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The Comparative Analysis of Carbon Pricing Policies on Canadian Northwest Territories' Economy under Different Climate Change Scenarios

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Abstract: Policymakers in the Northwest Territories have introduced carbon pricing as a strategy to reduce fossil fuel consumption and CO_2 emissions across various population segments and industries. This indirect approach, chosen for its acceptability, aims to influence behavior rather than directly limit carbon-intensive products. The main purpose of this study was to evaluate the economic and ecological impacts of this policy and its alignment with intended objectives. Using a CGE macroeconomic model incorporating economic structural and behavioral equations, we assessed the policy's effects on NWT's economy in general and on a subset of its key sectors. We also incorporated a few observed and simulated climate data for diverse climate change scenarios. The estimated results revealed that climate variables, especially precipitation, significantly influenced sectors like agriculture, construction, and manufacturing. The standardized precipitation evapotranspiration index (SPEI), which encompasses both temperature and precipitation, notably impacted the agriculture, oil, and gas sectors. However, temperature alone showed limited significance, except in the oil and gas sector. The simulation results indicated that, while carbon pricing reduced economic contributions of fossil fuel sector, household rebates could counteract these effects of the economic growth of NWT. Our findings offer valuable insights for shaping NWT's environmental policies, aligning them with Canada's goal of net-zero CO_2 emissions by 2050.

Keywords: carbon pricing; CO_2 emissions; Northwest Territories (NWT); macroeconomic analysis; environmental policies

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1. Introduction

The global challenge of climate change, driven primarily by carbon emissions, has prompted nations worldwide to seek effective mitigation strategies. These emissions, responsible for the accumulation of greenhouse gases, have been linked to drastic climatic anomalies, such as extreme temperature fluctuations, rising sea levels, and unpredictable food supply chains [1,2]. The Northwest Territories (NWT) of Canada, located at higher latitudes, exemplifies the acute effects of this phenomenon by experiencing a warming rate that is triple the global average. The NWT is already confronting both ecological and infrastructural challenges, from melting permafrost to deteriorating infrastructure [3,4]. Given the region's economic structure being heavily anchored in natural resource exploitation, the implications of these changes are profound.

In response to global initiatives, notably the 2015 Paris Agreement, Canada embarked on a mission to implement carbon pricing systems across all its provinces and territories by 2018. This initiative aimed to curtail annual GHG emissions by 30% from 2005 figures by 2030 [3,5]. The NWT, acknowledging its distinct challenges, responded by launching its

2030 Climate Change Strategic Framework (CCSF) in 2019, targeting a reduction in CO_2 emissions [6]. The economic ramifications of carbon pricing have been a focal point of numerous studies, each offering insights into its multifaceted impacts across various regions.

Devarajan et al. (2009) and Dissanayake et.al. (2018) [7,8] employed computable general equilibrium (CGE) models to study South Africa, Sri Lanka, and Pakistan. Their findings underscored the positive influence of carbon pricing on the welfare of citizens and the broader economy.

A study by Pradan et al. (2017) [9] highlighted the differential impacts of carbon pricing, noting that China's terms of trade effects resulted in higher carbon prices compared with India. Zhang et al. (2019) [10] further explored China's scenario, revealing that carbon pricing adversely affected competitiveness. However, the detrimental effects were somewhat mitigated in China's less-developed provinces.

Campagnolo and Davide (2019) [11] delved into the intersection of carbon pricing and global sustainable development goals. Using a dynamic CGE model, they assessed the potential of carbon pricing to mitigate carbon emissions in several countries with varied GHG reduction commitments. Their research suggested that nations with lenient commitments, like Egypt, might not derive substantial benefits from carbon pricing.

Parry (1995) and Yamazaki (2017) [12,13] both touched upon a few potential pitfalls of carbon pricing. Their findings suggested, that while a carbon tax could increase revenue and enhance efficiency, there was a risk of deterring employment and investment, especially in sectors directly impacted by the pricing.

Few studies have ventured into the long-term effects of carbon pricing. Notable exceptions include Goulder (1995) and Pereira et al. (2016) [14,15]. The latter identified three potential dividends of carbon pricing: environmental conservation, employment and growth stimulation, and a reduced public debt-to-GDP ratio.

The often-overlooked distributional consequences of carbon pricing have been highlighted in studies like Olale et al.'s 2019 [16] study, where the potential adverse effects on specific sectors were emphasized, even when exempt from carbon pricing.

In synthesizing the above literature, it becomes evident that while there are overarching themes, the effects of carbon pricing are highly contextual, varying based on the varied structures of regional economies and the policies used. This underscores the need for tailored analyses, such as the one required for the Northwest Territories (NWT) (a unique northern economy characterized by its sparse population, reliance on natural capital, and vulnerability to climate influences).

This study aimed to bridge this gap by developing a dynamic computable general equilibrium (CGE) model tailored for the NWT. We assessed the economic and ecological implications of carbon pricing in the NWT under various climate change scenarios and evaluated the effectiveness of the policy in achieving the GNWT's net-zero emission objectives. Through this comprehensive analysis, we hoped to provide valuable insights for policymakers and contribute to the broader understanding of carbon pricing's role in climate change mitigation.

2. Methodological Approach

2.1. Rationale for the Adopted Computable General Equilibrium Model

Computable general equilibrium (CGE) models offer a streamlined representation of the economic landscape, elucidating the interplay of economic variables in response to external stimuli. Contrasted with macrolevel traditional models, like input–output and linear programming frameworks, the CGE model uniquely leverages the concurrent adjustment of prices and values to attain optimization and equilibrium positions. Specifically, these conditions encompass zero profit, market clearance, and income equilibrium.

While models such as input–output and linear programming treat prices and values as external givens, in the CGE model, both are conceptualized as endogenous components. The primary ambition when explaining and elaborating the CGE model lies in pinpointing these endogenous variables—essentially, equilibrium prices, production values, and incomes—predicated on a given set of parameters and external variables.

The choice of a dynamic computable general equilibrium (CGE) model, is motivated by its efficacy in evaluating outcomes of introducing carbon pricing, as evidenced in the preliminary literature overview. Applying the dynamic CGE model to the NWT allows us to encapsulate the comprehensive ramifications of policy enactments, especially the distinctive consequences stemming from the adoption of carbon tax policies.

Distinct from econometric models, which necessitate extensive statistical and sequential data, CGE models are relatively parsimonious in their data needs, principally relying on reference-year statistics. Elasticity-related data can be assimilated from extant econometric analyses. Furthermore, CGE model parameters are gleaned via the calibration technique, anchored on reference-year data and statistics.

2.2. Data Sources for the Computable General Equilibrium Model

There are four types of data used in this study: (1) Basic input data required for the preparation of social accounting matrix (SAM) tables for the NWT's economy. The data consist of (a) the input–output table of the NWT in 2016, which were obtained from Statistics Canada, and (b) the basic economic data and statistical data such as government subsidies to households and tariffs, which were obtained from NWT Statistics Canada. The developed NWT SAM table is composed of 23 sectors by aggregating and disaggregating the IO table based on data availability and sector characteristics (23 industries and 23 commodities); (2) the national accounts or territorial accounts; (3) government budgetary accounts; and (4) balance of payments and trade statistics.

The supply-use table (another way of organizing the IO table) provides information on the production sectors of the economy, showing detailed inter-industry linkages and the contribution made by primary factors of production to each sector. For example, we know how much gas, labor, chemicals, etc., serve as inputs into the diamond industry. The macroeconomic accounts provide a breakdown of aggregate demand according to consumption, investment, government spending, and the international sector (exports and imports). The trade account usually covers data on the destination and product composition of exports and imports. These have been reconciled with the territorial/provincial accounts as well as with the standard input–output table. Such an integration means that the resulting SAM, for example, shows not only how much gas, labor, and chemicals go into the diamond industry but how much of each of those inputs are sourced domestically and how much are sourced from abroad and from each trading partner.

2.3. Description of the Computable General Equilibrium Model

The NWT CGE model is a comprehensive framework that encompasses various key components to analyze the economic equilibrium of a region in response to external factors, such as the introduction of a carbon tax policy [17]. This model serves as a valuable tool for evaluating the socio-economic and environmental (SEE) consequences of different policy interventions. By utilizing the NWT CGE model, we can explore the intricate relationships between policies and their respective SEE impacts, while also capturing economic shifts over specific timeframes. Through comparative analyses of scenarios with and without policy interventions, we gain valuable insights into the diverse SEE implications of various policies and their interconnected dynamics.

The NWT CGE model is structured around four key agents: households, government, investment, and the rest of the world. It encompasses a wide range of sectors and activities, including production, trade, revenue, expenditure, labor market equilibriums, and calibration. By employing customized production and consumption functions, the model can assess changes in commodity prices, industrial output, and agent consumption, enabling a comprehensive cross-sectoral examination of the impact of carbon pricing.

The foundational economic data used in this analysis are derived from a specially tailored social accounting matrix that is based on data from 2016. This matrix forms the basis for our modeling framework, allowing us to accurately represent the economic relationships within the NWT and the rest of Canada. The forthcoming subsections delve into the specifics of these blocks.

2.3.1. Production Block

The production block of the CGE model plays a crucial role in understanding the economic repercussions of environmental strategies. The value-added share (Equation (A1), Appendix A) is pivotal, as industries in the NWT would reassess their production contributions based on carbon costs embedded in value-added rates. As industries in the region source goods and services for intermediate consumption (Equation (A2), Appendix A), their patterns might alter depending on the carbon footprint of these commodities and the carbon pricing mechanisms in place. The cost structure for production, specifically the value-added price (Equation (A3), Appendix A), would integrate carbon taxes and subsidies, reflecting the region's climate policy priorities. Furthermore, as industries adjust to carbon constraints, their demand for labor, both resident (Equation (A4) and non-resident (Equation (A8), Appendix A), and their capital requirements (Equation (A7), Appendix A) might shift, influenced by evolving green technology and practices.

Carbon pricing would also play an influential role in reshaping the pricing dynamics in NWT industries. The composite price for capital and non-resident labor (Equation (A9), Appendix A) could see fluctuations based on carbon pricing policies, impacting the overall production cost structures. The zero-profit condition (Equation (A10), Appendix A) becomes even more relevant, ensuring industries account for carbon costs while setting their prices. By aggregating costs linked with carbon-taxed inputs (Equation (A6), Appendix A) and those of intermediate consumption (Equation (A11), Appendix A), one can derive the total carbon-adjusted production cost (Equation (A12), Appendix A). Marginal costs (Equation (A13), Appendix A) would reflect the costs of additional production in a carbon-constrained environment. Finally, the supply dynamics of each industry (Equation (A14), Appendix A) and the average selling price across all outputs (Equation (A15), Appendix A) would provide insights into how NWT industries navigate production amidst carbon pricing policies and varying climate change scenarios.

2.3.2. Trade Block

The trade block of the CGE model represents a comprehensive mechanism detailing the flow of goods between regions and their associated values. In the model, interprovincial trade between NWT and the rest of Canada (ROC) is meticulously articulated to ensure balance. Equations (A16)–(A38) (Appendix A) dictate that the quantity and monetary value of commodities that NWT trades with ROC (whether imports or exports) must correspond precisely to ROC's trade records with NWT, confirming both the physical and monetary consistency in interprovincial trade. Moreover, Equations (A29)–(A32) (Appendix A) highlight how domestic and interprovincial trade prices are shaped by import prices, and the markup industries apply. Special cases in trade are addressed by Equation (A35) (Appendix A), ensuring unique trade conditions are considered.

Internationally, when trading with the rest of the world (ROW), the model employs Equations (A42) and (A43) to set the Canadian dollar prices for imports and exports, respectively. These prices are influenced by world prices, exchange rates, and potential taxes. Additionally, the aggregate demand for a specific commodity within NWT is calculated using Equation (A44) (Appendix A), considering all demand sources, including industry, household, investment, and government spending.

2.3.3. Revenue and Expenditure Block

The revenue and expenditure block in the CGE model essentially breaks down and represents the flow of money into and out of the government's coffers. It captures how policies, economic activities, and external factors (like climate change) affect government revenues and how the government then allocates these funds in the form of expenditures.

This block is integral in understanding the financial feasibility and implications of various policies within the economy.

Equations (A45)–(A57) (Appendix A) detail the potential revenue streams for the NWT government with an emphasis on carbon pricing mechanisms. For instance, a direct carbon tax on CO_2 emissions can be represented by Equation (A45) (Appendix A). The subsequent equations might encapsulate revenues from an emissions' trading system or the impact of climate change on traditional revenue sources like Arctic resource extraction royalties. Meanwhile, potential federal subsidies aiding NWT's transition to a low-carbon economy or mitigating climate impacts can be modeled in the latter part of this section.

On the expenditure side, Equations (A58)–(A70) (Appendix A) outline how the NWT government might spend its funds in response to carbon pricing and climate change. Costs associated with carbon-pricing administration, infrastructure upgrades for climate adaptation, investments in green technologies, and compensation packages for stakeholders affected by these changes are examples of expenses that can be represented within these equations.

2.3.4. Dynamic Equations

In the NWT, Equation (A77) (Appendix A) is pivotal in capturing how real expenditure-side GDP at market prices evolves in response to carbon pricing. The alteration in GDP dynamics could result from shifts in industrial activity or consumption patterns due to carbon pricing. This equation leverages a lagged growth rate to gauge the current GDP in the region, thereby reflecting the territory's macroeconomic adjustments to the carbon policy and associated climatic changes. Equations (A78) and (A79) (Appendix A) highlight labor dynamics. Given the unique labor market of the NWT, with its resident and non-resident labor force distinctions, these equations measure the potential labor shifts. These arise from changes in industry demand due to carbon pricing or from migration patterns influenced by climatic changes. Furthermore, for NWT's industries, Equation (A80) (Appendix A) becomes central in understanding capital accumulation dynamics, especially under carbon pricing. Industries can adjust their investments based on the perceived benefits or costs of such policies. The equation gauges the present capital stock by considering the past accumulated capital, adjusting for depreciation, and incorporating the current investment. In essence, this equation depicts how industries in the NWT reallocate or modify their capital considering carbon pricing policies and varying climatic scenarios.

2.4. Linkage of the CGE Model to Climate Change Impacts

In the preceding sections, we delineated a proposed CGE model specifically designed to assess the ramifications of carbon tax policies on pivotal macroeconomic indicators, while elucidating the intricate interplay across diverse sectors foundational to the NWT economy. However, this model inherently did not factor in the dynamic influences of climate change. To bridge this gap, we formulated a novel integration of an "interior-exterior" model. This innovative approach zeroes in on the nuanced responses of specific economic variables to climate shifts, leveraging regression modeling to pinpoint the direct economic repercussions of climatic fluctuations on select economic sectors. Subsequently, the insights gleaned from these regression analyses—embodied in the derived coefficients—were seamlessly integrated into the CGE model's production module. This ensured an accurate representation of the climate's tangible impact on sectors where significant correlations were identified. The ensuing subsections offer a deeper dive into the mechanics of this interior–exterior model.

2.4.1. Data Sources for the Inter–Exterior Model

Our modeling, informed by macroeconomic data from 1991 to 2020, utilized climate data from Canada's Federal Ministry of Environment and Climate Change. These data, derived from 24 advanced climate models, retroactively assessed the climate from 1850 to 2005 and projected the climate from 2006 to 2100 using IPCC greenhouse gas emission scenarios. The models' outputs, initially between 100 km^2 and 250 km^2, were honed to 10 km × 10 km resolution through Natural Resources Canada's observed dataset, starting from 1950 due to earlier data scarcities in Canada's North. Key climate metrics in our economic modeling included annual temperature, precipitation, and the 12-month standardized precipitation evapotranspiration index (SPEI), a universal gauge for drought and wet periods. SPEI classifications range from no drought (SPEI > −0.5) to extreme drought (SPEI < −2). Our study spanned 1991–2019 data and 2020–2100 projections, centering on five principal NWT regions (Table 1), showcasing their varied geography and economy.

Table 1. Study regions.

City	Country/Region	Acronym	Latitude and Longitude
Inuvik	Beaufort	EV	68.3607° N, 133.7230° W
Norman Wells	Sahtu	VQ	65.2815° N, 126.8287° W
Yellowknife	North Slave	ZF	62.4540° N, 114.3718° W
Hay River	South Slave	SS	60.8162° N, 115.7854° W
Fort Simpson	Dehcho	FS	61.8628° N, 121.3530° W

2.4.2. Presentation of the Inter–Exterior Model

We utilized a modified Cobb–Douglas production function to account for technological growth, labor, capital, and climate variables, aiming for a detailed depiction of NWT's climate dynamics. The equation is:

$$Y_{it} = e^{A_{it}} \cdot L_{it}^{\alpha} \cdot K_{it}^{\beta} \cdot C_{it}^{c} \cdot e^{(\varepsilon_{it} + v_i)} \quad (1)$$

where (E) signifies the error component, (t) denotes time, and (i) represents regions. The function encompasses:

- Y_{it}: GDP or its growth rate at a specific time and region.
- A_{it}: level of technological advancement.
- K_{it}: accumulation of physical capital or tangible investments.
- L_{it}: human capital accumulation, quantified by employment figures.
- C_{it}: the climate regime, bifurcated into average annual temperature and precipitation metrics.

The adapted Cobb–Douglas production function was used to predict GDP based on labor, capital, and current climate metrics. The model can be simplified as:

$$lnY_{it} = A_{it} + \alpha lnL_{it} + \beta lnK_{it} + clnC_{it} + \mathcal{E}_{it} + v_i \quad (2)$$

This expansion is in line with research from Barro (1991), Levine and Renelt (1992), and Alagidede et al. (2016) [18–20].

Our study examined climate change's effects on NWT's economic growth using three climate variables. To avoid multicollinearity and to obtain consistent results, various model versions were explored. Both linear and log-linear forms were used, with the latter highlighting the relationships between dependent (Y) and independent variables (L, K, C). Separate models were developed, associating GDP with individual or multiple climate metrics.

Co-integration techniques are primarily used when variables are found to be non-stationary or have a unit root. This is based on the understanding that non-stationary variables can give rise to spurious regressions if not handled appropriately. But, in our study, almost all variables were stationary (Appendix B). Thus, given that most of our variables were stationary at levels, there was not a pressing need to check for co-integration among them. This reduced the need for co-integration testing, ensuring that our analysis avoided the pitfalls of spurious regression and offered robust and reliable results. For the "Ta" variable, which is non-stationary, methods like differencing and the inclusion of appropriate control variables such as precipitation and SPEI were employed to ensure the validity and reliability of the analysis.

2.5. Model Calibration

The CGE model often faces questioning due to perceived weaknesses in its empirical parameter estimations, and constraints stemming from data limitations might compromise the integrity of simulation outcomes [21]. To bolster the reliability of our simulation findings, we undertook rigorous calibration processes, particularly focusing on elasticity and marginal propensity parameters. Calibration, a commonly utilized approach for parameter determination, was implemented in line with standard procedures, anchoring the model to the base year, 2016. Once parameters were set, the model was primed for simulating various policy-driven impacts or "shocks". The resulting solution yielded a fresh equilibrium that could then be compared with the benchmark equilibrium.

2.6. Policy Simulations

In our study, we initially established a benchmark scenario by simulating the status of economic variables without introducing a carbon tax (business as usual). This provided a baseline against which to measure the impact of various carbon tax scenarios and, subsequently, implementing carbon pricing, with and without a rebate offset, on the GDP and household consumption in the NWT. We also applied the dynamic CGE model, adjusting for climate change influences, to analyze the outcomes based on the Intergovernmental Panel on Climate Change's (IPCC) established greenhouse gas (GHG) emission scenarios spanning from 2006 to 2100. These IPCC scenarios, known as the representative concentration pathways (RCP), offer three distinct trajectories:

- RCP 2.6 (low): a scenario where CO_2 emissions peak by 2020 and then gradually reduce to zero by 2100.
- RCP 4.5 (moderate): a pathway where CO_2 emissions continue to rise until mid-21st century, eventually plateauing thereafter.
- RCP 8.5 (high): a scenario illustrating unchecked growth, where both CO_2 emissions and population see consistent increases throughout the 21st century, as detailed by Van Vuuren et al., 2011 [22].

In the Canadian context, these scenarios hold significant relevance. Given Canada's vast expanse, diverse ecosystems, and commitment to environmental sustainability, understanding the economic implications of these different emission trajectories is critical. The country's industries, resources, and overall economy are intricately linked to environmental health. Thus, simulating the economic implications under various carbon tax scenarios can guide policymakers in Canada towards more informed, effective, and future-proof decisions. Analyzing such scenarios can pave the way for strategies that balance both economic growth and environmental preservation, ensuring a sustainable future for generations to come.

3. Results

3.1. Results of the Inter–Exterior Model

Table 2 showcases regression analyses assessing the influence of climate variables on total factor productivity in four key sectors of NWT's economy: agriculture, oil and gas, construction, and manufacturing, spanning from 1991 to 2021. Notably, the capital/labor ratio exhibited diverse impacts across these sectors. Specifically, while agriculture experienced a negative association, the other three sectors—oil and gas, construction, and manufacturing—reflected positive correlations with the capital/labor ratio. Precipitation, designated as P20mn, prominently affected agricultural productivity and showed lesser but significant impacts on construction and manufacturing.

Table 2. Interior–exterior model results.

	Dependent Variable:			
	Ln (GDP/Labor)			
	Agriculture (1)	**Oil and Gas (2)**	**Construction (3)**	**Manufacturing (4)**
Ln(capital/labor)	−0.310 ***	0.854 ***	0.753 ***	0.686 ***
	(0.032)	(0.117)	(0.016)	(0.073)
Temperature	0.015	−0.01	0.003	0.033
	(0.013)	(0.077)	(0.009)	(0.022)
P20mn	−0.127 ***	0.055	−0.060 *	−0.164 *
	(0.047)	(0.047)	(0.036)	(0.095)
SPEI	−0.078	−0.133 *	−0.092 *	0.291 **
	(0.079)	(0.077)	(0.052)	(0.127)
Constant	1.246 ***	−0.471 ***	2.072 ***	−1.020 ***
	(0.189)	(0.095)	(0.097)	(0.153)
Observations	100	100	100	100
R^2	0.705	0.969	0.962	0.539
Adjusted R^2	0.692	0.967	0.961	0.52
Residual Std. Error	0.207	0.233	0.16	0.382
F Statistic	56.644 ***	735.803 ***	602.883 ***	27.800 ***

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; standard error in parentheses; P20mm—precipitations; SPEI—standardized precipitation evapotranspiration index.

The observed negative coefficient for the capital/labor ratio (K/L) in agriculture in the NWT (Northwest Territories) aligns with the geographical and climatic context of the region. The NWT is situated within the Arctic zone, which inherently limits its agricultural potential. The literature indicates that regions with such climatic conditions typically have a restricted agricultural window, confined mainly to summer months. Due to these constraints, much of the agricultural activity remains manual and rudimentary.

Elaborating further on the results, temperature, though seemingly relevant to the oil and gas sector, did not achieve statistical significance in any of the examined sectors. This might be attributed to the presence of the SPEI variable, which integrated temperature elements. SPEI itself was indicative in its associations with agriculture, oil and gas, and construction, yet it demonstrated an unexpected but significant relationship with manufacturing. The robustness of the model was particularly evident in the oil and gas and construction sectors, as reflected by the high R^2, adjusted R^2, and F-statistic values. However, the model's applicability was also validated for agriculture and manufacturing, as indicated by their respective significant F-statistics.

3.2. Results of the Policy Simulations

Table 3 presents the outcomes of implementing carbon pricing, with and without a rebate offset, in the NWT. As can be observed, implementing carbon pricing without an offset led to several significant economic shifts (Figure 1).

The real gross domestic product (GDP) of the NWT is projected to decrease by an average of 2.1% annually from 2020 to 2040 due to carbon pricing. While most sectors witness a dip in their real value-added contributions, the most affected are mining (−2.9%), transportation (−1.8%), other services barring public administration (−1.6%), and retail and wholesale trade (−1.5%). This translates to foregone annual real GDP of CAD 15 million, CAD 6 million, CAD 664 thousand, and CAD 1 million, respectively, over this period. In contrast, the finance, insurance, real estate, information and cultural industries, and public administration sectors are poised to see slight gains. Additionally, the extent of real GDP losses amplifies over time.

Table 3. Main macroeconomic effects (CAD millions, percentage change) of the carbon pricing in the NWT.

Sectors	BAU	SIM with Carbon Pricing	SIM with Carbon Pricing Rebate	Change without Rebate in		Change with Rebate in	
				CAD	%	CAD	%
Real gross domestic product at market price	3458.70	3387.59	3398.38	−71.112	−2.1%	−60.322	−1.7%
Agriculture, forestry, fishing, and hunting	3.19	3.16	3.18	−0.025	−0.8%	−0.005	−0.2%
Mining, quarrying, and oil and gas extraction	501.05	486.30	489.30	−14.752	−2.9%	−11.752	−2.3%
Utilities	45.37	44.87	44.88	−0.508	−1.1%	−0.498	−1.1%
Construction	435.05	432.22	432.52	−2.824	−0.6%	−2.524	−0.6%
Manufacturing	13.45	13.44	13.44	−0.005	0.0%	−0.005	0.0%
Retail and wholesale trade	66.25	65.24	65.30	−1.013	−1.5%	−0.953	−1.4%
Transportation and warehousing	331.80	325.82	325.92	−5.980	−1.8%	−5.880	−1.8%
Information and cultural industries	75.53	75.60	75.70	0.074	0.1%	0.174	0.2%
Finance and insurance, real estate, and rental and leasing	298.37	299.01	299.71	0.648	0.2%	1.348	0.5%
Professional, scientific, and technical services	114.33	112.91	112.99	−1.419	−1.2%	−1.339	−1.2%
Educational services, health care, and social assistance	54.52	54.41	54.47	−0.114	−0.2%	−0.054	−0.1%
Accommodation and food services	75.09	74.82	74.92	−0.277	−0.4%	−0.177	−0.2%
Other services (except public administration)	42.43	41.76	41.79	−0.664	−1.6%	−0.634	−1.5%
Public administration	1059.31	1059.91	1060.00	0.600	0.1%	0.690	0.1%

Figure 2 depicts the influence of the carbon pricing policy, without a rebate, on household consumption over the 2020–2040 duration. Despite the anticipated shift in consumer expenditure from more expensive carbon-intensive products to more affordable and eco-friendly alternatives, household consumption is negatively affected.

Conversely, Figure 3 illustrates the potential mitigation of this negative effect when a rebate is provided to households post-carbon pricing execution. The rebate to households alleviates some of the impacts on consumption expenditure.

From the data in Table 3 and the associated figures (Figures 1–3), several insights emerge. Primarily, the rebate causes a moderation in the GDP decline to 1.7% over the period. While some sectors exhibit reduced rates of decline, others like utilities, transportation and warehousing, and public administration do not exhibit any significant change whether the carbon pricing is implemented with or without the rebate. A handful of sectors, especially those with high-income elastic demands, depict an output rise.

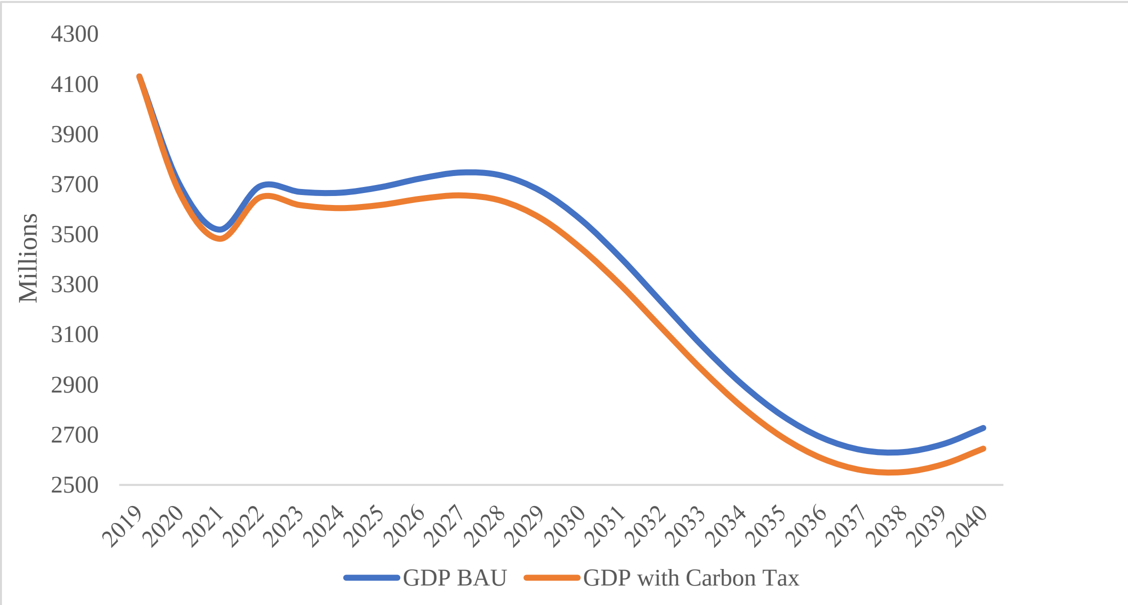

Figure 1. Simulated impact of carbon pricing on GDP in the NWT.

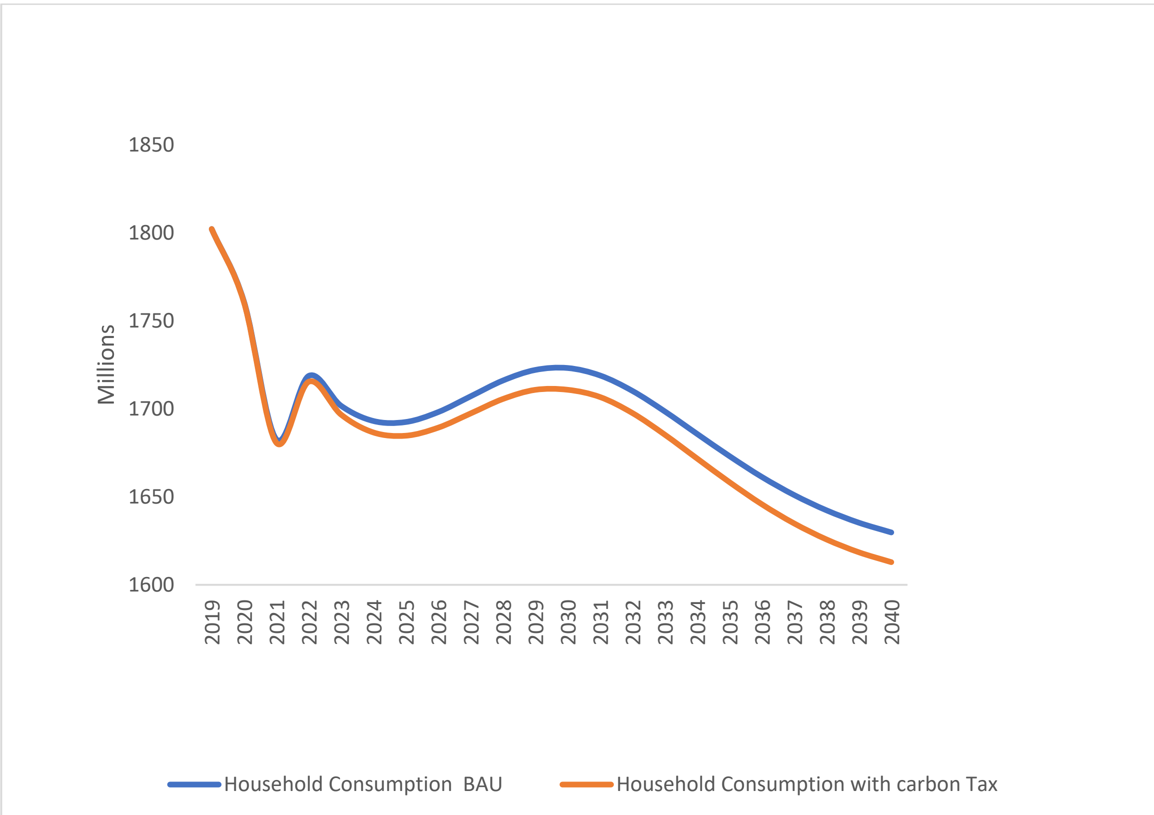

Figure 2. Simulated impact of carbon pricing on household consumption.

Introducing the three climate scenarios, the results under the RCP 8.5 scenario are largely positive for GDP. In contrast, RCP scenarios 4.5 and 2.6 are more negative compared with the baseline, likely because of the efforts to curb CO_2 emissions, leading to reduced economic output (Figure 4).

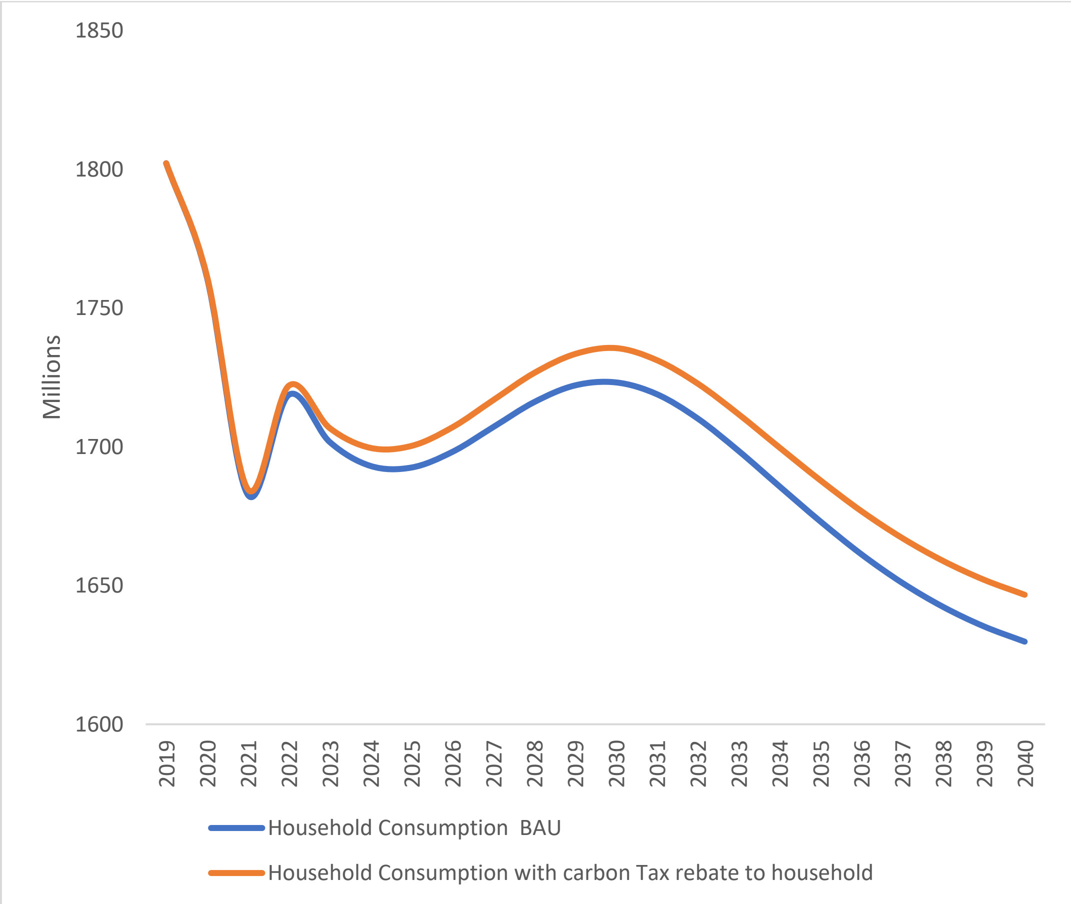

Figure 3. Simulated impact of carbon pricing with rebate on household consumption.

Figure 4. Carbon pricing impact under different scenarios of RCP.

4. Discussion

In the wake of growing environmental concerns, the Canadian government has expressed its commitment to curbing carbon emissions with the institution of a carbon pricing policy to usher in an era where economic agents are incentivized to adopt eco-friendly practices. This study ventured into an in-depth examination of the ramifications of such a policy on the economic landscape of the NWT, probing especially into its performance and structural transformations. Through the integration of climate models, along with three pertinent GHG emission and future warming trajectories, our computable general equilibrium analysis was subjected to climate-related shocks.

The findings from our simulations are illuminating. At the forefront, the introduction of the carbon pricing policy would precipitate a decline in the economic contributions from sectors entrenched in fossil fuel production, inevitably weighing down the GDP and overall economic growth of the NWT. However, an intriguing twist surfaced when households were brought into the rebate system: the economic repercussions of the carbon pricing policy were substantially mitigated. This unveiled a compelling narrative: while the unchecked implementation of a carbon pricing policy can constrict household consumption and overall economic vigor, the introduction of a rebate system can counterbalance these adverse effects, thus presenting policymakers with a nuanced perspective on the delicate equilibrium between economic growth and greenhouse gas emission goals.

Our research stands distinct in the literature on carbon pricing on two notable fronts. Firstly, our approach delved into the distributional aftermath of carbon pricing, navigated through the compass of an intertemporal general equilibrium model, a departure from the traditional static models that often sidestep the nuanced effects of pricing on investments. Secondly, our research pioneered the exploration of the intertwined relationship between growth, equity, and carbon pricing within the unique context of a northern economy graced with an environmentally delicate fabric.

However, as comprehensive as our study strove to be, it was not without limitations. Key hypotheses, especially those orbiting around cap-and-trade mechanisms, were beyond the purview of this study. The parameters evaluated here are but a fraction of the vast spectrum needed for an exhaustive dissection of the carbon pricing policy's imprint on NWT's economy. Consider, for instance, the rapidly evolving landscape of electric vehicles, progressively gaining traction owing to their affordability and widening range of options [1]. The carbon footprint of this mode of transportation hinges largely on the environmental efficiency of the electricity generation process. Hence, an in-depth understanding of the interplay between vehicle costs, charging infrastructures, and electricity costs and how they collectively steer the adoption rates of electric vehicles can further refine the policy nuances of carbon taxes.

In summation, while our study shines a light on the multifaceted implications of a carbon pricing policy in NWT, the real-world application of such policies demands a judicious balance. Policymakers in NWT are presented with invaluable insights, and the carbon pricing policy, when judiciously executed, can serve as a formidable tool in the arsenal against escalating greenhouse gas emissions, all the while nurturing the economic prosperity of the region.

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Glossary

Abbreviations used in this manuscript are directly explained throughout and in the Appendix A.

i (industries)	This set represents the different industries or sectors within an economic system. For example, i = {industry1, industry2, . . .}.
j (commodities)	This set represents the various commodities or goods that are produced or consumed in the economy. For example, j = {commodity1, commodity2, . . .}.
dft (final demand)	This set represents the components of final demand, which include consumption, investment, government spending, and net exports. For example, dft = {consumption, investment, government spending, net exports}.
ag_va (value added)	This set represents the value added to products or services by industries. For example, ag_va = {value_added1, value_added2, . . .}.
r (regions)	This set represents different geographical regions or areas within a country or economic system. For example, r = {region1, region2, . . .}.
g and g2 (government levels)	These sets represent different levels of government, such as federal, state, or local governments. For example, g = {federal, state, local} and g2 = {government_level1, government_level2, . . .}.
inst (institutions)	This set represents various institutions or organizations within the economy, such as banks, regulatory bodies, or educational institutions. For example, inst = {institution1, institution2, . . .}.
t (tax categories)	This set represents different categories or types of taxes imposed within the economy. For example, t = {tax_category1, tax_category2, . . .}.

Appendix A. Computable General Equilibrium Model Blocks for the Northwest Territories' Economy

Appendix A.1. Production Block

These equations represent various economic relationships within a production and demand framework, helping to analyze production, costs, demand, and pricing in NWT regional context.

Value-Added Share in Production

This equation calculates the value-added (VA) for each industry (i) in a specific region (r) by multiplying the value-added share ($v_{i,r}$) with the share of industry output ($XS_{i,r}$) in total production.

$$v_{i,r} \cdot XS_{i,r} = VA_{i,r} \tag{A1}$$

Intermediate Consumption Shares in Production

$$io_{j,i,r\cdot} \cdot XS_{i,r} = CI_{j,i,r} \tag{A2}$$

This equation calculates the intermediate consumption ($CI_{j,i,r}$) for each commodity (j) in an industry (i) and region (r) by multiplying the intermediate consumption share ($io_{j,i,r\cdot}$) with the share of industry output ($XS_{i,r}$) in total production.

Value-Added Price

$$pva_{i,r} * va_{i,r} = ps_{i,r} * xs_{i,r}\left(1 - \sum_g txp_{i,g,r} - \sum_g txs_{i,g,r}\right) - \sum_j CI_{j,i,r} {*} Pa_{j,r} \left(1 + txtmg_{j,r} + \sum_g txc_{j,g,r} + \sum_g txf_{j,g,r}\right) \quad (A3)$$

This equation calculates the price of value-added ($pva_{i,r}$) for each industry (i) in a region (r). It considers various factors, including value-added share, taxes, and intermediate consumption costs.

Demand for Resident Labor

$$LRD_{i,r} = \left(\frac{xs_{i,r}}{at_{i,r}}\right)^{(1-sigmak_{i,r})} \left(\frac{vc_{i,r}(1 - ava_{ir})}{wre_r}\right)^{sigmak_{i,r}} \quad (A4)$$

This equation represents the demand for labor ($LRD_{i,r}$) in an industry (i) and region (r). It depends on factors such as the share of industry output, labor productivity ($vc_{i,r}$), and wage rates (wre_r).

Demand for Capital Non-Resident Labor Composite

$$KND_{i,r} = \left(\frac{xs_{i,r}}{at_{i,r}}\right)^{(1-sigmak_{i,r})} \left(\frac{vc_{i,r} ava_{ir}}{pkn_{i,r}}\right)^{sigmak_{i,r}} \quad (A5)$$

This equation calculates the demand for a composite of capital and non-resident labor ($KND_{i,r}$) in an industry (i) and region (r). It considers factors such as the share of industry output, capital productivity (ava_{ir}), and the price of capital ($pkn_{i,r}$).

Total Primary Factors Costs

$$VC_{i,r} = WRE_r * LRD_{i,r} + PKN_{i,r} * KND_{i,r} \quad (A6)$$

This equation computes the total cost of primary factors ($VC_{i,r}$) in an industry (i) and region (r). It combines the costs of resident labor and the capital non-resident labor composite.

Demand for Capital Stock

$$KD_{i,r} = \left(\frac{KND_{i,r}}{atk_{i,r}}\right)\left(\frac{atk_{i,r}\ avak_{i,r}\ pkn_{i,r}}{RK_{i,r}}\right)^{sigmakk_{i,r}} \quad (A7)$$

This equation calculates the demand for capital stock ($KD_{i,r}$) in an industry (i) and region (r). It depends on factors like the composite of capital and non-resident labor, technology ($atk_{i,r}$), capital productivity ($avak_{i,r}$), and the price of capital ($pkn_{i,r}$).

Non-Resident Labor Demand

$$LND_{i,r} = \left(\frac{KND_{i,r}}{atk_{i,r}}\right)\left(\frac{atk_{i,r}\ (1 - avak_{i,r})\ pkn_{i,r}}{WNR_r}\right)^{sigmakk_{i,r}} \quad (A8)$$

This equation represents the demand for non-resident labor ($LND_{i,r}$) in an industry (i) and region (r). It considers factors such as the composite of capital and non-resident labor, technology ($atk_{i,r}$), capital productivity ($avak_{i,r}$), and wage rates for non-resident labor (WNR_r).

Composite Capital and Non-Resident Labor Unit Price

$$PKN_{i,r}KND_{i,r} = RK_{i,r}KD_{i,r} + WNR_r LND_{i,r} \quad (A9)$$

This equation calculates the unit price of the composite of capital and non-resident labor ($PKN_{i,r} * KND_{i,r}$) in an industry (i) and region (r).

Price-Marginal Cost Equality (Zero-Profit Condition)

$$MC_{i,r} = PS_{i,r}\left(1 - \sum_g txp_{i,g,r} - \sum_g txs_{i,g,r}\right) \quad (A10)$$

This equation equates the marginal cost ($MC_{i,r}$) to the price of output ($PS_{i,r}$), considering taxes and subsidies.

Total Intermediate Consumption Costs

$$IGC_{i,r} = \sum_j io_{j,i,r} * PA_{j,r}\left(1 + txtmg_{j,r} + \sum_g txc_{j,g,r} + \sum_g txf_{j,g,r}\right)XS_{i,r} \quad \text{(A11)}$$

This equation computes the total intermediate consumption costs ($IGC_{i,r}$) for an industry (i) and region (r). It considers the intermediate consumption for various commodities, their prices, and relevant taxes.

Total Costs

$$TC_{i,r} = VC_{i,r} + IGC_{i,r} \quad \text{(A12)}$$

This equation calculates the total costs ($TC_{i,r}$) for an industry (i) and region (r). It combines the costs of primary factors (labor and capital) with intermediate consumption costs.

Marginal Costs

$$MC_{i,r} = \frac{TC_{i,r}}{XS_{i,r}} \quad \text{(A13)}$$

This equation calculates the marginal cost ($MC_{i,r}$) for an industry (i) and region (r) by dividing the total costs by the share of industry output.

Supply of Commodity j by Industry i in Region r

$$XPP_{j,i,r} = \left(\frac{XS_{i,r}}{bp_{i,r}}\right)\left(\frac{PT_{j,r}}{beta_{P_{j,i,r}}bp_{i,r}}\right)^{tau_{i,r}} \quad \text{(A14)}$$

This equation represents the supply of commodity j produced by industry i in region r ($XPP_{j,i,r}$). It depends on the share of industry output, the price of the commodity, and various parameters like elasticity ($tau_{i,r}$).

Composite Price of all Commodities j Produced by Industry i

$$PS_{i,r}XS_{i,r} = \sum_j PT_{j,r}XPP_{j,i,r} \quad \text{(A15)}$$

This equation calculates the composite price ($PS_{i,r}$) of all commodities produced by industry i in region r. It sums up the prices of individual commodities weighted by their respective shares in industry output.

Appendix A.2. Trade Block

These equations describe various aspects of trade, including exports, domestic supply, and composite prices, within a regional economic framework. They help analyze how commodities are traded and priced in different regions and markets.

CET Transformation System

The CET transformation system is a valuable analytical tool in economics, particularly in trade theory and production analysis. It allows economists to study how resources are allocated and transformed in response to changes in relative prices and to make predictions about trade patterns and welfare effects in various economic scenarios.

Composite Export of Commodity j to ROW and Other Canadian Regions

$$XEM_{j,r} = \left(\frac{XPT_{j,r}}{ate_{j,r}}\right)\left(\frac{PEM_{j,r}}{ae_{j,r}ate_{j,r}PT_{j,r}}\right)^{sigmax_{j,r}} \quad \text{(A16)}$$

This equation calculates the composite export ($XEM_{j,r}$) of commodity j from a specific region (r) to both the rest of the world (ROW) and other Canadian regions. It considers the price of the commodity ($PT_{j,r}$), the allocation factor ($ae_{j,r}$), and various parameters ($ate_{j,r}$ and $sigmax_{j,r}$) that affect the export.

Domestic Supply Within Each Region

$$XD_{j,r} = \left(\frac{XPT_{j,r}}{ate_{j,r}}\right)\left(\frac{PD_{j,r}}{(1 - ae_{j,r})ate_{j,r}PT_{j,r}}\right)^{sigmax_{j,r}} \quad \text{(A17)}$$

This equation calculates the domestic supply ($XD_{j,r}$) of commodity j within a specific region (r). It considers the price of the commodity ($PT_{j,r}$), the allocation factor ($ae_{j,r}$), and parameters ($ate_{j,r}$ and $sigmax_{j,r}$) affecting supply.

Total Supply of Commodity j Equal Sum of Supply of Commodity j by all Industries i

$$XPT_{j,r} = \sum_i XPP_{j,i,r} \quad \text{(A18)}$$

This equation ensures that the total supply ($XPT_{j,r}$) of commodity j in a region (r) equals the sum of the supply of commodity j by all industries (i) within that region.

Composite Price of Commodity j

$$PT_{j,r} * XPT_{j,r} = PD_{j,r} * XD_{j,r} + PEM_{j,r} * XEM_{j,r} \quad \text{(A19)}$$

This equation calculates the composite price ($PT_{j,r}$) of commodity j in a region (r). It is determined by the product of the price and supply of the commodity and is influenced by domestic supply ($XD_{j,r}$) and composite export ($XEM_{j,r}$) factors.

Supply of Non-Tradable Commodity j

$$XPT_{j,r} = XD_{j,r} \quad \text{(A20)}$$

This equation specifies that the supply of a non-tradable commodity j within a region (r) is equal to its domestic supply ($XD_{j,r}$).

Trade Sector Commodity Output Equals Sum of Margins

$$PT_{j=ctrd,r} * XPT_{j=ctrd,r} = \sum_j PA_{j,r} * txtmg_{j,r}\left(\sum_i CI_{j,i,r} + XH_{j,r} + \sum_g XG_{j,g,r} + XI_{j,r} + XV_{j,r}\right) \quad \text{(A21)}$$

This equation expresses that the output of commodity j in the trade sector (j = $ctrd, r$) within a region (r) is equal to the sum of margins (markup) across various industries (i), households ($XH_{j,r}$), government sectors ($XG_{j,g,r}$), institutions ($XI_{j,r}$), and imports ($XV_{j,r}$). It depends on price adjustments ($PA_{j,r}$), taxes ($txtmg_{j,r}$), and intermediate consumption ($CI_{j,i,r}$).

Export of Commodity j to Other Canadian Regions

$$XEP_{j,r} = \left(\frac{XEM_{j,r}}{ate\_p_{j,r}}\right)\left(\frac{PEP_{j,r}}{ae\_p_{j,r} * ate\_p_{j,r}PEM_{j,r}}\right)^{sigmax\_p_{j,r}} \quad \text{(A22)}$$

This equation calculates the export ($XEP_{j,r}$) of commodity j from a specific region (r) to another Canadian region. It considers the price of the commodity ($PEP_{j,r}$), the allocation factor ($ae\_p_{j,r}$), and parameters ($ate\_p_{j,r}$ and $sigmax\_p_{j,r}$) affecting the export.

International Export of Commodity j

$$XE_{j,r} = \left(\frac{XEM_{j,r}}{ate_{p_{j,r}}}\right)\left(\frac{PE_{j,r}}{\left(1 - ae\_p_{j,r}\right) * ate_{p_{j,r}}PEM_{j,r}}\right)^{sigmax_{p_{j,r}}} \quad \text{(A23)}$$

This equation calculates the international export ($XE_{j,r}$) of commodity j from a specific region (r) to the rest of the world (ROW). It considers the price of the commodity ($PE_{j,r}$), the allocation factor ($ae\_p_{j,r}$), and parameters ($ate_{p_{j,r}}$ and $sigmax\_p_{j,r}$) affecting the export.

Composite Price of Exports

$$PEM_{j,r}XEM_{j,r} = PE_{j,r}XE_{j,r} + PEP_{j,r}XEP_{j,r} \quad \text{(A24)}$$

This equation calculates the composite price ($PEM_{j,r}$) of exports for commodity j from a region (r). It considers the price and export quantities to both the rest of the world ($XE_{j,r}$) and another Canadian region ($XEP_{j,r}$).

Export of Commodity j Only to Another Canadian Region

$$XEM_{j,r} = XEP_{j,r} \tag{A25}$$

This equation specifies that the export of commodity j from a specific region (r) is equal to its export to another Canadian region ($XEP_{j,r}$), meaning it doesn't have international exports.

Export of Commodity j Only to the Rest of the World

$$XEM_{j,r} = XE_{j,r} \tag{A26}$$

This equation specifies that the export of commodity j from a specific region (r) is equal to its international exports to the rest of the world ($XE_{j,r}$), meaning it does not have exports to other Canadian regions.

International and Interprovincial Imports

These equations help describe the dynamics of imports, including their quantity, price, and sources, within a regional economic framework. They play a crucial role in analyzing trade and supply chain decisions in the context of regional and international trade.

Composite Import of Commodity j from ROW and Another Canadian Region

$$XMM_{j,r} = \left(\frac{XA_{j,r}}{atm_{j,r}}\right)\left(\frac{am_{j,r}atm_{j,r}PA_{j,r}}{PMM_{j,r}}\right)^{sigmam_{j,r}} \tag{A27}$$

This equation calculates the composite import ($XMM_{j,r}$) of commodity j into a specific region (r) from both the rest of the world (ROW) and another Canadian region. It considers the availability of the commodity ($XA_{j,r}$), the allocation factor ($am_{j,r}$), price adjustments ($PA_{j,r}$), and parameters ($atm_{j,r}$ and $sigmam_{j,r}$) that influence the import quantity and price.

Internal Demand of Commodity j in Region r

$$XD_{j,r} = \left(\frac{XA_{j,r}}{atm_{j,r}}\right)\left(\frac{(1 - am_{j,r})atm_{j,r}PA_{j,r}}{PD_{j,r}}\right)^{sigmam_{j,r}} \tag{A28}$$

This equation calculates the internal demand ($XD_{j,r}$) for commodity j within a specific region (r). It takes into account the availability of the commodity ($XA_{j,r}$), the allocation factor ($am_{j,r}$), price adjustments ($PA_{j,r}$), and parameters ($atm_{j,r}$ and $sigmam_{j,r}$) that influence the demand for the commodity within the region.

Composite Price of Commodity j

$$PA_{j,r}XA_{j,r} = PD_{j,r}XD_{j,r} + PMM_{j,r}XMM_{j,r} \tag{A29}$$

This equation calculates the composite price ($PA_{j,r}$) of commodity j in a specific region (r). It is determined by the product of the price and the availability of the commodity and is influenced by internal demand ($XD_{j,r}$) and composite import ($XMM_{j,r}$) factors.

Composite Demand of Non-Tradable Commodity j

$$XA_{j,r} = XD_{j,r} \tag{A30}$$

This equation specifies that the demand for a non-tradable commodity j within a region (r) is equal to its internal demand ($XD_{j,r}$).

Import of Commodity j in Region r from Another Canadian Region

$$XMP_{j,r} = \left(\frac{XMM_{j,r}}{atm\_p_{j,r}}\right)\left(\frac{am\_p_{j,r}\ atm\_p_{j,r}PMM_{j,r}}{PMP_{j,r}}\right)^{sigmam\_p_{j,r}} \tag{A31}$$

This equation calculates the import ($XMP_{j,r}$) of commodity *j* into a specific region (*r*) from another Canadian region (in this case, the "*p*" subscript refers to the other Canadian region). It depends on the composite import ($XMM_{j,r}$), the allocation factor ($am\_p_{j,r}$), price adjustments ($PMM_{j,r}$), and parameters ($atm\_p_{j,r}$ and $sigmam\_p_{j,r}$) that determine interprovincial imports.

Import of Commodity *j* in Region *r* from the Global Market

$$XM_{j,r} = \left(\frac{XMM_{j,r}}{atm\_p_{j,r}}\right)\left(\frac{\left(1 - am\_p_{j,r}\right) atm\_p_{j,r} PMM_{j,r}}{PM_{j,r}}\right)^{sigmam\_p_{j,r}} \quad \text{(A32)}$$

This equation calculates the import ($XM_{j,r}$) of commodity *j* into a specific region (*r*) from the global market (rest of the world). It depends on the composite import ($XMM_{j,r}$), the allocation factor ($am\_p_{j,r}$), price adjustments ($PM_{j,r}$), and parameters ($atm\_p_{j,r}$), and $sigmam\_p_{j,r}$) that influence international imports.

Unit Price of Composite Imports

$$PMM_{j,r}XMM_{j,r} = PM_{j,r}XM_{j,r} + PMP_{j,r}XMP_{j,r} \quad \text{(A33)}$$

This equation calculates the unit price ($PMM_{j,r}$) of composite imports for commodity *j* into a specific region (*r*). It is determined by the product of the price and the quantity of imports and is influenced by both international imports ($XM_{j,r}$) and interprovincial imports ($XMP_{j,r}$).

Import Exclusively from Another Canadian Region

$$XMM_{j,r} = XMP_{j,r} \quad \text{(A34)}$$

This equation specifies that the import of commodity *j* into a specific region (*r*) is exclusively from another Canadian region (interprovincial import), indicating that there are no international imports for this commodity in that region.

Import Exclusively from the International Market

$$XMM_{j,r} = XM_{j,r} \quad \text{(A35)}$$

This equation specifies that the import of commodity *j* into a specific region (*r*) is exclusively from the global market (rest of the world), indicating that there are no interprovincial imports for this commodity in that region.

Interprovincial Imports from Rest of Canada (ROC) Should be Equal to ROC Interprovincial Exports to NWT

These equations describe various aspects of imports, including composite imports, internal demand, unit prices, and the sources of imports, within a regional economic framework. They help analyze how commodities are imported and priced in different regions and markets.

NWT Interprovincial Exports to ROC Should be Equal to NWT Interprovincial Imports from NWT

These equations describe various aspects of trade, prices, and demand in the context of NWT's interprovincial and international trade relationships with ROC (rest of Canada) and ROW (rest of the world). They help analyze trade balances, value flows, and price determination in these trade scenarios.

NWT Imports of Commodity *j* from ROC Equal to ROC Exports of Commodity *j* to NWT

$$XMP_{j,r=\text{``}nwt\text{''}} = XEP_{j,r=\text{``}roc\text{''}} \quad \text{(A36)}$$

This equation states that the quantity of commodity *j* that NWT imports from ROC ($XMP_{j,r=\text{``}nwt\text{''}}$) should be equal to the quantity of commodity *j* that ROC exports to NWT ($XEP_{j,r=\text{``}roc\text{''}}$). It represents a trade balance between the two regions.

Value of NWT Imports of Commodity *j* from ROC Equal to ROC Value of Exports of Commodity *j* to NWT

$$PMP_{j,r=``nwt"} * XMP_{j,r=``nwt"} = PEP_{j,r=``roc"} * XEP_{j,r=``roc"} \tag{A37}$$

This equation ensures that the total value (price multiplied by quantity) of commodity *j* that NWT imports from ROC ($PMP_{j,r=``nwt"} * XMP_{j,r=``nwt"}$) is equal to the total value of commodity *j* that ROC exports to NWT ($PEP_{j,r=``roc"} * XEP_{j,r=``roc"}$). It maintains trade balance in terms of value.

NWT Exports of Commodity *j* to ROC Equal to ROC Imports of Commodity *j* from NWT

$$XEP_{j,r=``nwt"} = XMP_{j,r=``roc"} \tag{A38}$$

This equation asserts that the quantity of commodity *j* that NWT exports to ROC (XEP) should be equal to the quantity of commodity *j* that ROC imports from NWT (XMP). It represents reciprocity in trade between the two regions.

Value of NWT Imports of Commodity *j* from ROC Equal to ROC Value of Exports of Commodity *j* to NWT

$$PMP_{j,r=``nwt"} * XMP_{j,r=``nwt"} = PEP_{j,r=``roc"} * XEP_{j,r=``roc"} \tag{A39}$$

This equation ensures that the total value (price multiplied by quantity) of commodity *j* that NWT imports from ROC ($PMP_{j,r=``nwt"} * XMP_{j,r=``nwt"}$) is equal to the total value of commodity *j* that ROC exports to NWT ($PEP_{j,r=``roc"} * XEP_{j,r=``roc"}$). It maintains trade balance in terms of value.

NWT Exports of Commodity *j* to ROC Equal to ROC Imports of Commodity *j* from NWT

$$XEP_{j,r=``nwt"} = XMP_{j,r=``roc"} \tag{A40}$$

This equation asserts that the quantity of commodity *j* that NWT exports to ROC ($XEP_{j,r=``nwt"}$) should be equal to the quantity of commodity *j* that ROC imports from NWT ($XMP_{j,r=``roc"}$). It represents reciprocity in trade between the two regions.

Value of NWT Exports of Commodity *j* to ROC Equal to ROC Value of Imports of Commodity *j* from NWT

$$PEP_{j,r=``nwt"} * XEP_{j,r=``nwt"} = PMP_{j,r=``roc"} * XMP_{j,r=``roc"} \tag{A41}$$

This equation ensures that the total value of commodity j that NWT exports to ROC ($PEP_{j,r=``nwt"} * XEP_{j,r=``nwt"}$) is equal to the total value of commodity *j* that ROC imports from NWT ($PMP_{j,r=``roc"} * XMP_{j,r=``roc"}$). It maintains trade balance in terms of value for this trade relationship.

Price of Imports of Commodity *j* from ROW in Canadian Dollars

$$PM_{j,r} = \left(1 + \sum_g tm_{j,g,r}\right) * ER * wpm_{j,r} \tag{A42}$$

This equation calculates the price ($PM_{j,r}$) of importing commodity *j* from the rest of the world (ROW) in Canadian dollars. It takes into account the world price (wpm), exchange rates (ER), and taxes (tm) imposed by various government levels (g) within the region.

Price of Exports of Commodity *j* to ROW in Canadian Dollars

$$PE_{j,r} = ER * wpe_{j,r} \tag{A43}$$

This equation calculates the price ($PE_{j,r}$) of exporting commodity *j* to the rest of the world (ROW) in Canadian dollars. It depends on the world price ($wpe_{j,r}$) and the exchange rate (ER).

Composite Demand of Commodity j

$$XA_{j,r} = \sum_i CI_{j,i,r} + XH_{j,r} + XI_{j,r} + XV_{j,r} + \sum_g XG_{j,g,r} \tag{A44}$$

This equation calculates the composite demand ($XA_{j,r}$) for commodity j in a specific region (r). It is the sum of demand from various sources, including intermediate consumption by industries ($CI_{j,i,r}$), household consumption ($XH_{j,r}$), investment ($XI_{j,r}$), government spending ($XV_{j,r}$), and demand from government levels ($XG_{j,g,r}$).

Appendix A.3. Revenue and Expenditures Block

The revenue and expenditures block is a component of an economic model or analysis that focuses on tracking and managing the financial flows within an economy. This block typically includes various economic agents, such as households, corporations, and governments, and it accounts for their sources of revenue, expenditures, savings, and transfers.

Corporations' Revenue and Expenditures

These equations are essential for analyzing the financial aspects of the corporation sector within a regional economic model, including profits, revenue, taxes, transfers, and savings. They provide a framework for understanding the flow of funds within this sector and its interactions with governments and households.

Corporation Sector Profits in Region r

$$PROF_r = \sum_i RK_{i,r} * KD_{i,r} \tag{A45}$$

This equation calculates the total profits (PROF) of the corporation sector in a specific region (r). It is the sum of profits earned by individual industries (i) in the region, where $RK_{i,r}$ represents the return on capital for industry i, and $KD_{i,r}$ represents the capital stock of industry i in region r.

Corporation Sector Revenue in Region r

$$YE_r = PROF_r + TRANSFERS\_H\_CORP_r + \sum_g TRANSFERS\_GOV\_CORP_{r,g} \tag{A46}$$

This equation calculates the total revenue (YE) of the corporation sector in a specific region (r). It includes profits (PROF), transfers received from households ($TRANSFERS\_H\_CORP_r + \sum_g TRANSFERS\_GOV\_CORP_{r,g}$), and transfers received from various government levels (g) ($TRANSFERS\_GOV\_CORP_{r,g}$).

After-Tax Corporation-Distributed Profits in Region r

$$DPROF_r = YE_r - \sum_g kappae_{g,r} * YEe_r \tag{A47}$$

This equation calculates the after-tax distributed profits ($DPROF$) of the corporation sector in a specific region (r). It is the difference between total revenue (YE) and taxes paid to various government levels (g) ($kappae_{g,r} * YEe_r$), where YEe_r), represents the pre-tax revenue of the corporation sector.

Firms' Transfers to Governments g in Region r

$$transfers\_corp\_gov_{g,r} = shr\_corp\_gov_{g,r} * dprof_r \tag{A48}$$

This equation calculates the transfers made by corporations to various government levels (g) in a specific region (r). It depends on the share of transfers allocated to each government level ($transfers\_corp\_gov_{g,r}$) and the after-tax distributed profits ($dprof_r$) of the corporation sector.

Firms' Transfers to Households in Region r

$$transfers\_corp\_h_r = shr\_corp\_gov_r * dprof_r \tag{A49}$$

This equation calculates the transfers made by corporations to households in a specific region (r). It depends on the share of transfers allocated to households ($shr\_corp\_gov_r$) and the after-tax distributed profits ($dprof_r$) of the corporation sector.

Corporation Savings in Region r

$$save_r = saverate\_c_r * dprof_r \quad (A50)$$

This equation calculates the savings (save) of the corporation sector in a specific region (r). It depends on the savings rate specific to corporations ($saverate\_c_r$) and the after-tax distributed profits ($dprof_r$) of the corporation sector.

Household Revenue and Expenditures

These equations provide insights into the financial activities of households, including their sources of income, expenditures, transfers to other sectors, and savings. They are essential for understanding household financial behavior within an economic model.

Household Revenue in Region r

$$yh_r = \sum_i wre_r * LRD_{i,r} + wnr_r * LRD_{i,r} + shr\_corp\_h_r * dprof_r + transfers\_row\_h_r + \sum_g transfers\_gov\_h_{g,r} \quad (A51)$$

This equation calculates the total revenue (yh_r) of households in a specific region (r). It includes various sources of income, such as wages (wre_r) from resident and non-resident labor, corporate profits received by households ($shr\_corp\_h_r * dprof_r$), transfers from the rest of the world (ROW) ($transfers\_row\_h_r$), and transfers from various government levels (g) ($transfers\_gov\_h_{g,r}$).

Household Revenue Net of Income Tax in Region r

$$yd_r = yh_r * \left(1 - \sum_g kappah_{g,r}\right) \quad (A52)$$

This equation calculates the net revenue (yd_r) of households in a specific region (r) after accounting for income taxes. It is obtained by multiplying the total revenue (yh_r) by the complement of the income tax rates for various government levels (g) ($kappah_{g,r}$).

Household Transfers to Corporations in Region r

$$transfers\_h\_corp_r = shr\_h\_corp_r * yd_r \quad (A53)$$

This equation calculates the transfers made by households to corporations in a specific region (r). It depends on the share of transfers allocated to corporations ($shr\_h\_corp_r$) and the net revenue (yd_r) of households.

Household Transfers to Governments g in Region r

$$transfers\_h\_gov_{g,r} = shr\_h\_gov_{g,r} * yd_r \quad (A54)$$

This equation calculates the transfers made by households to various government levels (g) in a specific region (r). It depends on the share of transfers allocated to each government level ($shr\_h\_gov_{g,r}$) and the net revenue (yd_r) of households.

Household Transfers to ROW in Region r

$$transfers\_h\_row_r = shr\_h\_row_r * yd_r \quad (A55)$$

This equation calculates the transfers made by households to the rest of the world (ROW) in a specific region (r). It depends on the share of transfers allocated to ROW ($transfers\_h\_row_r$) and the net revenue (yd_r) of households.

Household Total Consumption Expenditures in Region r

$$cth_r = shr\_cth_r * yd_r \quad (A56)$$

This equation calculates the total consumption expenditures (cth_r) of households in a specific region (r). It is obtained by multiplying the share of income allocated to consumption (shr_cth_r) by the net revenue (yd_r) of households.

Household Expenditures on Commodity j in Region r

$$xh_{j,r} = \frac{shr_{con_h\,j,r}\; cth_r}{pa_{j,r}\left(1 + txtmg_{j,r} + \sum_g txc_{j,g,r} + \sum_g txf_{j,g,r}\right)} \tag{A57}$$

This equation calculates the expenditures ($xh_{j,r}$) of households on commodity j in a specific region (r). It is determined by the share of consumption allocated to commodity j ($shr_{con_h\,j,r}$), the total consumption expenditures (cth) of households, and the price of commodity j ($pa_{j,r}$) adjusted for taxes ($txtmg_{j,r}$) and other factors.

Household Savings in Region r

$$savh_r = saverate\_h_r * yd_r \tag{A58}$$

This equation calculates the savings ($savh_r$) of households in a specific region (r). It depends on the savings rate specific to households ($saverate\_h_r$) and the net revenue (yd_r) of households.

Government Revenue and Expenditures

These equations help model and analyze government finances, including sources of revenue, transfers, expenditures, and savings within a regional economic context.

Government g Revenue in Region r

$$\begin{aligned} yg_{g,r} = {} & \sum_j \sum_i CI_{j,i,r}\left(txc_{j,g,r} + txf_{j,g,r}\right) PA_{j,r} + \left(\sum_j \left(XH_{j,r} + XI_{j,r} + XV_{j,r} + \sum_{g2} XG_{j,g2,r}\right)\right)\left(txc_{j,g,r} + \right.\\ & \left. txf_{j,g,r}\right) pa_{j,r} + \sum_j tm_{j,g,r} * XM_{j,r} * ER * wpm_{j,r} + \left(\sum_i txp_{i,g,r} + txs_{i,g,r}\right) PS_{i,r} XS_{i,r} + kappah_{i,r} * YH_r + \\ & kappae_{g,r} * YE_r + \sum_{g2} transfers_{gov_{gov}\,g2,g,r} + transfers_{row_{gov}\,g,r} + shr_{h_{gov}\,g,r} * yd_r + shr_{corp_{gov}\,g,r} * \\ & dprof_r \end{aligned} \tag{A59}$$

This equation calculates the total revenue ($yg_{g,r}$) of government g in a specific region (r). It includes various sources of income, such as taxes ($txc_{j,g,r}$ and $txf_{j,g,r}$) collected from households and corporations on commodity j produced by industry i, as well as other sources like import taxes ($tm_{j,g,r}$), taxes on production ($txp_{i,g,r}$ and $txs_{i,g,r}$), transfers from households ($kappah_{i,r} * YH_r$) and corporations ($kappae_{g,r} * YE_r$), transfers from other government levels and the rest of the world, and shares of households' net revenue ($shr_{h_{gov}\,g,r} * yd_r$) and corporate profits ($shr_{corp_{gov}\,g,r} * dprof_r$).

Government g Transfers to Government $g2$ in Region r

$$transfers\_gov\_gov_{g,g2,r} = shr\_gov\_gov_{g,g2,r} * YG_{g,r} \tag{A60}$$

This equation calculates the transfers made by government g to government $g2$ in a specific region (r). It depends on the share of transfers allocated to government $g2$ ($shr\_gov\_gov_{g,g2,r}$) and the total revenue ($YG_{g,r}$) of government g.

Government g Transfers to Households in Region r

$$transfers\_gov\_h_{g,r} = shr\_gov\_h_{g,r} * yg_{g,r} \tag{A61}$$

This equation calculates the transfers made by government g to households in a specific region (r). It depends on the share of transfers allocated to households ($shr\_gov\_h_{g,r}$) and the total revenue ($yg_{g,r}$) of government g.

Government g Transfers to Corporations in Region r

$$transfers\_gov\_corp_{g,r} = shr\_gov\_corp_{g,r} * yg_{g,r} \tag{A62}$$

This equation calculates the transfers made by government g to corporations in a specific region (r). It depends on the share of transfers allocated to corporations ($shr\_gov\_corp_{g,r}$) and the total revenue ($yg_{g,r}$) of government g.

Government g transfers to ROW in region r

$$transfers\_gov\_row_{g,r} = shr\_gov\_row_{g,r} * yg_{g,r} \tag{A63}$$

This equation calculates the transfers made by government g to the rest of the world (ROW) in a specific region (r). It depends on the share of transfers allocated to ROW ($shr\_gov\_row_{g,r}$) and the total revenue ($yg_{g,r}$) of government g.

Government g Savings in Region g

$$SAVG_{g,r} = saverate\_gov_{g,r} * YG_{g,r} \tag{A64}$$

This equation calculates the amount of money that government g is saving in a specific region, considering its savings rate and total revenue. It provides insight into the government's financial discipline and its capacity to allocate funds for future use or investment.

Government g Expenditures on Commodity j in Region r

$$XG_{j,g,r} = \frac{shr\_con\_gov_{j,g,r} * YG_{g,r}}{pa_{j,r} * \left(1 + txtmg_{j,r} + \sum_{g2} txc_{j,g2,r} + \sum_{g2} txf_{j,g2,r}\right)} \tag{A65}$$

This equation calculates government g's expenditures ($XG_{j,g,r}$) on commodity j in a specific region (r). It considers the share of consumption allocated to commodity j ($shr\_con\_gov_{j,g,r}$), the total revenue ($YG_{g,r}$) of government g, and the price of commodity j ($pa_{j,r}$) adjusted for taxes ($txtmg_{j,r}$), commodity-specific taxes ($txc_{j,g2,r}$), and other factors. This represents government spending on specific goods and services.

Investment–Saving Macroeconomic Identity

These equations help to understand the relationships between investment, savings, and the allocation of resources within an economy.

Total Investment Equals total Savings

$$\begin{aligned} &PK * INVT + \sum_j \sum_r XV_{j,r}\left(1 + txtmg_{j,r} + \sum_{g2} txc_{j,g2,r} + \sum_{g2} txf_{j,g2,r}\right)PA_{j,r} = \sum_r SAVH_r + \\ &\sum_r \sum_g SAVG_{j,r} + \sum_r SAVE_r + ER * bop \end{aligned} \tag{A66}$$

This equation represents the fundamental macroeconomic identity that total investment in an economy is equal to total savings. It considers various components such as private investment ($PK * INVT$), the demand for investment goods (given by the summation involving $XV_{j,r}$), and savings by households, government, and the rest of the world. It also accounts for the balance of payments (bop) and exchange rate (ER).

Total Investment in Region r

$$invr_r = shr\_gov\_inv_r * invt \tag{A67}$$

This equation calculates the total investment in a specific region (r). It depends on the share of investment allocated to government in that region ($shr\_gov\_inv_r$) and the overall total investment in the economy ($invr_r$).

Investment in Industry i in Region r

$$\frac{INV_{i,r}}{KD_{i,r}} = shfti_{i,r}\left(\frac{RK_{i,r}}{\left(intr + depr_{i,r}\right)PK}\right)^{gamma_{i,r}} \tag{A68}$$

This equation calculates the investment in industry i within a specific region (r). It takes into account the capital stock ($KD_{i,r}$), the interest rate ($intr$), and the depreciation

($depr_{i,r}$). The equation is influenced by the share of investment allocated to industry i ($shfti_{i,r}$) and a production function parameter ($gamma_{i,r}$).

Total Real Investment in the Economy

$$invt = \sum_i \sum_r inv_{i,r} \tag{A69}$$

This equation calculates the total real investment in the entire economy. It sums up the investments across all industries (i) and regions (r).

Demand of Commodity j for Investment in Region r

$$XI_{j,r} = \frac{shr\_inv_{j,r} * INVR_r * PK}{PA_{j,r}\left(1 + txtmg_{j,r} + \sum_g txc_{j,g,r} + \sum_g txf_{j,g,r}\right)} \tag{A70}$$

This equation calculates the demand for commodity j for investment purposes in a specific region (r). It considers the share of investment allocated to commodity j ($shr\_inv_{j,r}$), the total regional investment ($INVR_r$), and the price of commodity j ($PA_{j,r}$). It also adjusts for various taxes and margins.

Labor Market Equilibrium Condition

These equations help analyze labor market equilibrium, price indices, economic output, and the balance of payments in region r.

Resident Labor Market Equilibrium Condition

$$LRS_r * (1 - unemp_r) = \sum_i LRD_{i,r} \tag{A71}$$

Wage Curve or Resident Labor Real Wage Rigidity in Region r

$$\frac{WRE_r}{CPI_r} = Alab_r (unemp_r)^{elab_r} \tag{A72}$$

Consumer Price Index in Region r

$$CPI_r = \sum_j shr\_con\_h_{j,r} * PA_{j,r} \tag{A73}$$

Non-Resident Labor Market Equilibrium Condition

$$LNS_r = \sum_i LND_{i,r} \tag{A74}$$

Real Expenditure-Side GDP at Market Price in Region r

$$\begin{aligned} gdpmp_r = {} & \sum_j \left(XH_{j,r}\middle|+\middle|XI_{j,r}\right|+XV_{j,r}) pa0_{j,r} * \left(1 + txtmg_{j,r} + \sum_g txc_{j,g,r} + \sum_g txf_{j,g,r}\right) + \\ & \sum_j \sum_{g2} Xg_{j,g2,r} pa0_{j,r} \left(1 + txtmg_{j,r} + \sum_g txc_{j,g,r} + \sum_g txf_{j,g,r}\right) + \sum_j pe0_{j,r} xe_{j,r} + \sum_j pep0_{j,r} xep_{j,r} - \\ & \sum_j wpm0_{j,r} er0xm_{j,r} - \sum_j pmp_{j,r} xmp_{j,r} + \sum_j \sum_i CI_{j,i,r} \left(\sum_g txc_{j,g,r} + txf_{j,g,r}\right) pa0_{j,r} + \sum_j \left(XH_{j,r} + XV_{j,r} + \right. \\ & \left. \sum_{g2} XG_{j,g2,r}\right) \left(\sum_g \left(txc_{j,g,r} + txf_{j,g,r}\right)\right) pa0_{j,r} + \sum_j \sum_g tm_{j,g,r} * XM_{j,r} * ER0 * wpm0_{j,r} \end{aligned} \tag{A75}$$

Balance of Payment

$$\begin{aligned} er * bop = {} & \sum_j \sum_r wpm_{j,r} * xm_{j,r} * er + \sum_r \sum_g transfers_{gov_{row}\,g,r} + \sum_r transfers_{h_{row}\,r} - \\ & \sum_r \sum_g transfer\_row\_gov_{g,r} - \sum_r transfers\_row\_h_r - \sum_j \sum_r wpe_{j,r} * xe_{j,r} * er \end{aligned} \tag{A76}$$

Appendix A.4. Dynamic Equations

These dynamic equations capture the growth and changes in labor force, GDP, and capital stock over time in region r.

Growth Rate of Real Expenditure-Side GDP at Market Price in Region *r*

$$gdpmp_{r\ ,t} = \left(1 + grgdpmp_{r,t}\right) rgdpmp_{r,t-1} \quad \text{(A77)}$$

This equation represents the dynamic growth rate of real expenditure side GDP at market prices in region *r*. It uses a lagged value of the growth rate $rgdpmp_{r,t-1}$ to calculate the current GDP ($gdpmp_{r\ ,t}$ by applying a growth factor of $\left(1 + grgdpmp_{r,t}\right)$. This equation reflects how GDP evolves over time.

Resident Labor Force Growth

$$LRS_{r,t} = (1 + glrs_t) LRS_{r,t-1} \quad \text{(A78)}$$

This equation describes the growth in the resident labor force ($LRS_{r,t}$) in region *r* over time (t). It calculates the current labor force by multiplying the lagged labor force ($LRS_{r,t-1}$) with a growth factor $(1 + glrs_t)$. This factor accounts for changes in the size of the labor force due to population or other factors.

Non-Resident Labor Force Growth

$$LNS_{r,t} = (1 + glns_t) LNS_{r,t-1} \quad \text{(A79)}$$

Similar to the resident labor force growth equation, this equation represents the growth in the non-resident labor force ($LNS_{r,t}$) in region *r* over time (t). It calculates the current non-resident labor force by multiplying the lagged non-resident labor force ($LNS_{r,t-1}$) with a growth factor $(1 + glns_t)$. This factor reflects changes in the size of the non-resident labor force.

Capital Stock Accumulation

$$KD_{i,r,t} = KD_{i,r,t-1}\left(1 - depr_{i,r}\right) + INV_{i,r,t} \quad \text{(A80)}$$

This equation represents the accumulation of capital stock ($KD_{i,r,t}$) in industry i and region r over time (t). It calculates the current capital stock by taking the lagged capital stock ($KD_{i,r,t-1}$), accounting for depreciation $\left(1 - depr_{i,r}\right)$, and adding the current investment $INV_{i,r,t}$. It reflects how capital stock evolves as a result of investment and depreciation.

Appendix B

For all the sectors we have examined:

- Agriculture, Forestry, and Fishing (IAFH);
- Oil and Gas (IMOG);
- Construction (ICON);
- Manufacturing (IMAN);
- Retail Trade (ITRD);
- Scientific and Professional (STCG).

All the variables are stationary based on the ADF test at the 1% significance level (p-Value < 0.01), except for the "Ta" variable, which is non-stationary in every sector, indicated by p-values greater than 0.05.

Table A1. Agriculture, forestry, and fishing (IAFH).

Variable	Dickey–Fuller Statistic	Lag Order	*p*-Value	Stationary
laffhgdp_labor	−4.7833	1	0.01	Yes
laffhcap_labor	−3.6875	1	0.02891	Yes
P_20mm	−4.4413	1	0.01	Yes
Ta	−1.8385	1	0.6435	No
SPEI	−6.6446	1	0.01	Yes

Table A2. Oil and gas (IMOG).

Variable	Dickey–Fuller Statistic	Lag Order	*p*-Value	Stationary
lmqogegdp_labor	−4.0971	3	0.01	Yes
lmqogecap_labor	−4.2687	1	0.01	Yes
P_20mm	−4.4413	1	0.01	Yes
Ta	−1.8385	1	0.6435	No
SPEI	−6.6446	1	0.01	Yes

Table A3. Construction (ICON).

Variable	Dickey–Fuller Statistic	Lag Order	*p*-Value	Stationary
lconsgdp_labor	−6.1143	1	0.01	Yes
lconscap_labor	−4.5621	1	0.01	Yes
P_20mm	−4.4413	1	0.01	Yes
Ta	−1.8385	1	0.6435	No
SPEI	−6.6446	1	0.01	Yes

Table A4. Manufacturing (IMAN).

Variable	Dickey–Fuller Statistic	Lag Order	*p*-Value	Stationary
lmanfgdp_labor	−7.032	1	0.01	Yes
lmanfcap_labor	−6.8889	2	0.01	Yes
P_20mm	−4.4413	1	0.01	Yes
Ta	−1.8385	1	0.6435	No
SPEI	−6.6446	1	0.01	Yes

Table A5. Retail trade (ITRD).

Variable	Dickey–Fuller Statistic	Lag Order	*p*-Value	Stationary
lretrgdp_labor	−3.8822	1	0.01772	Yes
lretrcap_labor	−3.5964	2	0.03704	Yes
P_20mm	−4.4413	1	0.01	Yes
Ta	−1.8385	1	0.6435	No
SPEI	−6.6446	1	0.01	Yes

Table A6. Scientific and professional (STCG).

Variable	Dickey–Fuller Statistic	Lag Order	*p*-Value	Stationary
lpstcgdp_labor	−4.2596	4	0.01	Yes
lpstccap_labor	−3.9338	3	0.01523	Yes
P_20mm	−4.4413	1	0.01	Yes
Ta	−1.8385	1	0.6435	No
SPEI	−6.6446	1	0.01	Yes

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