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Fiscal Incentives for Critical Mineral Development in Canada: An Empirical Analysis

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Table of Contents

Abstract iv

Acknowledgement v

1.0 Introduction 1

2.0 Stylized Facts 3

2.1 Global critical minerals market condition 3

2.2 Canada's energy transition and the role of Critical minerals 6

2.3 Critical minerals in Canada 8

2.3.1 Mineral Production in Canada: The Case of Nickel and Zinc 10

2.3.2 State of Public Opinion on Mineral Production in Canada 14

3.0 Literature Review 16

4.0 Methodology 20

4.1 Data 20

4.1.1 Tax Policy Dummy Variables 20

4.2 Pre-estimation 22

4.2.1 Summary Statistics 22

4.2.2 Unit Root 23

4.3 Model and Estimation Procedures 24

4.3.1 Model Specification 24

4.3.2 Estimation Procedure 27

5.0 Empirical Results 28

5.1 Nickel Models 28

5.2 Zinc Models 30

6.0 Conclusion 33

References 36

Appendix A 38

Appendix B 41

Abstract

This capstone investigates empirically the effect of mining tax rate review on Nickel and Zinc production in Quebec, Ontario, and Manitoba. We employ the autoregressive distributed lag (ARDL) modelling technique to analyze the dynamic interactions between output of the two transition minerals and prices, mineral foreign direct investments, and relevant tax policy variables. Results show that long run relationship exist between Nickel production and the determinants for Quebec and Manitoba. However, no such relationship exists for Ontario. Zinc production is cointegrated with its determinants in Quebec, Ontario and Manitoba. The effect of mining tax policy is most discernible for Nickel in Manitoba, as a lower mining tax rate elicited improvement in Nickel production. Tax policy is not significant for Quebec and Ontario's Nickel production, but price and foreign direct investments are prime for Ontario and Manitoba, while only foreign direct investments matter for Quebec. Zinc output in Quebec is significantly impacted by price and foreign direct investments, while the gradual upward tweak to Quebec's mining tax rate coincides, curiously, with improvement in Zinc production. Possibly, the 2009/10 post-crisis growth momentum in Quebec's mineral space overshadowed sensitivity to a mining tax hike. To boost critical mineral supply in the era of energy transition, both federal and provincial governments need to roll out more critical mineral-friendly tax and non-tax incentives, oriented toward growing the supply chain responsibly and sustainably.

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1.0 Introduction

Against the backdrop of the skyrocketing global demand for transition minerals amidst current global energy supply pressures, this capstone studies the relationship between tax policy incentive and production of two critical minerals, Nickel and Zinc in Canada. Our aim is to observe the effect of mining tax rate review on Nickel and Zinc production Canada's three producer provinces of Quebec, Ontario and Manitoba between 2005 and 2020.

The crucial role critical minerals play in enhancing the building of net-zero economies of the future, powered by renewable energy and clean technology products amplifies the need to optimise critical mineral production and supply chains in Canada. Essentially, the success of the ongoing energy transition largely hinges on the robustness of global market for critical minerals. The Canadian Minerals and Metals Plan (CMMP) lists 31 minerals as critical for the Canadian economy. The current widening supply gaps, unprecedented price increases, the domination of the mineral production by a single supplier – China, the strategic importance of critical minerals to the transition toward net zero, the opportunity for Canada to improve its supply chain and capture the economic benefits associated with the booming critical minerals market provides strong bases for this investigation.

We apply the autoregressive distributed lag (ARDL) model developed by Pesaran and Shin (1998) to test for the existence of long run relationship between selected two critical minerals and the following determinants: price, non-fossil foreign direct investments and tax policy dummy which represents the period mining tax rate were reviewed upward or downward in the provinces. We specified and estimated six models, a pair of Nickel and Zinc models for Quebec, Ontario and Manitoba. Our results show that cointegration exist between Nickel output and its determinant variables, including Nickel price, non-fossil mineral foreign direct investments and tax policy dummy for Quebec and Manitoba. However, no cointegration is found between Nickel output and its determinants in the case of Ontario. Conversely, we found cointegration between Zinc output and the determinants for Quebec, Ontario and Manitoba.

The effect of mining tax policy is most discernible for Nickel production in Manitoba, as a percentage point lowering of mining tax rate elicits a 3 percentage points rise in Nickel output. Tax policy dummies are not significant for Quebec and Ontario's Nickel production, but Nickel price and non-fossil foreign direct investments are prime for Ontario and Manitoba, while only non-fossil foreign direct investments matter for Quebec. Zinc output in Quebec is significantly impacted by Zinc price and non-fossil foreign direct investments, while gradual upward raise in Quebec's mining tax rate curiously improved Zinc output. Current Zinc price predominates in Manitoba as a most important driver of Zinc output in the model.

The key point to note for policy purpose is that in mineral taxation, "one size may not fit all". Mineral tax policy prescriptions should consider factors peculiar to each mineral, mine/project, mineral price dynamics and province endowments. For example, Manitoba's Nickel production seemed to have benefitted from the 2010 mining tax rate cut, while in the case of Quebec, a staggered rate increase appeared not to have deterred the growth in Zinc production. The priority on boosting the supply chain of critical minerals should be sustained and funded with critical initiatives to encourage increased critical mineral mining based on best sustainability standards.

Section two presents salient stylized facts about global and Canadian critical minerals markets, while sections 3 surveys the literature. Section 4 treats methodology and 5 presents and discusses empirical results, while section 7 concludes the study.

2.0 Stylized Facts

2.1 Global critical minerals market condition

The global demand for critical minerals over their 2020 supply levels is forecast to rise by very high proportions. The demand for indium, used for building nuclear and solar energy; vanadium, used for making flow batteries and nuclear energy; and nickel, used for producing lithium-ion batteries, wind and geothermal energies are projected to rise 192, 161 and 91 percent, respectively, by 2050 (Govind Bhutada, 2021).

In 2020, over 7 million electric cars were estimated to have been on roads world-wide. The number is forecast to skyrocket to as high as 245 million by 2030 (IEA, 2020). Powering these cars requires a significant increase in the supply of batteries and advanced electric storage systems, made mainly with minerals like lithium, cobalt, and graphite. A typical electric car requires half a dozen times the mineral inputs of a normal car, while an onshore wind plant need nine times more mineral resources than a comparable gas-fired power plant (IEA, 2021). The Executive Director of the International Energy Association (IEA), Fatih Birol was forthright when he declared that "…the global energy system is undergoing a transition to clean energy. The efforts of an ever-expanding number of countries and companies trying to reduce their greenhouse gas emissions to net zero and requires a massive deployment of a wide range of clean energy technologies, many of which will in turn rely on critical minerals such as copper, lithium, nickel, cobalt, and rare earth elements". This commentary indicates the extent to which the successful transition to net zero very much depends on the availability of the critical materials for building clean, renewable energy infrastructures across the globe. The International Energy Agency (IEA) documents the extent to which critical minerals and rare earth elements are vital for specific renewable energy development, as shown in figure 1 below.

Figure 1: Critical mineral needs for clean energy technologies

	Copper	Cobalt	Nickel	Lithium	REEs	Chromium	Zinc	PGMs	Aluminium*
Solar PV	●	○	○	○	○	○	○	○	●
Wind	●	○	◍	○	●	◍	●	○	◍
Hydro	◍	○	○	○	○	◍	◍	○	◍
CSP	◍	○	◍	○	○	●	◍	○	●
Bioenergy	●	○	○	○	○	○	◍	○	◍
Geothermal	○	○	●	○	○	●	○	○	○
Nuclear	◍	○	◍	○	○	◍	○	○	○
Electricity networks	●	○	○	○	○	○	○	○	●
EVs and battery storage	●	●	●	●	●	○	○	○	●
Hydrogen	○	○	●	○	◍	○	○	●	◍

Notes: Shading indicates the relative importance of minerals for a particular clean energy technology (● = high; ◍ = moderate; ○ = low), which are discussed in their respective sections in this chapter. CSP = concentrating solar power; PGM = platinum group metals.

Culled from the IEA World Energy Outlook Special Report on the Role of Critical Minerals in Clean Energy Transitions

Figure 1 shows that electric vehicles and advanced storage systems require nearly all the critical minerals. To guarantee the growth of electric vehicles and advanced batteries, the pipeline of supply for copper, cobalt, nickel, lithium, rare earth elements (REEs) and aluminium must be high and steady. Growth of wind energy requires the availability of copper, REEs, nickel, chromium, zinc, and aluminium in varying levels of intensity.

The transition from fossil fuel to a clean energy system will drive a significant increase in the requirements for these minerals. Therefore, for the global energy sector to develop in line with transition timelines, the production and supply chain for key mineral elements must grow significantly. As energy transitions gathers momentum world-wide, clean energy technologies will become the fastest-growing segment of demand for critical minerals and rare earth elements.

Whilst the implications of Europe's over-reliance on Russian oil and gas rages on, serious concerns are now being expressed about a new risk of energy dependency on the account of shortage of "transition materials" in the continent.

In a study by Belgium's KU Leuven university commissioned by metals producers' body Eurometaux, Gregoir (2022) reports that the next 15 years will see "critical shortfalls without more mined and refined metals supplying the start of Europe's clean energy system". Specifically, the report states that Europe is faced with a supply crunch for five key materials – lithium, cobalt, nickel, rare earths, and copper from 2030, with demand peaking in 2040 after which recycling will start to ease the situation. Table 1 below shows the projected annual European demand for critical minerals by 2050.

Table 1: 2050 Projected Annual European Demand for Selected Critical Minerals

	Critical Mineral	**Projected Quantity Needed by 2050 (Tonnes)**	**Change over Current Levels (%)**
1	Lithium	800,000	3500%
2	Nickel	400,000	100%
3	Cobalt	60,000	330%
4	Rare Earths Metals	3,000	+700 - 2,600%
5	Copper	1,500,000	35%

Source: Eurometaux/KU Leuven

The European demand for lithium, nickel, cobalt, copper is forecast to rise by 3,500, 100, 330, and 35 percent respectively by 2050 over their current demand levels; while the demand for rare earth elements will is projected to rise by 700 to 2,600 percent, over the 2050 level. This creates a profound supply gap for European renewable energy future. If this gap is not shrunk, the likelihood that Europe will continue to survive on hydrocarbons for a very long time is high. This will be a significant blow to the transition to a renewable energy-powered Europe. Europe needs to decide expeditiously on how to bridge the looming supply gap for primary metals.

Europe may need to follow China's lead by investing in critical mineral mines outside its territory. There are concerns that the current absence of a decisive strategy could result to dependencies on unsustainable suppliers.

2.2 Canada's energy transition and the role of Critical minerals

The future of energy in Canada is highly critical minerals intensive. Canada Energy Regulator (CER)'s Energy Future 2021 Report depicts the country's transition paths to net zero under certain assumptions. It sets out the role clean and renewable energy sources will play in electricity generation across Canada. Failing to develop the sector through investment-friendly economic policy and fiscal regimes can lead to serious critical mineral supply gap that could clog the net zero transition wheel.

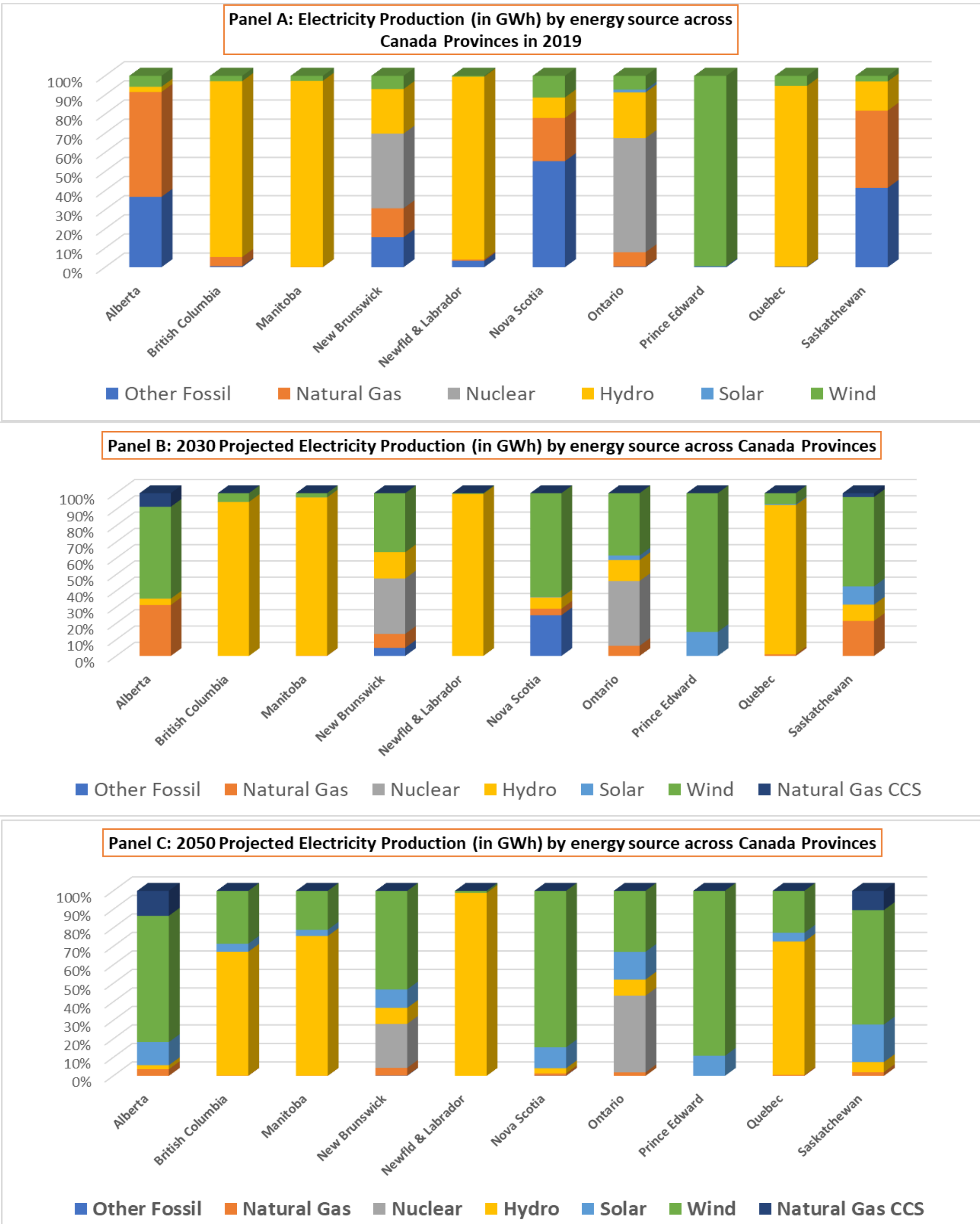
Table 2: Canada's Average Electricity Production: 2019 Actual vs 2030/50 Forecasts (in GWh)

	Other Fossil	Natural Gas	Natural Gas CCS	Nuclear	Hydro	Solar	Wind
2019	4,716.78	6,937.14	0.00	9,547.00	37,535.53	219.40	3,231.60
2030*	939.74	3,742.79	554.14	6,540.59	43,495.22	867.48	14,269.79
2050*	8.74	1,107.91	1,668.78	9,810.61	38,299.30	7,872.78	30,153.56

Data Source: Canada's Energy Future 2021 Report. *Projections

Table 2 depicts actual and forecast average electricity production in Canada for 2019, 2030 and 2050, respectively. The use of other fossil is predicted to fall to near zero, while Solar and Wind powered electricity are expected to increase significantly by 2050. In the visualisation presented in figure 2 below, I used data from Canada Energy Regulator to chart actual and projected electricity production (in GWh) by energy source across Canadian Provinces.

Figure 2: 2019 Actual and 2030/50 Projected Electricity Production (in GWh) by energy source across Canadian Provinces



Data Source: Canada Energy Regulator

Figure 2 above shows the distribution of electricity generation by source in Canadian provinces and territories in 2019 (Panel A), 2030 (Panel B) and 2050 (Panel C). Data for 2019 are actual while those for 2030 and 2050 are projections based on scenarios and assumptions by Canada Energy Regulator (2021). Summary insight from the figure includes the following: (i) Natural Gas with carbon capture and storage will join the energy mix in Canada; (ii) Alberta, Saskatchewan, Nova Scotia and New Brunswick are key for the net zero transition agenda. They are the heaviest on fossil-generated electricity; (iii) Hydro and Wind Energy sources will dominate the mix into the future; and (iv) Solar energy can do even better with the right policies. These projections may not be realized if the envisaged significant imminent demand-supply gap for critical minerals is not bridged.

2.3 Critical minerals in Canada

Canada is reputed as a major mining country, with leading advances in mineral mining, mining finance, mining services and supplies, and sustainability. Canada produces about 60 minerals; it leads the world in potash production, and is a major producer of primary cobalt, molybdenum, aluminium, nickel, diamonds, platinum group metals, salt, uranium, titanium concentrate, tungsten, and zinc.

However, there are indications that Canada's leading role is slipping, a situation that can jeopardize Canada's ability to seize new opportunities for growth, especially as net zero transition thickens. In 2020, Canada recorded a modest increase in the value of mining projects planned and under construction from 2020 to 2030 (by $2 billion year-over-year), the total 10-year projected value ($82 billion) is reported to remain nearly 50% below the 2014 level of $160 billion (Canada Mining Association, 2021).

Natural Resources Canada is leading the effort to develop a Critical Mineral Strategy for Canada. The work-in-progress strategy will advance the development of critical mineral resources and value chains to power the clean and digital economy in Canada and beyond. With a developed value chain in the sector, at each stage of the development process, Canada will maximise the opportunity to be a global leader in the responsible, inclusive, and sustainable production of critical minerals, from mines to manufacturing. The planned strategy will cover the following six areas: (i) driving research, innovation, and exploration; (ii) accelerating project development; (iii) building sustainable infrastructure; (iv) advancing Indigenous reconciliation; (v) growing a diverse workforce and prosperous communities; and (vi) strengthening global leadership and security.

Existing expertise in science, technology and mineral development will be strengthened through strategic funding for mining, materials, geological and explosives research. The proposed strategy will strengthen strategic partnerships and engagement forums, which will shape the implementation of the strategy itself. These strategic partnerships and engagement platforms include the following: (i) Critical Minerals Industry Engagement Forum (CMIEF); (ii) Critical Minerals Indigenous Engagement Strategy; (iii) Federal-Provincial-Territorial (FPT) Task Team on Critical Minerals and Battery Value Chains; (iv) Canada-U.S. Joint Action Plan on Critical Minerals Collaboration; (v) Critical Minerals Working Group under the Canada-Japan Energy Policy Dialogue; and (vi) other intergovernmental and stakeholder engagement forums.

Canada ranks high on sustainable mining. According to the Mining Association of Canada, it was the first country to develop an externally verified performance system for mining operations. Many countries around the world have followed Canada's lead to adopt "Towards Sustainable Mining (TSM)". The list includes Finland, Brazil, Argentina, Botswana, the Philippines, Spain, Norway and Australia, all committing to prioritizing sustainable mining practices where they operate. To encourage responsible mining globally, the Mining Association of Canada shares the TSM framework developed by it in 2004 with other countries with interest in promoting sustainable mining practices.

The Government of Canada developed the following list of 31 minerals deemed to be critical importance in pursuit of sustainable economic progress and in positioning Canada as the leading mining nation, as envisaged in the Canadian Minerals and Metals Plan (CMMP). The list of the minerals includes Aluminium (bauxite), Antimony, Bismuth, Caesium, Chromium, Cobalt, Copper, Fluorspar, Gallium, Germanium, Graphite, Helium, Indium, Lithium, Magnesium, Manganese, Molybdenum, Nickel, Niobium, Platinum group metals, Potash, Rare Earth elements, Scandium, Tantalum, Tellurium, Tin, Titanium, Tungsten, Uranium, Vanadium, and Zinc. The list was developed through consultations between Natural Resources Canada, provincial, and territorial governments, as well as exploration, mining and manufacturing industries and associations using a criteria-based approach. The synergy amongst the federal, provincial, and territorial (FPT) governments is key to advancing the exploration of the opportunities in critical mineral space. It is a widely shared belief amongst the different tiers of government in Canada that critical minerals are essential to Canada's economic and energy security, required for Canada's transition to a low-carbon economy, a sustainable source of critical minerals for our partners. In addition, the list signal greater certainty and predictability to investors, industry, provinces and territories and Canada's international partners on Canada's mineral priorities, and it also enables policy makers to consider and address strategic areas in the supply chains.

2.3.1 Mineral Production in Canada: The Case of Nickel and Zinc

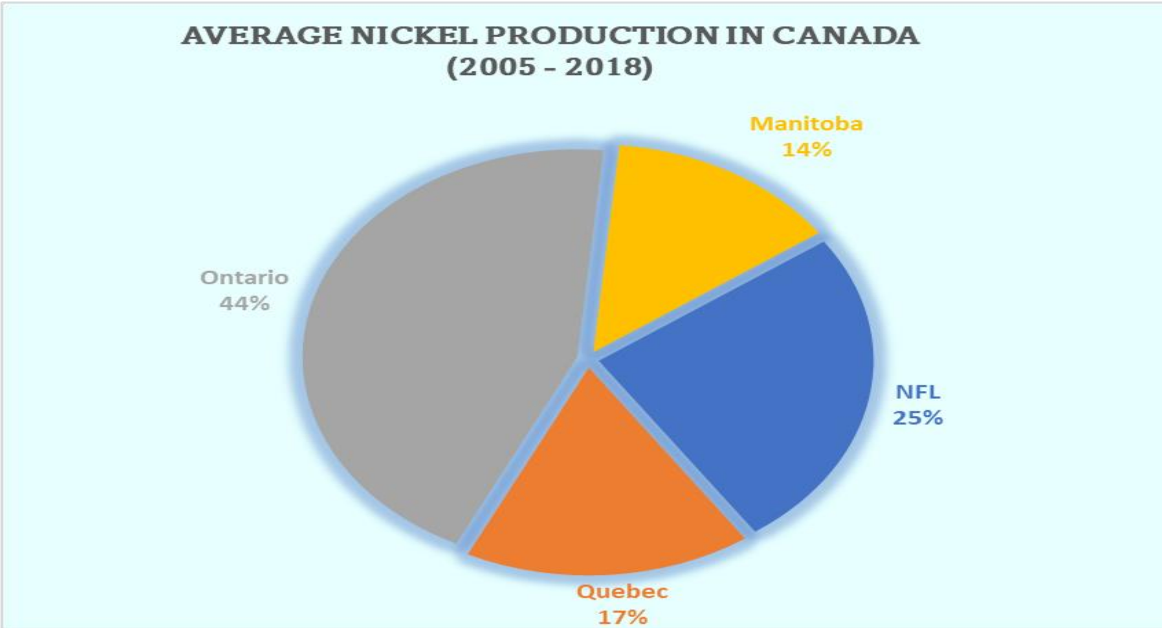
Nickel is produced in Ontario, Newfoundland & Labrador, Quebec, and Manitoba. As shown in table 3 below, the mineral has a strong clean tech application, and it is used in the production of rechargeable batteries for mobile phones, computers and electric vehicles, power plants and other advanced applications.

Table 3: Average Nickel and Zinc Production in Canada (2005 - 2018)

Mineral	Provinces	Value Chains/ Key Applications	Products
Nickel	Ontario	Clean technologies/ Stainless steel, solar panels, and batteries	Rechargeable batteries (phones, computers, EVs), power plant components, metal alloys (steel, super alloys, nonferrous alloys), jet and combustion engine components, industrial manufacturing machines, construction beams, anti-corrosive pipes, cookware, medical implants, etc.
	NFL & Labrador		
	Quebec		
	Manitoba		
Zinc	New Brunswick	Clean technologies and advanced manufacturing	Batteries, electronics, rust proofing, manufacturing of automobiles, paints, rubber, cosmetics, pharmaceuticals, plastics, inks, soaps, textiles, baby creams, sunscreen
	Quebec		
	Manitoba		
	Ontario		
	BC		
	NFL		

Zinc, on the other hand is found and produced in more provinces in Canada, including New Brunswick, Quebec, Manitoba, Ontario, British Columbia (BC) and Newfoundland & Labrador. The supply chain for Zinc is in the clean tech space and advanced manufacturing sector. It is used in the production of batteries, electronics, automobiles, textiles, etc. Figure 3a below shows the average production of Nickel in Canada between 2005 and 2018.

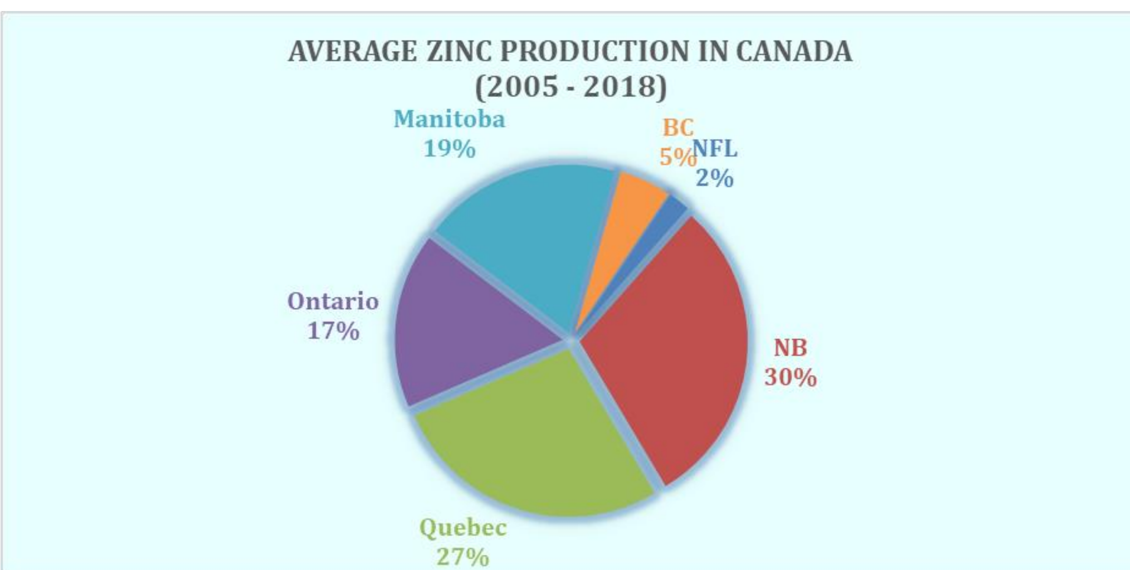
Figure 3a: Average Production of Nickel by province (2005 - 2018)



Source: Statistics Canada & Author's Calculations

Ontario, Newfoundland & Labrador, Quebec, and Manitoba account for all the Nickel produced in Canada between 2005 and 2015, at 44 percent, 25 percent, 17 percent, and 14 percent, respectively. Figure 3b below shows the average production of Zinc in Canada between 2005 and 2018.

Figure 3b: Average Production of Zinc by province (2005 - 2018)

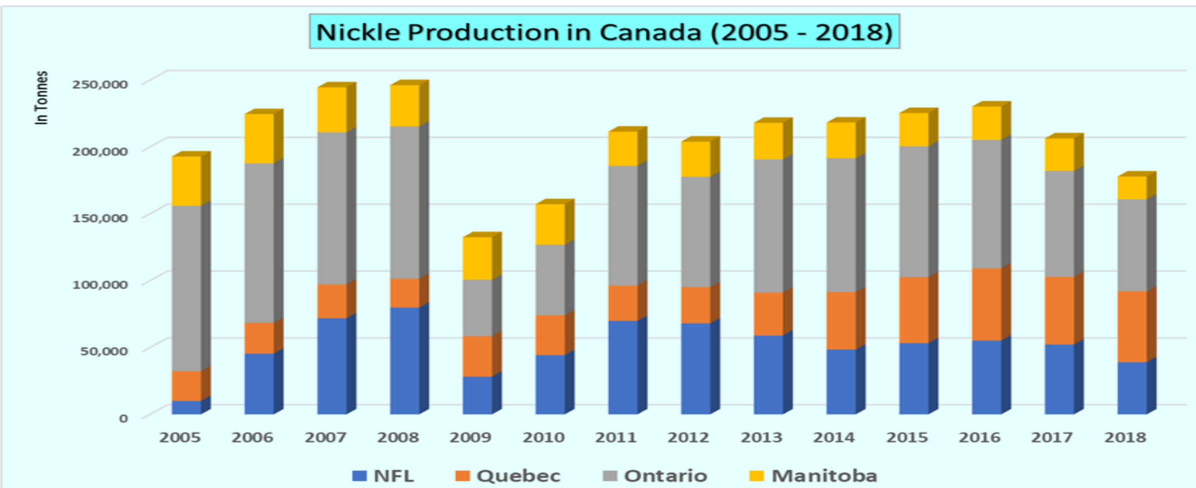


Source: Statistics Canada & Author's Calculations

New Brunswick, Quebec, Manitoba, Ontario, British Columbia (BC) and Newfoundland & Labrador account for all the Zinc produced in Canada between 2005 and 2018, at 30 percent, 27 percent, 19 percent, and 17 percent, 5 percent, and 2 percent, respectively.

Figure 4a below shows the yearly total production of Nickel by province between 2005 and 2018.

Figure 4a: Yearly Nickel Production by Province (2005 - 2018)

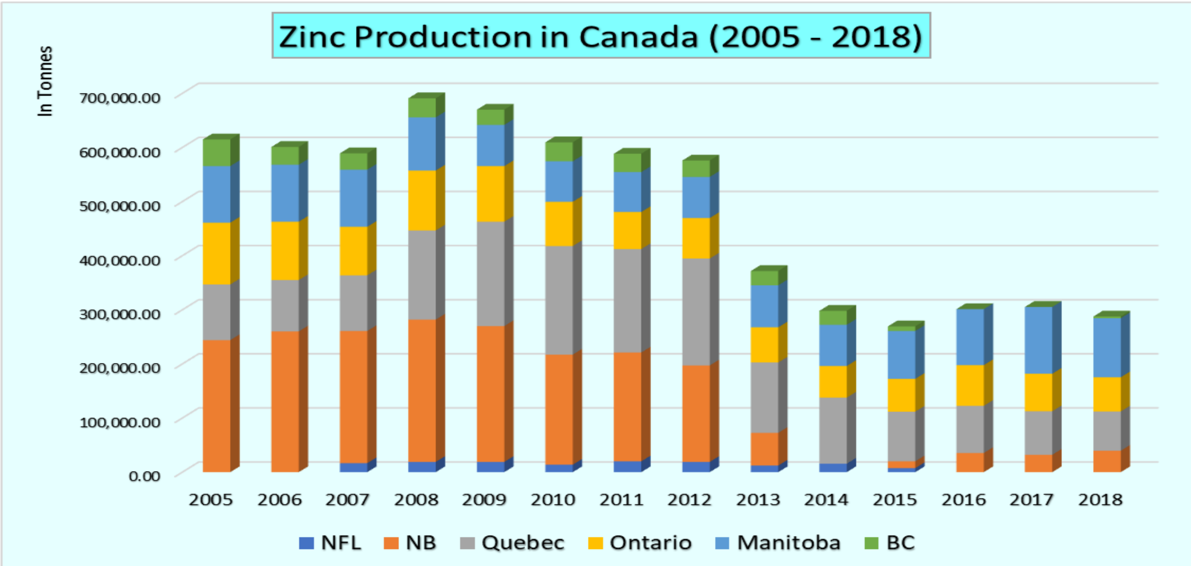


Source: Statistics Canada & Author's Calculations

The figure shows that Nickel production from Ontario and Newfoundland & Labrador experienced an acute decline in 2009. The decline is attributable to the decline in Nickel reserves. However, strong metal prices enabled the setting up of new mines, with established mines also re-positioned to expand reserves. This also led to the revamp of the old mines, thus significantly increasing some metal reserve levels in the following years (NRCan, 2012).

Figure 4b below shows the yearly total production of Zinc by province between 2005 and 2018.

Figure 4b: Yearly Zinc Production by Province (2005 - 2018)



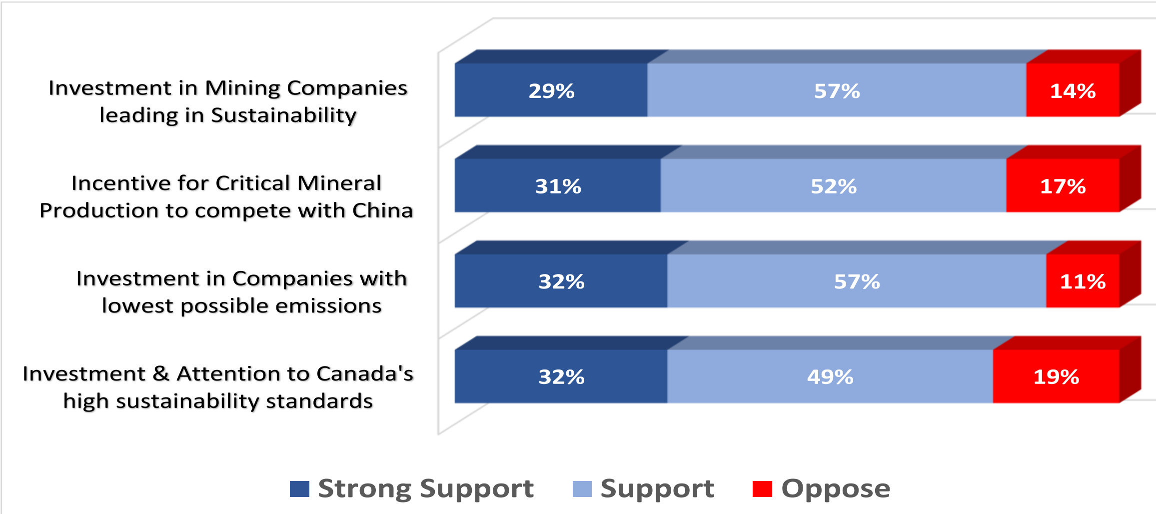
Source: Statistics Canada

From figure 4b, New Brunswick was Canada's dominant producer of Zinc between 2005 and 2012, but its production nosedived significantly onwards and has not recovered. The decline has been associated with the poor demand from foreign Zinc trading partners.

2.3.2 State of Public Opinion on Mineral Production in Canada

Public opinion supports accelerated critical mineral development in Canada. A 2021 poll conducted by Abacus suggests that strong support exist for critical minerals development in Canada, with average interprovincial and cross-party support amounting to 88%. The support reflects Canadians preference for: (i) high standards of sustainability, (ii) lowest possible emissions, and competition with China.

Figure 5: Canadian Public Opinion on Critical Mineral Investments



The poll indicates that 86% want to encourage international investment into Canadian Critical Minerals and Metals Companies that are Sustainability leaders; 83% want to encourage critical minerals production so Canada can compete with China; 89% want to encourage international investment into Canadian Critical Minerals and Metals Companies that make products with lowest possible emissions, and 81% want to promote interest in Canadian Critical Minerals by drawing attention to Canada's high environmental standards.

3.0 Literature Review

Extensions to the neoclassical theoretical characterisation of the relationship between output and capital and labour (Solow, 1957) accommodates the inclusion of other potentially output enhancing variables in the production function. A tax stimulus is assumed to raise output, ceteris paribus. It works via the easing of tax-induced deadweight losses, lowering of firms' tax liabilities and raising the demand for capital through their effects on reducing its rental price (Ghebremichael and Potter-Witter, 2009).

Whereas the discourse on critical mineral development for powering the energy transition is still evolving, the nexus between fiscal incentives and investments has received considerable attention over time. The literature assigns a fundamental role to fiscal behaviour in driving the economy towards its potential levels of growth. Keynes (1924) submitted that, government must recognize that even if a tax is not prohibitive, it may be unprofitable, and that a medium, rather than an extreme, imposition will produce the greatest gain.

Romer (1994), based on the endogenous growth model suggests that an economy can attain economic growth and fiscal health either by containing expenditure or by increasing tax revenue. Each proposition, however, have important implications depending on the state of the economy and the evolution of the business cycles. A government's capacity to raise more revenues through tax hikes is however limited. This is because, taxes and tax raises produce deadweight losses or efficiency costs to the economy.

Fölster and Henrekson (2001) opines that taxation is considered a major policy tool for achieving resource transfer from the private to the public sector to finance government operations and projects, as well as to nudge the market toward conformity to some fiscal objectives. Taxation has been shown to drive capital formation in many economies. This Keynesian submission underscores how optimal mineral taxation often require a balance between revenue requirement and investment growth objectives, particularly in the mineral sector. The standard theory of optimal taxation proposes that the end to which a tax system should be designed is the maximization of a social welfare function subject to a set of constraints (Mankiw et al., 2009).

Mineral taxation is of a peculiar distinction from the general taxation. Boadway and Keen (2009) explores the peculiarities which raises the risk profiles of mineral projects investments, and thus making investors deserving of generous fiscal incentives. First, mineral discovery, development, exploration and closing of mines often have huge capital outlay and may span decades. In essence, the sunk costs for mineral projects are huge, and the expenses often occur early, prior to cash flow realisations. This characteristic makes investors care about the prevailing tax or fiscal regimes. If investors perceive a potentially complicated and not-so-friendly fiscal framework, they could simply abandon the projects. However, if the sunk costs have been incurred, investors have limited options and would be constrained to continue with the project provided they can cover their variable costs. Continuing with production at that stage will be more profitable than ceasing operations. In the project planning phase, government has an incentive to offer relatively great tax incentives, but much less generous incentives once the project has been established.

A second argument for special tax considerations for mineral projects is uncertainty. Mineral projects uncertainty runs from exploration through to development, extraction, and closure stages. Uncertainty about geology, mineral deposit volumes, grades, accessibility, and appropriate technology are always very real in mineral development projects. Commodity price volatility adds an extra and serious layer of uncertainty to mineral projects. Commodity price oscillations often elicit both boom and gloom for mineral projects investors.

A third argument is about rent. Rent earned by mineral projects investors can fluctuate quite significantly, therefore taxing such rents require a special design. Rent extraction is a primary consideration in designing mineral tax regimes. A rent tax needs to reflect all production costs incurred by the firm. Failure to make allowance for these costs in rent taxation could precipitate distortions in decision making.

Fourthly, mineral projects can attract often substantial revenues to government such that alternative revenue sources of less efficient nature become less attractive to government. Fifth, in addition to tax revenue benefits, mineral projects can also attract benefits associated with foreign investments in the mineral sector. Such benefits may include employment growth, improvement in the per capita income and potential knowledge transfer.

Fifth, some international considerations make mineral projects the more serious for a conducive tax environment to be established for them. The projects are usually subject to multiple tax jurisdictions and rules, thus increasing the effective tax rates applicable to these projects. Also, the prevalence of foreign ownership may also influence host countries' tax incentive package given that the after-tax profits accruing to foreigners are presumably less socially valuable than the profit cash flow accruing to citizens (Boadway and Keen, 2009). They may thus be assigned relatively low weight in the mineral tax revenue design. Sixth, policy makers often face an information asymmetry problem. Data on geology, commercial situations, business and arm's length relationships, and specific financial and non-financial circumstances at all stages in the life of a mineral project is typically known to government. The situation further complicates the design of incentives and royalty regimes that produces socially and economically optimal outcomes.

Mintz and Chen (2012) provide an extensive discourse on optimal royalty design in Canada. They report that Canadian provinces have increasingly adopted a net profit system which makes cost deductible in the determination of applicable royalty base, as opposed to the practice where a percentage of mineral production revenues is charged as royalty. Mining taxes in many provinces now apply to profits gross of interest deductions. Others have resorted to extracting resource royalty or mining tax imposed on rents, often calculated as revenue net of current and capital expenditures. The Federal government and provincial/territorial governments across Canada provide specific incentives to maximise mineral resource development and revenues. The rights over mineral resources resides with the provincial governments, and the territorial government in the case of Yukon and the Northwest Territories. For Nunavut and the offshore, the federal government holds the mineral rights. Mineral rights can be leased by individuals or companies, and these leases are fully transferable without government intervention or review. In most cases, both federal and provincial/territorial incentives can be accessed by business concerns in the mineral mining space. A comprehensive list of federal and provincial/territorial incentives and funding initiatives is presentenced in Appendices A and B.

4.0 Methodology

We set up an autoregressive distributed lag (ARDL) model to test for the existence of long-run relationship between mineral production and tax policy/fiscal incentives, mineral reserves, and non-fossil foreign direct investments. Determining the kind and magnitude of relationship that may exist between mineral production and the three regressors, namely, tax policy dummy variable, mineral reserves, and non-fossil foreign direct investments in the mining sector.

4.1 Data

For our estimation exercise, we obtained annual data sourced from Statistics Canada and the Mining Association of Canada on two of the minerals on Canada's list of critical minerals, namely, Zinc and Nickel between 2005 and 2020. Our data include mineral production volume measured in tonnes, tax policy dummy variable, mineral reserves in tonnes, and foreign investments flows into Canada's non-fossil mineral sector. Using appropriate frequency conversion technique, the annual data were spliced into quarterly series as a remedy against the small sample bias pitfall. Our sample size is constrained by data availability.

4.1.1 Tax Policy Dummy Variables

To implement our objective of investigating the effect of mining tax rate on Nickel and Zinc production in Quebec, Manitoba and Ontario, we set up three mining tax policy dummy variables, representing each of the provinces. Each dummy is intended to capture the period in our data when a specific mining tax policy change was implemented.

Quebec

The Quebec Mining Act sets the current mining tax (or royalty) rate at 16%, provides exploration expenses deductibility rate of 100 – 125%, pre-production development expense deductibility rate of 100%, depreciation of mining assets at 30%, and puts the processing allowance rate of 7-13%. We are zeroing in on the potential impact of the mining royalty rate change implemented in the 2011/2021 fiscal year. The rate was reviewed upward from 12% to 16%. The Quebec tax policy dummy series is therefore assigned the value of 1s in the middle 4 quarters of 2011/2012 when the royalty review was implemented and 0s otherwise.

Manitoba

The Manitoba Mining Tax Act sets up a graduated mining royalty regime ranging between 10 – 17%, based on mining companies' profit margins, provides for mining tax exemptions for new mines, exploration expenses deductibility rate of 100 – 150%, pre-production development expense deductibility rate of 20%, depreciation rate of 20%, processing allowance rate of 20% and tax holiday until payback is attained (available for new mines established after January 1, 1993). The mining tax rate was reduced from 18% to the 10 – 17% range in 2009. We used 2010 to reflect policy change period in our tax dummy variable to account for the implementation lag observed in the data. The reduction in rate is expected to boost Nickel and Zinc production in Manitoba as implementation kicks in ceteris paribus. Manitoba tax policy dummy sets 2009 to 1s and 0s otherwise.

Ontario

The Ontario Mining Tax Act stipulates a current mining tax (royalty) rate of 10% on profit margins and 5% for operators in remote areas. Profit under $0.5M per year and first $10M or first 3 years (10 years for remote area), whichever comes first are tax-exempt. Exploration expenses and pre-production development expense are deductible at 100% rate. Depreciation for mining and processing assets are 30% and 15% straight line, respectively. Ontario dropped corporate income tax (CIT) rate for businesses in the manufacturing and processing sectors, including mining from 12% to 10% in July 2010. Such intervention is expected to give impetus to mineral production in Ontario. Our model recognises 2009Q3 – 2010Q2 as the period the tax policy shock materialised.

Table 4: Summary of mineral tax policy review

	Tax Variable	Review Period	Nature of Review	Expected Sign of Coefficients
Quebec	Mining Tax Rate	2011Q3 – 2012Q2	**Increase** from 12% to 16%	**Negative**
Ontario	CIT on Mining profit	2010Q3 – 2011Q2	**Decrease** from 12% to 10%	**Positive**
Manitoba	Mining Tax Rate	2010Q1 – 2010Q4	**Decrease** from 18% to 14% average	**Positive**

4.2 Pre-estimation

To observe key attributes of the data, we conduct two diagnostic tests and report the summary descriptive statistics and the levels at which the series are devoid of unit root. The unit root test allows us to determine the level in which the variables are stationary; either at levels or at first difference. Variables that are of higher order of integration cannot enter the model, as the approach allows only variables which are integrated of order (0) and (1) to be modelled to determining the existence of co-integrating relationship among the model variables.

4.2.1 Summary Statistics

The summary descriptive statistics in table 4 below shows the mean, median and the standard deviation of the two series, Nickel on panel A and Zinc on panel B, each with 61 observations. It shows that for both Nickel and Zinc, price and reserves are the less volatile, compared to the high volatility of production volumes and foreign direct investment flows.

Table 5: Data Summary Statistics

Variables	MFDI	Price	Production		
			Ontario	Quebec	Manitoba
Panel A: Zinc					
Mean	22350.94	264.1	79680.0	126359.0	94776.5
Median	21473.08	250.7	72167.5	102958.0	98299.0
Maximum	42155.81	371.4	114154.0	200693.0	123384.0
Minimum	3362.65	159.2	58390.0	72666.0	73775.0
Std. Dev.	9393.64	51.1	17345.6	46081.4	16792.0
Observations	61	61	61	61	61
Panel B: Nickel					
Mean	22350.94	7.91	88617.44	37243.36	26786.59
Median	21473.08	6.84	93167.87	31020.75	6546.47
Maximum	42155.81	17.22	125206.0	54686.18	37358.69
Minimum	3362.65	4.27	33233.31	21015.22	12939.28
Std. Dev.	9393.64	3.11	23705.26	12906.41	6552.31
Observations	61	61	61	61	61

The observed potential volatility correlation between production volumes and investment flows may be a pointer to the nature of the kind of the interaction between the two series.

4.2.2 Unit Root

We performed the Phillips–Perron (PP) unit root test on the series. As shown below in table 5, for both Nickel and Zinc, the logarithm values of FDI, price and production are stationary at first difference while the logarithm value reserves are stationary at level.

Table 6: Unit Root Test Results

Models	Zinc		Nickel		
Variables	p-value	Integration Order	Variables	p-value	Integration Order
lmfdi	0.0029	I(0)*	lmfdi	0.0029	I(0)*
lozprod	0.0019	I(1)***	lonprod	0.0010	I(1)*
lqzprod	0.0089	I(1)***	lqnprod	0.0007	I(1)*
lmzprod	0.0093	I(1)***	lmnprod	0.0028	(1)**
lzprice	0.0000	I(0)*	lnprice	0.0069	I(1)*

(*) = With Intercept
(**) = With Intercept and Trend
(***) = Without Intercept and Trend

From table 6 above, the I(0) variables are those stationary at levels while the I(1) variables are those stationary at first difference. This result satisfies the condition that the series should be stationary either at levels or at first difference to apply the ARDL modelling strategy.

4.3 Model and Estimation Procedures

We provide the specify model equations and discuss steps involved in the estimation of the specified equations.

4.3.1 Model Specification

Our objective is to examine if there is a relationship between mineral production and tax incentives, mineral reserves, and non-fossil foreign direct investment inflows through empirical co-integration analysis. Pesaran and Shin (1998) and Pesaran, Shin and Smith (2001) showed that the autoregressive distributed lag (ARDL) methodology remedies the technical pitfall arising from modelling variables of different order of integration. Therefore, using the ARDL Bound testing procedure we can estimate variables in different order of integration (i.e. I(0) and I(1) variables), to ascertain the presence of stable long-run relationships amongst the model variables. Compared to Engle and Granger (1987), Johansen (1991) and Johansen and Juselius (1990), the Pesaran et al (2001) proved that coefficients from the ARDL estimators are very consistent with small sample sizes as in our case with a short data span of 2005Q1 – 2020Q4. Also, given that the ARDL framework is devoid residual correlation, endogeneity issues are less of a concern, due to appropriate lag length selection (Menegaki, 2019).

Based on the standard neoclassical Cobb Douglas production function $Y_t = A_t K_t^{\alpha}$, where Y_t is real per capita output, A_t is productivity variable; and K_t is the capital series per worker; we develop in line with the literature a mineral production function, with the following general form:

$$Y_t^m = f(T, V_t) \qquad (1)$$

Where Y_t^m is mineral output, V_t is a vector of variable that could affect mineral output in each province. These include mineral investments flows, mineral tax policies, and the price of minerals, while T captures the dynamic (time) elements in the model. The Cobb Douglas production function has been widely applied in many theoretical and empirical works (i.e Murthy, 2002; Biddle, 2012; etc) despite its restrictive assumption that the elasticity of substitution between capital and labour is equal to unity.

From equation (1), and for estimation purpose, we specify the following equation:

$$Y_t^m = \alpha + \beta_1 Price_t^m + \beta_2 FDI_t^m + \beta_3 T_t^p + \mu_t \qquad (2)$$

Where Y_t^m is mineral output, $Price_t^m$ is the international price of each mineral, FDI_t^m is the non-fossil foreign direct investment flows into Canada, while T_t^p is the dummy variable calibrated to capture mining tax policy changes in the three provinces in focus. As indicated earlier, our focus is on two critical minerals, namely, Nickel and Zinc. α is the constant parameter, $\beta_1 - \beta_3$ are coefficients, while μ_t is the stochastic error term. Whereas β_1 and β_2 are expected to be positively signed, the sign for β_3 can be positive or negative, depending on the direction of mining tax changes. β_3 is expected to be positive if mining tax rate is being reviewed downward, impacting mineral production positively; and negative if it is an upward review in the tax rate, impacting profit after tax (by extension mineral output) negatively.

Equation (2) produces six (6) separate models, a pair of Nickel and Zinc models for each of the three (3) provinces. These can be written as follows:

$$OY_t^n = \alpha + \beta_1 Price_t^n + \beta_2 FDI_t^m + \beta_3 T_t^p + \mu_t \quad (3)$$

$$OY_t^z = \alpha + \beta_1 Price_t^z + \beta_2 FDI_t^m + \beta_3 T_t^p + \mu_t \quad (4)$$

$$QY_t^n = \alpha + \beta_1 Price_t^n + \beta_2 FDI_t^m + \beta_3 T_t^p + \mu_t \quad (5)$$

$$QY_t^z = \alpha + \beta_1 Price_t^z + \beta_2 FDI_t^m + \beta_3 T_t^p + \mu_t \quad (6)$$

$$MY_t^n = \alpha + \beta_1 Price_t^n + \beta_2 FDI_t^m + \beta_3 T_t^p + \mu_t \quad (7)$$

$$MY_t^z = \alpha + \beta_1 Price_t^z + \beta_2 FDI_t^m + \beta_3 T_t^p + \mu_t \quad (8)$$

Equations (3) and (4) represents Ontario's output equations for Nickel and Zinc, respectively; equations (5) and (6) are Quebec's output equations for Nickel and Zinc, respectively; and equations (7) and (8) are Manitoba's output equations for Nickel and Zinc, respectively. The autoregressive distributed lag (ARDL) model specifications for equations (3) to (8) are written in differenced logarithm form as follows in equations (9) to (14):

$$\Delta lnoy_t^n = \alpha + \sum_{i=1}^{p} \beta_1 \Delta lnoy_{t-i}^n + \sum_{i=1}^{p} \beta_2 ln\, Price_{t-i}^n + \sum_{i=1}^{p} \beta_3 \Delta lnFDI_{t-i}^m + \sum_{i=1}^{p} \beta_4 T_{t-i}^p + \lambda_1 lnoy_{t-1}^n + \lambda_2 lnPrice_{t-1}^n + \lambda_3 lnFDI_{t-1}^m + \lambda_4 lnT_{t-i}^p + \epsilon_t \quad (9)$$

$$\Delta lnoy_t^z = \alpha + \sum_{i=1}^{p} \beta_1 \Delta lnoy_{t-i}^z + \sum_{i=1}^{p} \beta_2 ln\, Price_{t-i}^z + \sum_{i=1}^{p} \beta_3 \Delta lnFDI_{t-i}^m + \sum_{i=1}^{p} \beta_4 T_{t-i}^p + \lambda_1 lnoy_{t-1}^z + \lambda_2 lnPrice_{t-1}^z + \lambda_3 lnFDI_{t-1}^m + \lambda_4 lnT_{t-i}^p + \epsilon_t \quad (10)$$

$$\Delta lnqy_t^n = \alpha + \sum_{i=1}^{p} \beta_1 \Delta lnqy_{t-i}^n + \sum_{i=1}^{p} \beta_2 ln\, Price_{t-i}^n + \sum_{i=1}^{p} \beta_3 \Delta lnFDI_{t-i}^m + \sum_{i=1}^{p} \beta_4 T_{t-i}^p + \lambda_1 lnqy_{t-1}^n + \lambda_2 lnPrice_{t-1}^n + \lambda_3 lnFDI_{t-1}^m + \lambda_4 lnT_{t-i}^p + \epsilon_t \quad (11)$$

$$\Delta lnqy_t^z = \alpha + \sum_{i=1}^{p} \beta_1 \Delta lnqy_{t-i}^z + \sum_{i=1}^{p} \beta_2 ln\, Price_{t-i}^z + \sum_{i=1}^{p} \beta_3 \Delta lnFDI_{t-i}^m + \sum_{i=1}^{p} \beta_4 T_{t-i}^p + \lambda_1 lnqy_{t-1}^z + \lambda_2 lnPrice_{t-1}^z + \lambda_3 lnFDI_{t-1}^m + \lambda_4 lnT_{t-i}^p + \epsilon_t \quad (12)$$

$$\Delta lnmy_t^n = \alpha + \sum_{i=1}^{p} \beta_1 \Delta lnmy_{t-i}^n + \sum_{i=1}^{p} \beta_2 ln\, Price_{t-i}^n + \sum_{i=1}^{p} \beta_3 \Delta lnFDI_{t-i}^m + \sum_{i=1}^{p} \beta_4 T_{t-i}^p + \lambda_1 lnmy_{t-1}^n + \lambda_2 lnPrice_{t-1}^n + \lambda_3 lnFDI_{t-1}^m + \lambda_4 lnT_{t-i}^p + \epsilon_t \quad (13)$$

$$\Delta lnmy_t^z = \alpha + \sum_{i=1}^{p} \beta_1 \Delta lnmy_{t-i}^z + \sum_{i=1}^{p} \beta_2 ln\, Price_{t-i}^z + \sum_{i=1}^{p} \beta_3 \Delta lnFDI_{t-i}^m + \sum_{i=1}^{p} \beta_4 T_{t-i}^p + \lambda_1 lnmy_{t-1}^z + \lambda_2 lnPrice_{t-1}^z + \lambda_3 lnFDI_{t-1}^m + \lambda_4 lnT_{t-i}^p + \epsilon_t \quad (14)$$

Where λ_1 - λ_4 denotes long run relationship between the variables, β_1 - β_4 corresponds to the short run dynamics of the model variables, and α and ϵ_t are the constant and Gaussian white noise elements, respectively.

4.3.2 Estimation Procedure

The ARDL bounds testing procedure is used to derive results for short-run and long-run dynamics of the models for Nickel and Zinc, respectively. First, equation (9) is estimated using ordinary least square (OLS) method and F-test will be performed to check for existence of long run relationships among the variables. The F-test's null hypothesis is that $H_0: \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0$, indicating that long run relation does not exist. The alternative hypothesis, on the other hand, is $H_0: \lambda_1 \neq 0;\ \lambda_2 \neq 0;\ \lambda_3 \neq 0;\ \lambda_4 \neq 0$.

To reach a decision, the calculated F-statistic is compared with the upper and lower critical values provided in Pesaran et al (2001). If the calculated F-statistic is bigger than upper critical value, we reject the null hypothesis of no co-integration, if it is below the lower critical value, we cannot reject the null hypothesis and if it lies between the two critical values, the result is deemed to be inconclusive. Second, we then estimate the long run relationship based on the selected ARDL model using the adjusted R^2 criterion. Third, we estimate the error correction model for each pair of Nickel and Zinc equations for Ontario, Quebec and Manitoba. The error correction model results produce an error correction term which measures the speed of adjustment back to equilibrium in the long run after a disturbance by a shock in the short run.

5.0 Empirical Results

We implemented the procedure outlined in section 4.3[1] presents and discuss the results of the ARDL bounds test and the long run ARDL estimates for the estimated Nickel and Zinc models, respectively.

5.1 Nickel Models

Results of the ARDL bounds test performed on the Nickel models is presented in table 7. The table reports the computed F-Statistic, significance levels, the critical values and cointegration decision for the Nickel models for Quebec, Ontario, and Manitoba. A comparison between each calculated F-Statistic and the critical values show that cointegration exist for the Quebec and Manitoba Nickel models while it does not for the Ontario Nickel model. The F-Statistic for the two models is greater than the upper bounds at 5% significance level. Thus, we established that equilibrium long run relationship exist between Nickel production, Nickel price, non-fossil foreign direct investments and mining tax policy in Quebec and Manitoba.

Table 7: Bounds Tests Results - Nickel Models

Models	F-Statistic	Sig. Level	Lower Bound [I(0)]	Upper Bound [I(1)]	Co-integration
Quebec	5.59	5%	3.79	4.85	Yes
Ontario	0.93	5%	3.79	4.85	No
Manitoba	7.82	5%	3.88	4.61	Yes

Conversely, given that the computed F-statistic for Ontario Nickel model is lower than both lower and upper bounds, we conclude that there is no cointegration amongst the model variables. The result for Ontario suggests that the Ontario mining CIT reduction of 2009 may not have impacted Nickel production.

Results of the long run ARDL estimation for Nickel is presented in table 8 below. The error correction terms for the three Nickel models are correctly signed and

[1] Eviews 12 package was used to implement all empirical analysis.

statistically significant; a confirmatory indication of the existence of long run relationship amongst the Quebec and Manitoba's model variables. The same conclusion cannot be reached for the Ontario model since it fails bounds test earlier, and its error correction term's significance level is weak compared to other models.

Table 8: Nickel Models - Long run ARDL Estimates

Models/Variables	Coefficient	t-statistic	P-values
Quebec			
D(LQNPROD(-1))	0.583649	5.226241	0.0000
D(LMFDI)	0.141932	4.669847	0.0001
D(LNPRICE)	0.101764	1.843856	0.0721
QTPD	-0.006193	-0.482371	0.6320
ECM(-1)	-0.108664	-4.192125	0.0001
Ontario			
D(LONPROD(-1))	0.606865	3.221214	0.0045
D(LNPRICE(-4))	0.744835	2.384499	0.0277
D(LMFDI)	0.586511	2.533243	0.0203
OTPD	0.044544	0.592733	0.5603
ECM(-1)	-0.255020	-2.375290	0.0282
Manitoba			
D(LMNPROD(-1))	0.468814	3.764344	0.0008
D(LNPRICE(-5))	0.229422	4.379196	0.0002
D(LMFDI(-4))	0.200161	7.342613	0.0000
MTPD	0.033886	3.406555	0.0021
ECM(-1)	-0.446162	-5.895157	0.0000

The speed of adjustment to long run equilibrium sequel to a short run disequilibrium is obtained as 10 percent for Quebec, 25 percent for Ontario and 45 percent for Manitoba. The tax policy dummy in the Manitoba Nickel model may have contributed to the high level of equilibrium recovery following a shock. In addition, tax policy dummy for Manitoba is shown to impact Nickel production positively, such that a percentage point decrease in Manitoba's mining tax rate boosts Manitoba's Nickel output by 3 percentage points. Tax policy dummies are not significant in the Quebec and Ontario Nickel models, but the impact of the past one period (one period lag) Nickel production is significant on current production in all three provinces. Next to Nickel output's autoregressive component, current mineral foreign direct investment influences Quebec's Nickel production the most, with a percentage increase in it boosting Nickel production by 14 percentage points. Both Nickel price and tax policy dummy are not statistically significant for Quebec's Nickel production.

In the Ontario model, past four period Nickel price and current mineral foreign direct investment are significant drivers of Nickel output, with a percentage point increase in each yielding 74 and 58 percentage points increase in Nickel output, respectively. Manitoba presents the best model outcomes. All variables are statistically significant; with a percentage point rise in Nickel price from past five periods and mineral foreign direct investment from past four periods leading to 23 and 20 percentage points increase in Manitoba's Nickel output.

5.2 Zinc Models

Results of the ARDL bounds test for Zinc models is presented in table 9. It shows the computed F-Statistic, significance levels, the bounds and cointegration decision for the Zinc models for Quebec, Ontario and Manitoba. Comparing the calculated F-Statistic with the bounds test critical values show that cointegration exist amongst model variables for all three Zinc models. The calculated F-Statistic of 13.92, 4.94 and 17.44 are higher than the upper bound of the critical values of 5.82, 4.61 and 4.61, respectively for Quebec, Ontario and Manitoba at 5% significance levels.

Table 9: Bounds Tests Results - Zinc Models

Models	F-Statistic	Sig. Level	Lower Bound [I(0)]	Upper Bound [I(1)]	Co-integration
Quebec	13.92	5%	4.87	5.82	Yes
Ontario	4.94	5%	3.88	4.61	Yes
Manitoba	17.44	5%	3.88	4.61	Yes

Thus, we established that equilibrium long run relationship exist between Zinc production, Zinc price, non-fossil foreign direct investments and mining tax policy in Quebec, Ontario and Manitoba.

Results of the long run ARDL estimation for Zinc is presented in table 10 below. The error correction terms for the three Zinc models are correctly signed and are strongly statistically significant. This is a confirmation of the earlier bounds testing results which indicates cointegration amongst the variables in the Quebec, Ontario and Manitoba's Zinc models.

Table 10: Zinc Models - Long run ARDL Estimates

Models/Variables	Coefficient	t-statistic	P-values
Quebec			
D(LQZPROD (-1))	0.437062	3.816255	0.0006
D(LMFDI(-4))	0.185973	3.700623	0.0008
D(LZPRICE (-5))	0.254636	1.922884	0.0637
QTPD	0.058022	3.153306	0.0036
ECM(-1)	-0.205047	-6.668842	0.0000
Ontario			
D(LOZPROD(-1))	0.437788	3.788632	0.0005
D(LZPRICE(-4))	-0.537773	3.384413	0.0016
D(LMFDI)	-0.033537	-2.273569	0.0283
OTPD	0.004219	0.236474	0.8143
ECM(-1)	-0.175196	-4.611661	0.0000
Manitoba			
D(LMZPROD(-1))	0.518835	5.290293	0.0000
D(LZPRICE)	0.736632	6.242969	0.0000
D(LMFDI(-3))	-0.255572	-5.159555	0.0000
MTPD	0.019831	1.374156	0.1821
ECM(-1)	-0.678417	-8.857628	0.0000

The size of the error correction terms for Quebec and Ontario indicates that only about 21 and 16 percent of disequilibrium is corrected for in the long run, respectively. This suggests slower speeds of adjustment; compared Manitoba where over 67 percent system disequilibrium is corrected for in the long run.

Tax policy dummy variables are not statistically significant in the Ontario and Manitoba Zinc models. For Quebec, the tax policy dummy is significant, but its sign is counter-intuitive given that the mining tax increase from 12% to 16% should ceteris paribus, should impact Quebec's Zinc output negatively. The tax policy parameter is positive, suggesting tax raise improved production. Two possible explanations may suffice; first, it is possible that the profit margins were so high on account of high Zinc prices that the Zinc producers in Quebec did not worry about the tax raise; and second, it is also possible that the staggering of the mining tax increase over two budget cycles helped Quebec Zinc producers absorb the shock well.

For Quebec, five past period Zinc price drove current Zinc output the most, with a percentage point increase in it accounting for 25 percentage points rise in Zinc output. Four past period mineral foreign direct investment is next as a percentage point increase in it elicited a 19 percentage points increase in Quebec's Zinc output. In the Ontario's Zinc model, the price and investment variables are significant, but they are negatively signed, which is out of tune with economic intuition. Current Zinc price predominates in Manitoba as a most important driver of Zinc output in the model. A percentage point increase in current price elicited a 74 percentage points increase in Manitoba's Zinc output.

6.0 Conclusion

The study examined the effect of tax policy on critical minerals production in Quebec, Ontario and Manitoba. Data suggests evidence of a tightening global market conditions for critical minerals. In addition, the ongoing energy transition and the current energy security challenge in many continents is forecast to continue to drive demand to unprecedented levels. Widening supply gaps further amplify mineral price acceleration, creating both opportunities and challenges for Canada. Thus, it has become imperative for Canada to improve critical minerals supply chain.

We narrowed our focus on two key critical elements contained on the list of minerals identified by the government of Canada as strategic to Canada's economic interests, namely, Nickel and Zinc. Ontario leads Canada in Nickel production, while New Brunswick used to be by far Canada's leader in Zinc production, but the significant fall in demand from foreign trade partners reversed the fortune. New Brunswick on the average still leads Canada, but Quebec is doing much better than any other province currently. Opinion poll results indicate a high appetite for Canada's critical mineral mining based on high sustainability standard and to diminish China's dominance in the space.

Based on extant literature, we employ the autoregressive distributed lag (ARDL) model to estimate models for Nickel and Zinc in Quebec, Ontario and Manitoba. We aimed to ascertain the extent to which tax policy impact Nickel and Zinc production, in addition to other determinant variables. Our results show that cointegration exist between Nickel output and its determinant variables, including Nickel price, non-fossil mineral foreign direct investments and tax policy dummy for Quebec and Manitoba. However, no cointegration is found between Nickel output and its determinants in the case of Ontario. Conversely, we found cointegration between Zinc output and the determinants for Quebec, Ontario and Manitoba.

The effect of mining tax policy is most discernible for Nickel production in Manitoba, as a percentage point lowering of mining tax rate elicits a 3 percentage points rise in Nickel output. Tax policy dummies are not significant for Quebec and Ontario's Nickel production, but Nickel price and non-fossil foreign direct investments are prime for Ontario and Manitoba, while only non-fossil foreign direct investments matter for Quebec.

Zinc output in Quebec is significantly impacted by Zinc price and non-fossil foreign direct investments; while gradual upward raise in Quebec's mining tax rate curiously coincided with improvement in Zinc output. It is possible that post-recession growth momentum in Quebec's mineral industry overshadowed operators' sensitivity to the tax hike. Current Zinc price predominates in Manitoba as a most important driver of Zinc output in the model.

Our conclusion and the key point for policy is that, in mineral taxation, "one size may not fit all". Mineral tax policy prescriptions should consider factors peculiar to the sector, the mineral, individual mines, mineral price dynamics and province endowments, amongst others. For example, Manitoba's Nickel production seemed to have benefitted from the 2010 mining tax rate cut, while in the case of Quebec, a staggered rate increase appeared not to have deterred growth in the Zinc sub-sector. The priority on boosting critical mineral supply chain should be sustained and adequately funded, with strategic initiatives to attract new prospectors and investors while the support for existing mining businesses is well sustained.

To boost critical mineral supply chain in Canada, we recommend that the federal government reduce corporate income tax rate for businesses in the critical mineral mining space. In addition, the Canadian federal government can coordinate a mineral friendly inter-provincial tax policy orientation across Canada. Canadian provinces should set mineral tax policy rate in a way that ensures their jurisdictions remain competitive in North America and globally. Also, critical mineral supply chain in Canada should be enhanced to establish a “one-stop-shop” for global critical mineral needs. Lastly, we recommend that Canada sustains international cooperation on advanced geological survey systems for detecting mineral reserves. The scope for further works in this area is ample as more data become available.

References

Biddle, J., 2012. Retrospectives: The introduction of the Cobb-Douglas regression. Journal of Economic Perspectives, 26(2), pp.223-36.

Boadway, R. and Keen, M., 2010. Theoretical perspectives on resource tax design. In The taxation of petroleum and minerals (pp. 29-90). Routledge.

Canadian Energy Regulator. 2021. 'CER – Canada's Energy Future 2021 - Key Findings'. https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/key-findings.html.

Church, Clare, and Alec Crawford. 2018. 'Conflict Minerals: The Fuels of Conflict', no. August: 47. https://www.iisd.org/publications/green-conflict-minerals-fuels-conflict-transition-low-carbon-economy.

Clark, Colin. 1976. "Keynes on taxation." Quadrant 20, no. 6 (1976): 15-17.

Engle, R.F. and Granger, C.W., 1987. Co-integration and error correction: representation, estimation, and testing. Econometrica: journal of the Econometric Society, pp.251-276.

Fölster, S. and Henrekson, M., 2001. Growth effects of government expenditure and taxation in rich countries. European economic review, 45(8), pp.1501-1520.

Ghebremichael. A and Potter-Witter, K. 2009. Effects of tax incentives on long run capital formation and total factor productivity growth in the Canadian Sawmilling industry. Forest Policy and Economics. 11(2), 85 – 94. http://doi.org/1016/j.forpol.2008.09.004

Govind Bhutada. 2021. 'The Raw Material Needs of Energy Technologies'. 2021. https://elements.visualcapitalist.com/the-raw-material-needs-of-energy-technologies/.

https://pm.gc.ca/en/news/news-releases/2022/03/29/delivering-clean-air-and-strong-economy-canadians

https://www.areadevelopment.com/canada-investment-guide/locationcanada2009/ontario-cuts-corporate-income-tax897756.shtml

https://www.canada.ca/en/campaign/critical-minerals-in-canada/canadas-critical-minerals-strategy.html

https://www.gov.mb.ca/iem/mines/incentives/tax.html

https://www.gov.mb.ca/iem/mines/incentives/tax.html#pmtr

https://www.greencarcongress.com/2022/04/20220408-canada-cm.html

https://www.iea.org/reports/global-ev-outlook-2020

https://www.miningtaxcanada.com/pdfs/Measures%20Concerning%20Businesses.pdf

https://www.miningtaxcanada.com/provincial-mining-taxes/

https://www.nrcan.gc.ca/mining-materials/exploration/8294. 2012

https://www.nrcan.gc.ca/mining-materials/mining/taxation/mining-taxation-canada/overview-main-tax-instruments/tables-on-the-structure-and-rates-main-taxes/24269

https://www.rechargenews.com/energy-transition/critical-shortfall-metals-industry-warns-supply-crunch-threatens-europes-green-plans/2-1-1207124

International Energy Association. 2021. The Role of Critical in Minerals in Clean Energy Transitions. World Energy Outlook Special Report.

Johansen, S. and Juselius, K., 1990. Maximum likelihood estimation and inference on cointegration—with appucations to the demand for money. Oxford Bulletin of Economics and statistics, 52(2), pp.169-210.

Johansen, S., 1991. Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. Econometrica: journal of the Econometric Society, pp.1551-1580.

Liesbet Gregoir. 2022. 'Metals for Clean Energy : Pathways to Solving Europe's Raw Materials Challenge'. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://eurometaux.eu/media/20ad5yza/2022-policymaker-summary-report-final.pdf.

Mankiw, N.G., Weinzierl, M. and Yagan, D., 2009. Optimal taxation in theory and practice. Journal of Economic Perspectives, 23(4), pp.147-74.

Menegaki, A.N., 2019. The ARDL method in the energy-growth nexus field; best implementation strategies. Economies, 7(4), p.105.

Mintz, J. and Chen, D., 2012. Capturing economic rents from resources through royalties and taxes. SPP research paper, (12-30).

Murthy, K.V., 2002. Arguing a case for Cobb-Douglas production function. Review of Commerce Studies, 20, p.21.

Pesaran, H.H. and Shin, Y., 1998. Generalized impulse response analysis in linear multivariate models. Economics letters, 58(1), pp.17-29.

Pesaran, M.H., Shin, Y. and Smith, R.J., 2001. Bounds testing approaches to the analysis of level relationships. Journal of applied econometrics, 16(3), pp.289-326.

Romer, P.M., 1994. The origins of endogenous growth. Journal of Economic perspectives, 8(1), pp.3-22.

Solow, R. M. 1957. Technical Change and the Aggregate Production Function. Review of Economics and Statistics 39: 312-20

The Mining Association of Canada. 2022. The State of Canada's Mining Industry: Facts and Figures.

Appendix A

Federal Incentives
Flow-Through Shares (FTS) Flow-through shares are common shares issued by corporations to finance the exploration and development of resource properties. Resource expenses financed with the funds raised by issuing flow-through shares are allocated to and treated as expenses incurred by the initial shareholder. The allocated expenses are fully deductible by the shareholder in computing income. The corporation relinquishes the deduction associated with the expense in consideration of the subscription proceeds for the shares. Because the shareholder can fully deduct the cost of the share in computing income, the tax cost of the share is deemed to be nil, and any proceeds realized on a subsequent disposition are typically treated as capital gains. By issuing flow-through shares, a corporation can "flow through" certain expenses to the shareholder. The expenses are considered to have been incurred by the shareholder (investor), not the corporation, which can lower the investor's taxable income. The benefits of a flow-through share to an investor can be realized in two ways: (a) 100% tax deduction for the amount they invested in the shares, and (b) 15% tax credit on eligible expenses. The shareholders' investment could appreciate if the exploration is successful. FTS-issuing corporations do not have to be Canadian, but they must be Canadian taxpayers that incur the expenses in Canada on qualified activities. This is a deduction earned by a publicly listed company against taxable income. The Canada Income Tax Act in section 66(15) provides that an investor can claim a CEE or CDE or a CRCE (Canadian Renewable Energy and Conservation expense) deduction earned by a publicly listed company against their taxable income. However, the expenses must be reduced by any provincial or federal assistance received and, in that flow-through shares have a zero adjusted cost base, when the share is sold the entire income from the sale is subject to capital gains tax. Budget 2022 introduced a new 30 per cent Critical Mineral Exploration Tax Credit for specified mineral exploration expenses incurred in Canada and renounced to flow-through share investors. The tax credit would apply to certain exploration expenditures targeted at nickel, lithium, cobalt, graphite, copper, rare earths elements, vanadium, tellurium, gallium, scandium, titanium, magnesium, zinc, platinum group metals, or uranium, and renounced as part of a flow-through share agreement entered after Budget Day and on or before March 31, 2027. **Canadian Exploration Expenses (CEE)** Section 66.1(6) of the Federal Income Tax Act provides for a deduction of 100% of eligible exploration expenses and those incurred in determining the existence, location, extent, or quality of a mineral resource in Canada against taxable income. Eligible CEE expenses include grassroots exploration expenses. CEEs are 100% deductible in the year in which they occur. Taxpayers can carry unused balances forward indefinitely or transfer them to flow-through-share investors. The deduction for pre-production development expenses, as defined in sub-section 66.1(6)(g) no longer receives CEE treatment but instead receives Canadian Development Expense (CDE) treatment, which is a deduction of 30% of expenses on a declining balance basis. 100% CEE deduction for community consultation and environmental expenses undertaken for exploration permit.

Canadian Exploration Expense (CEE) eligibility extension

The Canada Revenue Agency (CRA), on January 24, 2017 released administrative guidelines confirming that community consultation and environmental expenses undertaken to obtain an exploration permit are eligible for the 100% CEE deduction. That was in response to some of the changes made to Tax Act in 2016. The changes allowed for some expenditures on environmental studies and community consultation to be included as CEE. Further guidance on the interpretation of expenses incurred in relation to community consultation and environmental studies, were provided by the CRA in 2018. They treated eligibility of expenditures in relation to capacity payments, on-going consultation expenditures during exploration, and legal documentation expenses on engagement and consultation with an Indigenous community, as well as environmental assessment expenses. A comprehensive range of CRA's guidelines and interpretations on CEE applications are contained in AME Members Guide to Canadian Exploration Expenses (CEE).

The Mineral Exploration Tax Credit (METC)

METC is a time-limited 15% tax credit, linked to flow-through shares, that can be claimed on a more limited part of grassroots expenses, for exploration conducted "from or above the surface of the earth" as defined in section 127(9) of the Income Tax Act as "flow-through mining expenditures". It was introduced to assist exploration companies raise equity funds in addition to the regular tax deduction associated with flow-through-share investments. The 2018 Fall Economic Statement extended the METC for five years, until March 31, 2024. The credit can be claimed in addition to the CEE deduction, but the expenses for CEE must be reduced by any provincial or federal assistance and the tax credit applied to the reduced amount. In addition, the tax credit must be taken into income in the following year.

Prospector's and Grubstaker's Shares Deduction

This is a tax deduction of 50% from income of the value of shares received from a corporation after disposition of a right or a mining property. This provision, as defined in sub-section 110(1) (d.2) of the Income Tax Act, allows a deduction from income of 50% of the value of shares, received and included as income, for that year.

The Critical Mineral Exploration Tax Credit (CMETC)

The CMETC was introduced in the 2022 Federal Budget. It is a new 30 percent credit for specified mineral exploration expenses incurred in Canada and renounced to flow-through share investors. The qualifying exploration expenditures that can benefit from the credit include those for critical minerals, including nickel, lithium, cobalt, graphite, copper, rare earths elements, vanadium, tellurium, gallium, scandium, titanium, magnesium, zinc, platinum group metals, and uranium. It is renounced as part of flow-through share agreement entered after Budget Day 2022 and on or before March 31, 2027. The CMETC does not apply to development or post-production expenses. It is intended to serve as an enhanced alternative to the METC and not a supplementary tax credit. In essence, a taxpayer will potentially be eligible to claim the CMETC or the METC, but not both credits.

Canadian Development Expense (CDE)

These are expenses incurred on (a) sinking or excavating a mine shaft, main haulage way, or similar underground work for a mine in Canada built or excavated after the mine came into production; (b) the cost of any Canadian mineral property, and (c) pre-production mine development expenses (after 2017). Section 66.1(6) of the Income Tax Act permits CDEs deductions at a 30% declining balance. Balances that are not claimed in any year can be carried forward indefinitely or transferred to flow-through-share investors (excluding the cost of any Canadian mineral property).

Accelerated Capital Cost Allowances (ACCA)
The ACCA allowed the taxpayer in certain situations to deduct up to 100% of the asset cost, in addition to the normal 25% CCA. Budget 2013 phased out the ACCA for mining over 2017-2020.

Foreign Resource Expense (FRE)
Canadian mining companies that incur exploration and development expenses abroad can claim the Foreign Resource Expense (FRE) on a country-by-country basis for income tax purposes. The basic FRE deduction for each country is between 10% and 30% of the cumulative FRE balance for that country, with the upper limit restricted to the amount of available foreign resource income for that country. However, an additional FRE deduction may be allowed if the country limitation results in a global FRE claim of less than 30%.

Appendix B

Jurisdiction	Innovation/ Training	Exploration	Development	Processing
Alberta[2]	**Alberta Innovates Clean Resource Continuous Intake Program** • **Grant**: Alberta Innovates provides funding support up to $1.8 million to a resource and technology company developing a lithium project in Alberta. The project is Alberta's First Direct Lithium Extraction Pilot. Alberta Innovates also provides grant of $100,000 for a project on Ion-Exchange Extraction of Lithium from Petro-Brines in Alberta.	None	None	None

[2]Alberta has a few existing programs under Alberta's Recovery plan to attract investment into the province, however none of these programs are specifically designed for mineral exploration and development. These include Alberta Indigenous Opportunities Corporation (AIOC), Indigenous Litigation Fund, Aboriginal Business Investment Fund, Innovation Employment Grant, The Alberta Export Expansion Program (AEEP) and others.

Jurisdiction	Innovation/ Training	Exploration	Development	Processing
British Columbia	None	**Mining Exploration Tax Credit (BC METC)** • **Tax Credit**: The credit is calculated as 20% of qualified mining exploration expenses less the amount of any assistance received or receivable. • Enhanced rate of 30% available for qualified mineral exploration undertaken in prescribed Mountain Pine Beetle affected areas. **B.C. Mining Flow-Through Share Tax Credit (MFTS)** • **Tax Credit**: a non-refundable tax credit of 20% of B.C. flow-through mining exploration expenditures.	None	None

Saskatchewan	**Saskatchewan Advantage Innovation Fund** • **Grant:** R&D funding up to 30% of project budget to accelerate commercialization of new mining technologies. **Tax Credit for Research** • 10% provincial income tax credit for scientific research and development expenditures. **Potash Production Incentives** • A 40% tax credit for innovation to improve production efficiency, mitigate environmental impacts, and lower risks or develop new/improved products.	**Targeted Mineral Exploration Incentive (TMEI)** • **Rebate**: 25% rebate on drilling costs ($50,000 maximum) in a region of high potential for base metals, precious metals and diamonds. **Saskatchewan Mineral Exploration Tax Credit (SMETC)** • **Tax Credit:** offers a non-refundable 10% mineral exploration tax credit to Saskatchewan taxpayers who invest in eligible flow-through shares (FTS) issued by mining or exploration companies. **Fuel Tax Rebate For Mineral Exploration** • **Rebate:** on fuel used in unlicensed machinery and equipment in pre-production activities in mineral exploring or prospecting.	**Base and Precious Minerals Production Incentives** • **Royalty**: 10-year royalty holiday for base and precious metals produced in the province. • All allocated pre-production expenses of a producer are recognized at 150%. **Potash Production Incentives** • A 10-year holiday from the base payment portion of the Potash Production Tax for production from approved expansions and new potash mines. **Sodium Sulphate Incentive** • 10% expenditure claim on (eligible) projects that diversify products or improve operating efficiency in	**Mineral Processing Tax Incentive** • **Tax:** 5-year corporate tax rebate for mineral processing that maintains minimum capital investment of $125 million and employment of 75 full-time employees in the province.

Jurisdiction	Innovation/ Training	Exploration	Development	Processing
			the current year. **Diamond Production Incentives** • A 5-year holiday from the basic portion of the Crown royalty. • A processing allowance deduction equal to 8% of the original costs of the processing capital, up to 65% of net revenue.	

Quebec	None	**Flow-Through Share**
		• **Tax Deduction**: a deduction of 100% of the cost of flow-through shares.
		• **Additional deductions**
		  ○ 10% mineral exploration costs incurred in Quebec.
		  ○ 10% surface mineral exploration cost incurred in Quebec.
		  ○ Issuing cost of 20% per annum for 5 years.
		
		Mining Tax Regime exploration provisions
		• **Tax Credit Amendments**: amendment of the calculations related to exploration expenses and consultation to introduce allowances.
		• Provisions include the total of: (1) the operator's exploration expenses incurred after March 30, 2010, and (2)
			Tax Credit relating to resources
			• Tax Credit:
			  ○ 28% of exploration expenses incurred by non-operating corporations.
			  ○ 12% for corporations operating a mineral resource.
			  ○ 18.75% of expenses incurred in the North of Quebec.
			
			Venture Capital for Mineral Exploration and Development
			• Grant:
			  ○ Financing of up to $200,000 per company (100,000 for exploration and $100,000 in working capital).
			  ○ Investments of $5 million to $20 million in Québec companies in the natural resources sector in the
				Investment Tax Credit
				• **Tax Credit:** ranging from 4% to 32% for mineral manufacturing and processing equipment.

		25% of the above exploration expenses that were incurred in Northern Quebec by the operator, and for which the refundable tax credit relating to resources could not be claimed. **Expanded eligibility of exploration expenses** • **Grant**: to cover certain community consultation and environmental expenses.	development stage. ○ A total capitalization of $1.2 billion in non-renewable natural resources. ○ Funding to aboriginal exploration groups. **Investment and Innovation Tax Credit** 2020 Budget introduced the Tax Credit for Investment and Innovation or C3i for short. The credit is not restricted by sector; thus, mineral sector players can access it. Those with assets and gross income exceeding $100 million are instead eligible for a non-refundable tax credit. The location dependent tax credit applies as follows: (i) Montreal and Quebec – original credit of 10% and bonified credit of 20%; (ii) Other territories - original credit of 15% and bonified credit of 30%; and (iii) Regions with low eco. vitality index - Original	

Jurisdiction	Innovation/ Training	Exploration	Development	Processing
			credit of 20% and bonified credit of 40%	

Ontario	**Innovation and Junior Exploration Support** • $29 million to support junior exploration companies and a critical minerals innovation fund.	**Flow-through Share Tax Credits** • **Tax Credit**: a refundable tax credit of 5% of eligible Ontario exploration expenses. **Prospector Grants** • **Grant**: The Ontario Exploration Corporation (OEC) offers grants of up to $85,000 to qualified prospectors with properties with high economic potential. **Ontario Junior Exploration Program** • $200,000 per project to cover 50% of eligible costs • $10,000 to cover 100% of eligible costs per project supporting Indigenous employment and business opportunities **Aboriginal Participation Fund** • **Grant**: supports Aboriginal consultation capacity, education and relationship-	**Investment in Critical Minerals** • Investing $250,000 to support critical mineral, battery and EV supply chains in North America **Tax Exemption** • Up to $10 million of profit during an exempt period is available for each new mine. The exempt period for a non-remote mine is 3 years, and the exempt period for a remote mine is 10 years. • The exemption also available for a major expansion of an existing non-remote mine.	None

Jurisdiction	Innovation/ Training	Exploration	Development	Processing
		building (exploration and development phase).		

Manitoba[3]	None	**Manitoba Mineral Exploration Tax Credit (MMETC)** • **Tax Credit**: a 30% non-refundable personal income tax credit for Manitoba residents investing in flow-through shares of qualifying mineral. **Mineral Exploration Assistance Program (MEAP)** • **Grant:** of up to 25% of approved eligible expenditures (maximum of $200,000 per recipient per fiscal year). **Manitoba Prospectors Assistance Program (MPAP)** • **Grant**: up to 50% of approved eligible costs, to a maximum of $10,000 per fiscal year. **Manitoba Mineral Exploration Tax Credit (METC)** • Flow-through shares tax payer investors	**New Mine Tax Holiday** • **Royalty**: Mining tax holiday until profit equals capital outlays for new mines. **Investment Tax Credit (1994-2003)** • **Royalty**: Credit of 7% of investments deductible to a maximum of 30% of mining tax payable.	**Processing Allowance** • **Royalty:** 20% processing allowance for new mines or major expansions. **Investment Tax Credit (1994-2003)** • **Royalty:** Credit of 7% of investments deductible to a maximum of 30% of mining tax payable.

Jurisdiction	Innovation/ Training	Exploration	Development	Processing
		can claim 30% of qualifying investments. **Off-site Exploration Allowance** • Mining companies that increase exploration activities in search of new mines are entitled to a deduction equal to 150% of exploration expenditures.		

[3] The government of Manitoba is currently undertaking a review of its mineral exploration incentive programs so except the MMETC all other incentive programs are currently on hold.

Jurisdiction	Innovation/ Training	Exploration	Development	Processing
Newfoundland	**Prospector Training Course** • **Training**: a 14-day training course as part of the Prospectors Assistance Program.	**Junior Mining Exploration Assistance Program (JEA)** • **Grant**: Support of 40 – 75% of approved exploration costs, to a maximum of $150,000 per project on the island of Newfoundland and $225,000 for Labrador-based projects. **Prospecting Assistance Grants** • **Grant**: Up to $6,000 for traditional and grass-roots prospecting. • Maximum of $6,000 available for air (float plane or helicopter) support to access remote properties. • Maximum of $12,000.00 may be available for projects considered to be at an "advanced" stage,	None	None

Nova Scotia[4]	**Innovation Grants** • **Grant**: Maximum of $100K for innovations on minerals. **Research Grants** • **Grant**: Maximum $90K for research and university- or college-based research. **Education, Outreach and Engagement Grants** • **Grant**: Maximum $50K to educate and build public confidence/awareness in the mineral industry. **Marketing Grants** • **Grant**: to promote mineral properties at trade shows and mining events.	**Shared Funding Exploration Grants** • **Grant**: o $40,000 in a mineral exploration program. o Grant will match or partially match the applicant's exploration investments and will provide awards between $40,000 and $100,000 for eligible expenses. **Major Project Grants** • **Grant**: $500K or higher if required for regional surveys on exploration targets. **Prospecting Grants** • **Grant**: Up to $40,000 for grass-roots exploration activities. • Additional funding of up to $5,000 avilable to support post-secondary students employment.	**Nova Scotia Mineral Resources Development Fund (MRDF)** • **Grant** o The Fund is designed to assist prospectors, exploration companies, and researchers, employ post-secondary students, and support projects in the mining sector that attract investment and grow Nova Scotia's economy and create jobs, especially in rural areas.	None

Jurisdiction	Innovation/ Training	Exploration	Development	Processing
New Brunswick	**Prospector Promotion** • **Grant**: Offer sponsorships for prospectors attending either the Cordilleran Roundup in Vancouver or the Prospectors and Developers Association Conference in Toronto.	**Junior Mining Assistance Program (NBJMAP)** • **Grant**: up to 50% of project costs to a maximum of $100,000 per project per year for companies with no self-sustained cash flow. **Prospector Assistance Program (NBPAP)** • **Grant**: a maximum of $15,000 to eligible prospectors. **New Brunswick Exploration Tax Deduction** • **Tax Deduction**: a deduction of 150% of eligible New Brunswick exploration expenses.	None	None
Nunavut	None	**Nunavut Prospector's Program (NPP)** • **Grant**: a contribution of up to $8K per year to cover basic exploration expenses.	None	None

[4] All programs are under the Nova Scotia Mineral Resources Development Fund (MRDF). MRDF is designed to assist prospectors, exploration companies, and researchers in the search for new discoveries and to advance projects closer to production.

Jurisdiction	Innovation/ Training	Exploration	Development	Processing
North West Territories	None	**Mining Incentive Program (MIP)** • **Grant**: o Corporate Mining Incentive Program: for up to $240K (60% of eligible expenses). o Prospectus can apply for up to $25,000.	None	None

Jurisdiction	Innovation/ Training	Exploration	Development	Processing
Yukon	None	**The Yukon Mineral Exploration Program (YMEP)** • **Rebate:** ○ Hardrock Modules - Grassroots Prospecting: up to $15,000 per year. - Focused Regional: of up to $25K per year. - Target Evaluation: up to $50K per year. ○ Placer Module: The program reimburses up to 50% of approved expenses to a maximum of $40,000 per year.	None	None

Federal	**Geoscientific research in Canada's North:** • A continuation of the $200M Geo-Mapping for Energy and Minerals (GEM) program. • Support sustainable mineral development, environmental assessments or land-use decisions in the North. **Targeted Geoscience Initiative** • **Funding**: $22M funding to non-profit organizations, academia, Indigenous groups, and provincial or territorial governments or agencies to generate geoscience knowledge of Canada's economic minerals. **Clean Growth Sectors Program** **Funding**: $155M funding for Clean Growth in Natural Resource Sectors Innovation Program which provides support (till March 31, 2028) for clean technology research and development (R&D), and demonstration projects in Canada's energy, mining, and forest sectors.	**Flow-Through Shares (FTS)** • **Tax Deduction**: a deduction earned by a publicly listed company against taxable income. **Canadian Exploration Expenses (CEE)** • **Tax Deduction**: deduction of 100% of eligible exploration expenses against taxable income. **Canadian Exploration Expense (CEE) eligibility extension** • **Tax Deduction**: 100% CEE deduction for community consultation and environmental expenses undertaken for exploration permit. **The Mineral Exploration Tax Credit (METC)** • **Tax Credit**: a temporary 15% tax credit for exploration conducted from the surface or above the	**Canadian Development Expense (CDE)** • **Tax Deduction**: a deduction at a 30% declining balance for cost of Canadian mineral property, mine development expenses, sinking or excavation. **Capital Cost Allowances (CCA)** • **Tax Credit**: a depreciation rate of 25% on a declining balance basis. **Accelerated Capital Cost Allowances** • **Tax Credit**: Could provide for a depreciation allowance of up to 100% of the asset cost (2013 – 2016). **Foreign Resource Expense (FRE)** • **Tax Credit**: a deduction of 10% to 30% of the cumulative balance for Canadian mining companies that incur exploration	**Supply Chain Improvement** • **Funding**: $1.5 billion over 7 years to support critical minerals supply chain.

	Low Carbon Economy Leadership Fund • **Funding**: $1.4 B funding to provinces and territories who have adopted the Pan-Canadian Framework on Clean Growth and Climate Change. **Strategic Innovation Fund** • **Funding**: $100M funding over four years to help the Clean Resource Innovation Network to accelerate the development and adoption of innovative technologies and processes to lower the oil and gas industry’s environmental impacts. **Industrial Research Assistance Program** • **Funding**: $250M to assist Canadian small- and medium-sized enterprises to support research and development hiring. **Strategic Innovation Fund** • **Funding**: $1.5 billion over 7 years to be managed by Innovation, Science and Economic Development Canada.	surface of the earth. **Prospector’s and Grubstaker’s Shares Deduction** • **Tax Deduction**: a deduction from income of 50% of the value of shares. **The Critical Mineral Exploration Tax Credit (CMETC)**: **Tax Credit**: A 30% tax credit entitled to by flow-through share investors. **Integrated Data Access** • **Funding**: $79.2M for NRCAN to facilitate access to integrated data on critical mineral exploration and development.	and development expenses abroad. • **Funding**: $103.4 million to NRCAN for the development of a National Benefits-Sharing Framework for natural resources and expansion of the Indigenous Partnership Office and the Indigenous Natural Resource Partnerships program • **Funding**: $10.6 million to NRCAN to renew the Centre of Excellence on Critical Minerals, provide direct assistance to developers of critical minerals to navigate regulatory processes and existing support measures.	

Jurisdiction	Innovation/ Training	Exploration	Development	Processing
	Research, development, and deployment • **Funding**: $144.4 million over 5 years critical minerals value-chain. Managed by Natural Resources Canada (NRCAN) and the National Research Council (NRC). **Critical Minerals Research, Development and Demonstration Program** • **Funding:** $11 million for pilot plants and projects to support the development of critical mineral value chains. It is part of the $47M funding initiative announced in Budget 2021 for federal research and development to advance critical battery mineral processing and refining expertise.		• **Funding**: $40 million to Crown-Indigenous Relations and Northern Affairs Canada to support northern regulatory processes. • **Funding**: $70 million to NRCAN to advance Canada's global leadership on critical minerals, in particular to meet its responsibilities under the Extractive Sector Transparency Measures Act.	