066000	0.259000	0.193000	256229530.821538
Saskatchewan	2023	gross_cost	-0.066000	0.259000	0.193000	522843516.256834
Saskatchewan	2023	net_single_base	0.269000	0.259000	0.528000	185957916.256834
Saskatchewan	2024	direct_tax	-0.066000	0.258000	0.192000	327342160.717194
Saskatchewan	2024	gross_cost	-0.066000	0.258000	0.192000	585114024.000000
Saskatchewan	2024	net_single_base	0.276000	0.258000	0.534000	204486216.000000
Saskatchewan	2025	direct_tax	NaN	0.258000	NaN	0.000000
Saskatchewan	2025	gross_cost	NaN	0.258000	NaN	0.000000
Saskatchewan	2025	net_single_base	NaN	0.258000	NaN	0.000000

## 5.5 Internal consistency checks

Key identities satisfied by the generated outputs include:

- **Component identity:**  $\text{direct\_tax} = \text{tax\_gasoline} + \text{tax\_oil} + \text{tax\_ng}$ .
- **Wedge identity:**  $\text{gross\_cost} = \text{direct\_tax}(1+\text{kappa})$  and  $\text{indirect\_cost} = \text{gross\_cost} - \text{direct\_tax}$ .
- **Net identity:**  $\text{net\_type} = \text{gross\_cost} - \text{CCR\_type}$  for each household type and rural variant.

- **2025 cessation convention:** 2025 statutory rates are set to zero in the script, implying `direct_tax = gross_cost = 0` (and rebates also set to zero for 2025).

## 6 Outputs and reproducibility

Running `compute_ggppa_progressivity_v2.py` in the same directory as the input `.xlsx` files produces:

- `ggppa_progressivity_results_v2.csv`: main province $\times$ quintile $\times$ year incidence outputs (with intermediate calculations),
- `ggppa_kakwani_indices_v2.csv`: Kakwani indices for selected measures,
- `ggppa_finance_crosswalk_v2.csv`: indirect wedge calibration diagnostic.

A full variable dictionary is provided in `DATA_DICTIONARY.md`.

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