# The Study in Brief

If Canada is serious about reducing greenhouse gases (GHGs), then governments must put an economy-wide price on carbon dioxide and other GHG emissions. However, policymakers have yet to take such action because of concerns about the economic cost of GHG-reduction policies.

This *Commentary* shows that although policymakers do have reason to be concerned about the economic effect of GHG-reduction policies, both regionally and nationally, they have policy tools at their disposal to ameliorate the economic harm that taxing GHG emissions can cause.

For example, because provincial economies are very different from one another, a price on GHG emissions will affect them differently. If policymakers wanted to eliminate the inter-regional transfers that therefore would result from climate policy, one solution would be to return to the provinces the revenues collected through auctioned emissions permits, so that the provinces may offer personal and corporate income tax relief.

In addition to the regional economic effect, policymakers may also be concerned about the nationwide economic effect if Canada taxes emissions without the rest of the world also doing so. Indeed, if Canada acted alone to reduce GHGs, it would reduce the economic attractiveness of investing in Canada. However, reductions in personal and corporate income taxes or rebates to firms proportional to their GHG emissions would mostly offset the cost of reducing GHG emissions and would maintain the attractiveness of investing in Canada.

If a price on carbon emissions is to become a reality in Canada, a bargain must be struck that achieves some degree of regional equity while also supporting economic growth. Policymakers should carefully consider the regional impacts of climate policy as they pursue Canada's existing emissions reduction goals.

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Efforts to reduce greenhouse gas (GHG) emissions in Canada are confronted by the significant difference in emissions intensity across the country, especially the high emissions intensity of Alberta and Saskatchewan.

While it is generally acknowledged that a considerable amount of the country's reductions must occur in these two provinces, there is little agreement on the allocation of costs between them and the rest of the country, or what this might mean for economic performance in different regions.

Relatively few studies have assessed the regional impacts of alternative climate policy approaches in Canada. Snodden and Wigle (2009) explored the regional impacts of climate policies proposed and/or implemented at the federal and provincial levels of government. This study focused on the interactive effects of policies implemented in different jurisdictions and concluded that a nationally "fragmented" climate policy was likely to be economically inefficient. Bataille et al. (2009) produced a study for the Pembina Institute and David Suzuki Foundation that analyzed the level of effort required to reach two targets for greenhouse gas emissions – the government of Canada's previous GHG target of a 20 percent reduction from 2005 levels by 2020, and a target that calls for a 25 percent reduction from 1990 levels by 2020. That study was intended to estimate the economic effects of achieving a deeper GHG target than proposed by the federal government, rather than to explore the implications of different designs for climate policy. However, some commentators expressed concerns that the design selected for the analysis showed a strong reduction in economic growth from

1. The first approach is based on the federal government's proposed, but not implemented, *Regulatory Framework for Air Emissions*

**Box 1: The Methodology**

In our model, sectoral production is based on constant returns to scale technologies represented by nested constant elasticity of substitution functions. In resource extraction sectors, a sector-specific factor is required in production, which is used to capture resource payments (rents) and to calibrate the model to an exogenously specified elasticity of supply. The nesting structure adopted is identical to that used in the Emissions Prediction and Policy Analysis model applied by the Massachusetts Institute of Technology (Paltsev et al., 2005).

Economic output is divided between household consumption, investment, net exports, and government consumption. Government consumption is fixed in real terms. The treatment of investment and trade is described below. Household consumption is governed by a nested constant elasticity of substitution function representing the preferences of a representative consumer. At the top level of the nest, the household allocates its time between leisure and work. At the second and lower levels, the household chooses between non-energy commodities and between various energy commodities. Because this study is not focused on 9.6(e)TJtsentporal or transitional dynamics, a static model is used. In this formulation, the rate of domestic savings is treated as exogenous, and does not respond to the policy. The treatment of foreign savings is discussed below. The total capital stock available to be used in production in each sector is endogenous, however, since investors are able to allocate capital in order to equalize rates of return between sectors.[2]

In a CGE model, important assumptions are required about model “closure” – how the model reaches a new equilibrium in response to a policy. These assumptions relate to whether or not government balances its budget (and over what time frame), the balance of trade with other countries and between regions, movement of labour between regions and countries, movement of investment capital between regions and countries, and the balance of leisure and work in the labour market. The closure assumptions chosen for this study reflect its objective of exploring regional distributional issues while ma9.6a9.ing model simplicity. (For more on the methodology see Appendix A.)

approach: in one, revenue is used to reduce federal corporate and personal income taxes; in the second, the revenue collected by the federal government from each province is returned to that province, where it is used to cut provincial corporate and personal income taxes. The latter variation ensures no net transfer of revenue between provinces.

Because the second approach has two variants – federal government uses permit auction revenue to cut taxes and federal government transfers auction revenue to provinces who cut taxes – we actually test three scenarios in total. Scenario one is the emissions intensity approach. Scenarios two and three are the two tax cut approaches.

### Our Model Explained

The analysis in this paper relies on simulations using a computable general equilibrium (CGE) model of the Canadian economy. Such models are useful for this type of analysis because they connect all major activities in the economy (production, consumption, savings, investment, trade, public finances) to show how the structure and technological character of the economy changes in response to policies (See Box 1).

In the model, Canada is treated as a small open economy, meaning that policies implemented within Canada can affect domestic prices for commodities, but that Canada is a price taker on international export and import markets. Consistent with the objective of this study, the Canadian economy is disaggregated regionally, so that impacts of alternative policies on individual regions within the country can be discerned. The model is further disaggregated by sector and commodity, with 21 sectors and 18 commodities represented. Trade in the model occurs both between provinces and between Canada and other countries.[3]

2 In each sector, a proportion of capital is treated as sector-specific fixed capital, with this amount determined based on a initial stock of capital depreciated over the time period between the start of the policy (2010) and the reporting period (2020). This formulation is known as ‘putty-clay’ capital.

3 Like many CGE models, this one applies the so-called Armington formulation for representing international trade, in which goods produced in different regions are imperfect substitutes (Armington, 1969).

in economic growth as a result of the climate

Table 3: Annual Growth in GDP between 2010 and 2020 under Perfect Capital Mobility

Source: Authors' calculations from GEEM (see appendix for details).

The intensity-based cap-and-trade system, leads to a net transfer from the rest of Canada to Alberta and Saskatchewan, and shows the strongest economic growth in these two provinces. Alberta and Saskatchewan benefit from an intensity-based policy because they have cheaper options to reduce emissions intensity. For example, the electricity sector in Alberta and Saskatchewan can increase generation from renewable resources and natural gas, or adopt carbon capture and storage when using coal, to significantly reduce emissions intensity, while the electricity sectors in other provinces already have low emissions intensity (because of the large role of non-emitting hydropower and nuclear power) with fewer options for improvement. As a result, even though all firms receive permits equal to their emissions intensity targets, firms in Alberta and Saskatchewan would face lower costs to reduce emissions below their intensity targets and thus would reduce emissions in order to generate surplus permits to sell to firms in the rest of the country.

### *Sensitivity to Assumptions about Capital Mobility*

The results thus far are based on the assumption that net foreign savings in Canada will not change because of Canada's climate policies.We now test the alternative n which capital moves freely across international boundaries such that there is a single global return on capital.[5] Here, we treat Canada as a small economy, meaning that policies implemented domestically do not affect the global return on capital.

However, it turns out that the aggregate results are not significantly changed by altering this assumption. Even when Canada imposes a carbon policy while its trading partners do not, and when international capital markets are frictionless, growth rates are not significantly altered (Table 3). Under the revised assumptions, the changes from the assumption of no capital mobility are in parentheses.

In each scenario, the rate of annual growth in GDP declines by 0.02 percent or less, implying that net capital flows are largely unaffected by the policies. This small decline is mostly explained by the type of policies we simulated, which provide either direct or indirect subsidies to industry via the free emissions associated with an intensity target or the revenue provided by income tax cuts. Cutting corporate income taxes improves the after-tax return to investment, while the intensity-based allocations in the cap-and-trade system maintain robust returns to capital by indirectly subsidizing industrial output.[6]

However, the impact of capital mobility on Canada's GDP growth remains sensitive to

5 In the model, we exogenously impose a return on capital, and endogenously adjust net foreign savings until the domestic rate of return on capital matches the exogenously specified return on capital.

6 To disaggregate the effect of carbon costs from income tax cuts on net capital flows and GDP we would have to simulate an additional policy where the rents from permits are not allocated to firms or households. However this is not possible in a CGE model as the rents from a permit auction or free allocation must be allocated back into the economy somewhere, making the disaggregation difficult.

policy design. This analysis has explored two specific policies that were designed to highlight differences in inter-regional equity. They do not show significant differences in capital movement. A comprehensive analysis of policy designs or the effect of policies implemented in other countries would show that some designs can lead to greater

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## Appendix A - Description of GEEM model

The analysis employs a computable general equilibrium (CGE) model called GEEM. The GEEM model represents all economic activity in the economy and ensures equilibrium in all the markets (i.e., for commodities, services and factors of production) by adjusting prices until supply and demand reach an equilibrium. The version of GEEM used for this analysis represents British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec and Atlantic Canada, and each of these regions interacts through trade of commodities and services. Capital is assumed to be mobile among regions, while labour is assumed to be mobile within provinces or states. In the model, a representative household in each region is the owner of primary factors (labour, capital and natural resources) which they rent to producers who combine them with intermediate inputs to create commodities. Commodities can be sold to other producers (as intermediate inputs), to final consumers, or to other regions and the rest of the world as exports. Commodities can also be imported from other regions or the rest of the world. The key economic flows in GEEM are captured schematically in Figure A1.

The version of GEEM in this analysis is static – it solves for a single period in 2020; while the implicit time frame simulated in the model is from 2010 to 2020. Accordingly, in each sector a proportion of capital is treated as sector-specific fixed capital, with this amount determined based on an initial stock of capital depreciated over the time period between the start of the policy (2010) and the reporting period (2020). Any forecasted additions to the capital stock between 2010 and 2020 must be periock oE(uebeceTg s thr)5.8(S)24, Meach Dn each equ,T[f theif cAsso9(erracorld as exporP)53h tht a2d Cole(thP)2]T.

the price for the value-added bundle induce improvements in energy efficiency.

To model resource extraction sectors, we introduce the concept of "resource rent," which is profit earned by resource sectors that exceeds a normal rate of return on investment. Resource extraction sectors earn extra profits (some of which is collected by government in the form of royalties) because the resource they extract is scarce and resource plays have different costs of extraction. In other words, unlike manufactured commodities there is a finite amount resource to extract, such that buyers pay a premium that reflects the scarcity of the commodity. In addition, resource plays differ in their costs of extraction (quality), such that owners of easy to extract (high quality) resources earn additional profits relative to owners of resources that are more difficult to extract. For example, oil extraction from a conventional well would yield greater resource rent per unit of oil production than oil sands mining and upgrading (which has higher costs of extraction).

We use the concept of resource rent to characterize the supply curve for resources. As illustrated in Figure A2, we simulate the ability of a resource sector to substitute between the amount of a fixed resource and other inputs into production, which is represented by the elasticity value rr. If the price for the resource increases, the value of the resource rent (extra profits) for a given level of production increases. Assuming the price for other inputs into production stays constant, the model will simulate an increase in production by shifting away from the fixed resource towards greater inputs. This reflects industry moving towards more marginal resources. In an alternative scenario where the costs of extraction increase (due to the adoption of carbon capture and storage for example), the cost of inputs becomes more costly in comparison to the resource and the model simulates that the marginal resources will not be developed.

The values for all elasticity values used to parameterize the model are illustrated in Table A2.

An additional feature of the GEEM model is we include "alternative" methods of producing goods and services from sectors with specific abatement technologies (e.g., carbon capture and storage). These technologies are unprofitable in the reference case and only become active under certain economic or policy conditions (e.g., carbon pricing). Table A3 shows the key sectors and processes in which carbon capture and storage is available.

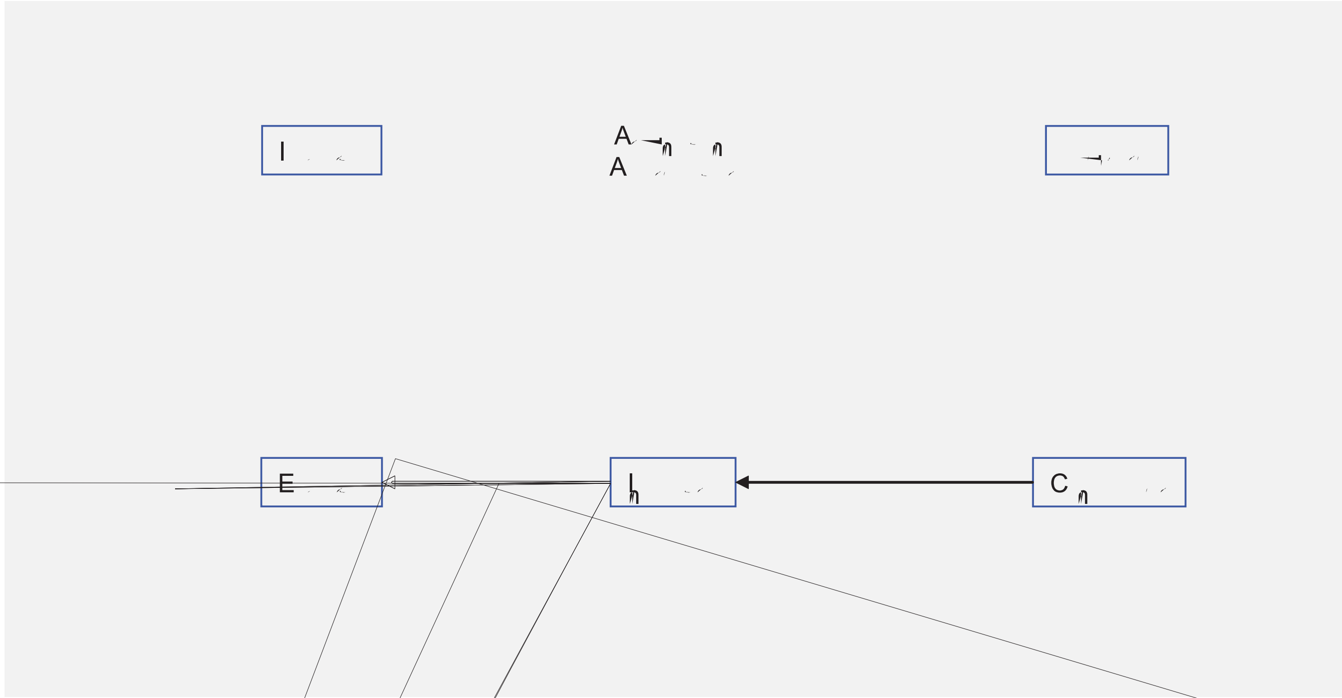
In the GEEM model, all industries maximize profits (i.e., revenue minus costs of production) subject to technology constraints. The projected growth rates for each industrial sector are based on projections provided to the authors by Informetrica.

### *Consumers*

GEEM uses a representative agent framework, where all households are represented by a single representative agent. In this framework, the representative agent maximizes his/her welfare, where welfare is a function of consumption of various commodities and leisure (see Figure A3 for the tree structure and Table A4 for the associated elasticity values). Note that the trees representing space heating, appliances and other goods are identical to the tree representing transportation, and therefore are not shown. Most of the elasticity values have been econometrically estimated from the CIMS energy-economy model, while the values representing the substitutability between an end-use and other goods ( transit) are from Paltsev (2005).

### *Trade*

The substitutability between domestically produced and imported goods is represented by an Armington formulation (see Figure A4 for the structure of imports and Table A5 for the corresponding elasticity values). An elasticity of infinity indicates that a commodity is homogeneous and Canada is a price taker. This is important to represent crude oil in international markets and natural gas in North American markets.



| | |
|---|---|
| PEXT | Crop and animal production |
| | Forestry and logging |
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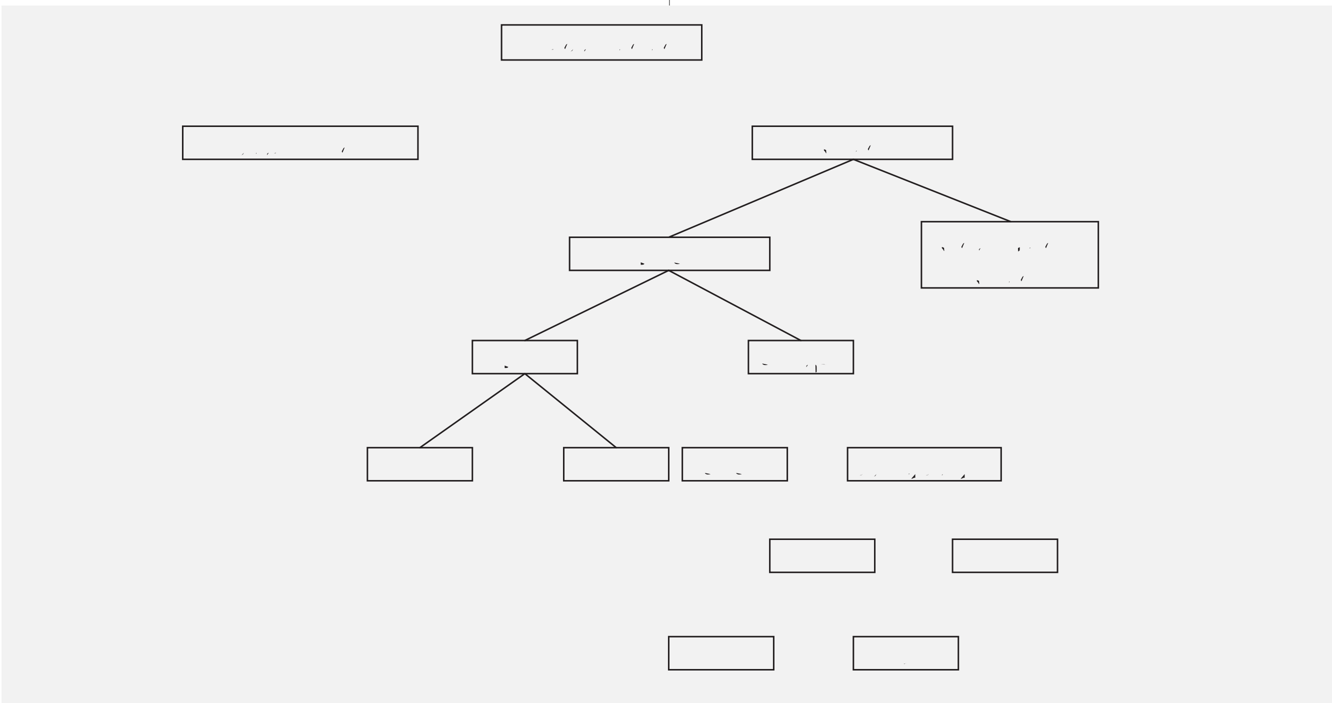
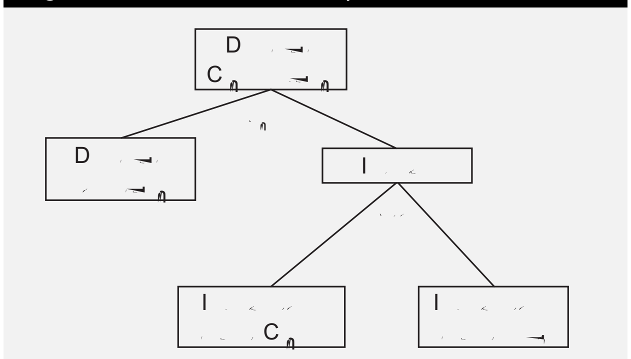


## Table A4: Elasticities of substitution for households

| | $\sigma_{cl}$ | $\sigma_{transit}$ | $\sigma_{hke}$ | $\sigma_{he}$ | $\sigma_{lqd}$ |
|---|---|---|---|---|---|
| Space Heating | | 0 | 3.3 | 3.5 | 3.4 |
| Transportation | 0.6 | 0.2 | 0.6 | 7.5 | 0 |
| Appliances | | 0 | 0.1 | 0 | 0 |
| Other Goods | | 0.25 | 0 | 0 | 0 |

Source: CIMS, 2009 and Paltsev, 2005.

## Figure A4: Structure of Imports



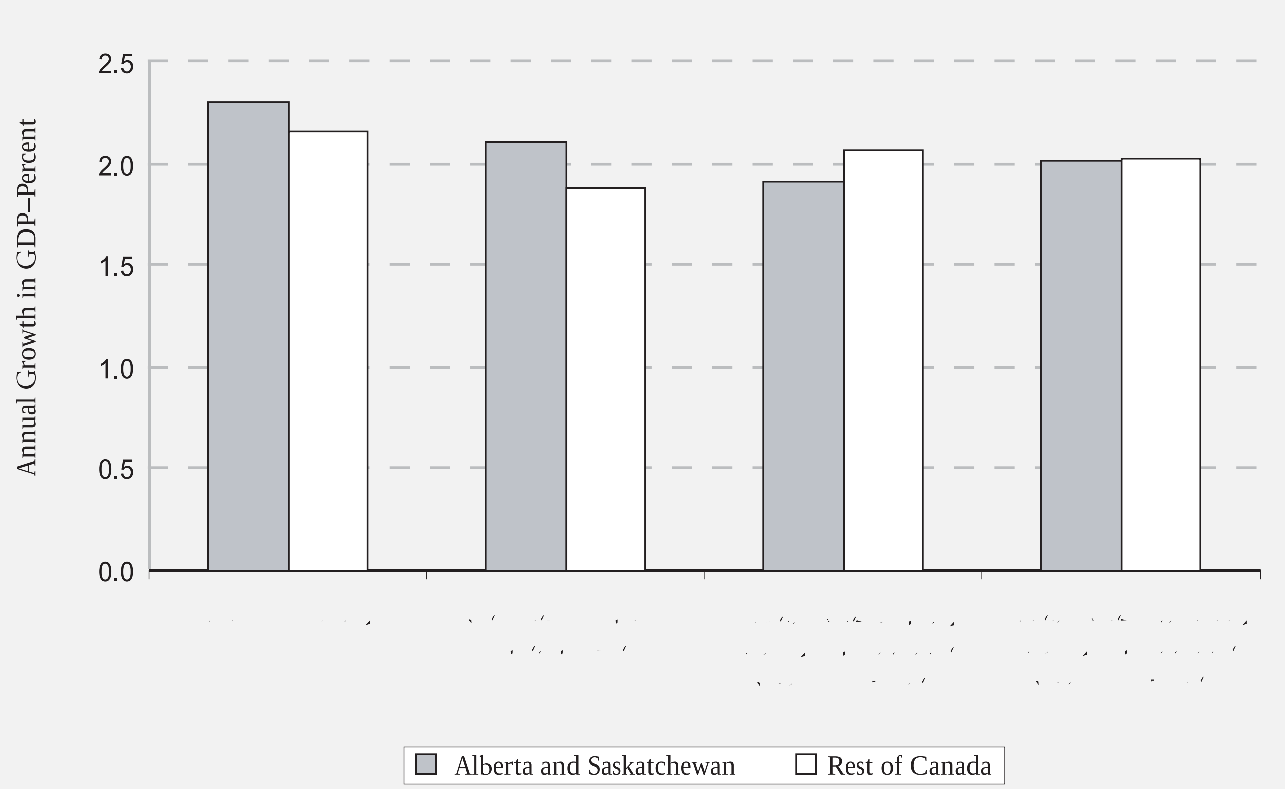
Source: Authors' calculations.

## Table A5: Armington Elasticities

| | $\sigma_{na}$ | $\sigma_{fr}$ |
|---|---|---|
| Crude Oil | ∞ | ∞ |
| Natural Gas | ∞ | 4.0 |
| Other Energy | 4.0 | 4.0 |
| Other Goods | 2.5 | 2.5 |

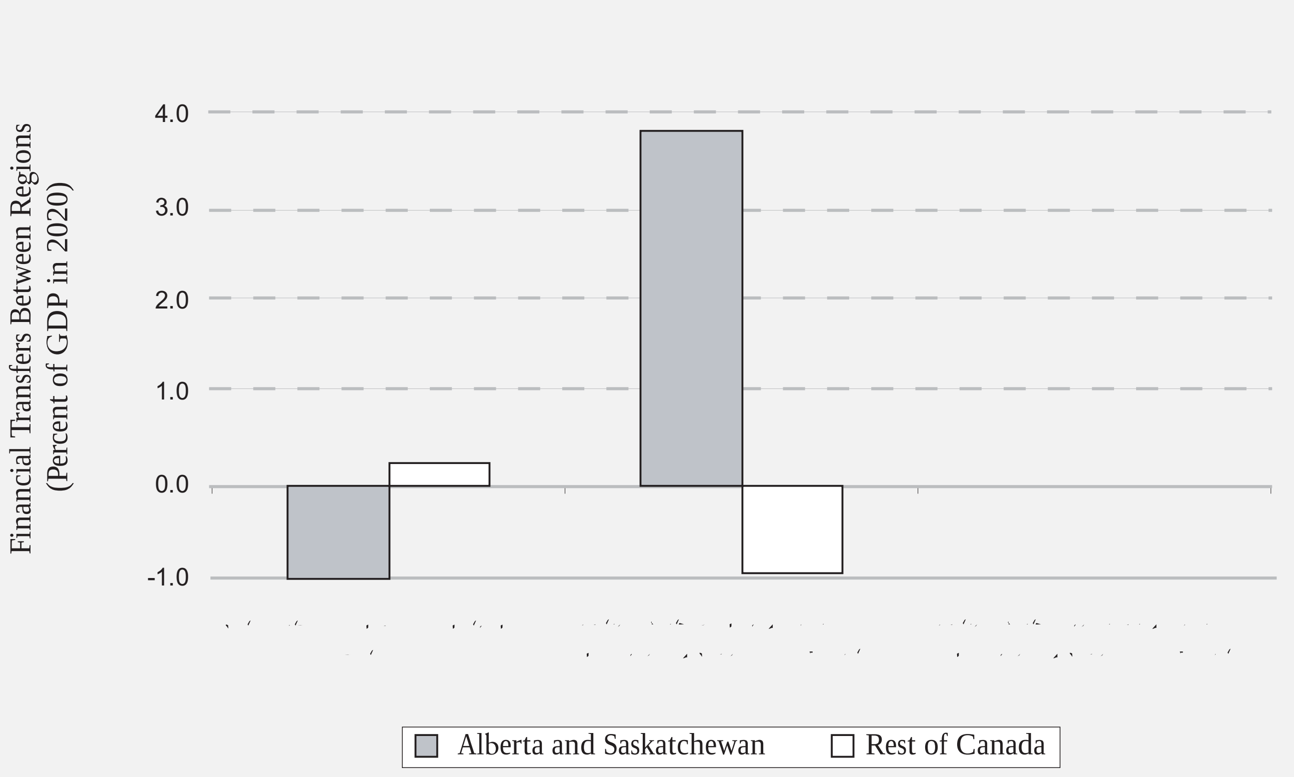
Source: Authors' calculations.

## Figure A5: Annual Growth in GDP, between 2010 and 2020




Source: Statistics Canada (2009); Environment Canada (2008).

## Figure A6: Financial Transfers Leaving Regions Under Different Policy Scenarios




Note: Positive numbers indicate a transfer from the region. No transfers occur when the auction revenue is used to cut provincial income taxes.
Source: Authors' calculations from GEEM (see appendix for details).

# NOTES

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