UNIVERSITY OF CALGARY

An Analysis on the Effects of Carbon Pricing in Alberta

by

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Abstract

For this research, the focus will be on the carbon pricing in Alberta. As one of the leading jurisdictions in Canada for reducing GHG emissions, Alberta has the responsibility to implement policies to reduce GHG emissions, while maintaining its economic prosperity. The effects of carbon pricing policies on unemployment rate, economy diversification and socio-economic sectors will be investigated in the paper. Recommendations will be provided on how Alberta should move forward with carbon pricing after analysing the trend and relationships between carbon pricing and the economic and social structures in the province. As such, by extrapolating the results and reaching a thorough understanding of the impacts of carbon pricing, the effectiveness of carbon-pricing related policies may be bettered. Studies on other jurisdictions in Canada may be conducted in the future for comparative purposes.

Keywords: carbon pricing, revenue breakdown, socio-economic impact

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List of Symbols, Abbreviations and Nomenclature

AICCP	Alberta Indigenous Climate Capacity Program
AICEP	Alberta Indigenous Community Energy Program
AICPP	Alberta Indigenous Climate Planning Program
AIEERP	Alberta Indigenous Energy Efficiency Retrofit Program
AIGEP	Alberta Indigenous Green Employment Program
CCEMC	Climate Change and Emissions Management Corporation
CCIR	Carbon Competitiveness Incentive Regulation
CLP	Climate Leadership Plan
CO_2	Carbon Dioxide
ERA	Emissions Reduction Alberta
GDP	Gross Domestic Product
GGPPA	Greenhouse Gas Pollution Pricing Act
GHG	Greenhouse Gas
IP	Industrial Process
NDP	New Domestic Party
PC	Progressive Conservative
TIER	Technology Innovation and Emissions Reduction Regulation

Chapter 1. Introduction

1.1 Research Questions and Objectives

With an increase in average global temperatures, global warming is no doubt a serious concern that had been raised in the past decade. It is commonly believed that greenhouse gases (GHG) such as CO2 are responsible for global warming. To combat the rising CO2 concentration and adverse effects of global warming, countries are trying to lower their CO2 emissions through varies means. For Canada, carbon pricing is the answer.

The purpose of the study is to do an analysis of carbon pricing for the province of Alberta. The study will try to answer the following questions:

- What is the current state and trend of carbon pricing in Alberta?
- Does the implementation of carbon pricing affect unemployment rate?
- What have the carbon policies done to diversify the Albertan economy?
- How is carbon pricing affecting GDP growth and carbon-emission reduction in Alberta?

The study will focus on how the revenue generated from carbon tax have been broken down with respect to the socio-economic aspect of impact for carbon pricing in Alberta. The unemployment rates of Alberta between the years 2004 to 2019 will also be looked at and compared.

The objective of the study is to evaluate the effects and trends of carbon pricing in Alberta, and to examine any potential effects that carbon pricing may have on the diversification of economy and job creation.

1.2 Reasons for Carbon Tax and Effects of Carbon Tax

As the human population grows at an unprecedented rate, so does the energy required to sustain such a large population. Like a large population, the ever-expanding global economy also needs a sufficient amount of energy to support its growth. Through the use of a Johansen multivariate cointegration approach, it was found that there exists a long-term relationship between energy consumption, CO2 emissions and economic growth (Alshehry & Belloumi, 2014). A huge proportion of our energy comes from fossil fuels such as petroleum and coal. In fact, to this day, coal remains to be the biggest energy source for the Chinese population. Energy consumption and economic prosperity are inseparable. Despite the fact that fossil fuels may provide us with the energy and economic prosperity we need, there is no denying that they release a non-negligible amount of carbon into the atmosphere. Due to electricity generation and road transportation, the global CO2 emission from fossil fuels is likely to continue to increase with time (Andres, et al., 2012)

To combat the increase of carbon dioxide concentration in the atmosphere, countries have decided to reduce the use of fossil fuels. However, in a free market, where there is a demand, there is always a supply. If the demand for energy is always there, then the supply is unlikely to fall. This is where carbon pricing comes into play. With now an additional cost inflicted on carbon emissions, consumers are less likely to demand for more, thus lowering carbon emissions. The enactment of the carbon tax is also a pushing force for the market to transition from a fossil-fuel-based market to a renewable-based market.

The inevitable trend of energy transition may play a role in the diversification of Alberta's economy. For many years, Alberta had mainly relied on fossil fuels for its economic growth. However, with the additional costs inflicted by the carbon tax, behaviours of consumers

may be changed dramatically. This may cause the economy of Alberta to diversify. But is this necessarily a good change? As suggested by some researchers (Hambel, Kraft, & van der Ploeg, 2020), diversification of an economy and a carbon-free economy may have overlapping goals at first, but as time passes, conflicts may arise. This paper aims to investigate the effects of carbon tax and the diversification of economy in the province of Alberta.

From past research, the main source of CO2 emissions in Alberta is mostly from the energy sector. Under a carbon tax, the government simply sets a price on carbon and everyone who buys a product that creates emissions must pay for it. In theory, people will cut their carbon use over time to avoid paying the tax. In 2003, Alberta became the first jurisdiction in North America to adopt carbon pricing by passing the Climate Change and Emissions Management Act. In 2007, Alberta passed the Specified Emitters Regulation to regulate large emitters in the province. Provincial carbon tax had been around in Alberta for a long time until May 2019, when Alberta repealed their provincial carbon tax, and then everything has changed on January 1, 2020 when the federal carbon tax has been imposed on Alberta. The different approaches to carbon pricing may have played an important role in the economy of Alberta. The trend of carbon pricing in Alberta will be carefully analyzed to gain an insight into the effects of carbon pricing on the province.

The research is multi-disciplinary as it covers energy (MJ), environment (carbon and GHG emissions) and economics.

1.3 Determining Results

The purpose of the report is to present the past and current trends of carbon pricing in Alberta, as wells as the effects of carbon pricing on employment and GDP growth. Therefore, the report is not intended to illustrate either effectiveness or ineffectiveness of the carbon pricing

system in Alberta. The report shall be concluded with suggestions made for any future changes and improvements on the matter.

1.4 Related Literature

Relevant researches cover a review on how energy technology innovation can help with reducing GHG emission in Canada(Jordaan, et al., 2016), chronological development of climate policy in the province of Alberta (Swallow & Goddard, 2016), from experiments to adoption of carbon pricing mechanisms in time period of 1995-2014 (Houle, 2015), economic impacts of carbon pricing and investments in green technology development (Coad, Gibbard, MacDonald, & Stewart, 2017) etc. Most of the existing research papers have a good introduction and analysis for how carbon pricing works chronologically in policy and political related area, as well as the economic impact on carbon pricing and eliminating fossil fuel-fired electricity generation plants in Canada.

However, there are not many academic analyses address the economic portion of the policies, such as showing where the revenue generated from carbon pricing has been spent, what may Alberta do to further its economy diversification, or how have the recent changes like Alberta's mechanism from Carbon Competitive Incentive Regulation (CCIR) to Technology Innovation and Emissions Reduction Regulation (TIER) affect carbon pricing. Carbon emission revenue is a critical part that cannot be ignored as it creates opportunities for governments to develop future changes. How a government recycles their carbon tax determines the trend and plan they want to go with. For example, more than one-quarter of the carbon tax revenues have been rebated to lower- and middle-income families in Alberta (Hogue, 2017). This is an indication showing that not all funds will be strictly budgeted towards GHG emission reduction, it could be rebates to specific household or investment to green innovations. Thus, it will be

important for people to see what the full revenue breakdown is and compare the differences with different jurisdictions in order to have a more comprehensive understanding. Furthermore, the current trend of energy transition may change the status quo of Alberta market which has been dominated by oil and gas. The potential effects of carbon pricing policies on the diversification of economy and job creation will be worth to examine as they implicate the future trend of Alberta. As for recent updates, Alberta proposed a new legislation called TIER to replace CCIR which is effective starting January 1, 2020. According to TIER regulation, emitters that are governed by the TIER system (other than electricity generators) can apply for a facility-specific benchmark. This implicates that a facility's emissions intensity will be measured against the facility's own past emissions instead of a common industry standard (Olexiuk, Saric, Kennedy, & Wetter, 2019). Additionally, there will be lower emission targets, lower opt-in threshold. The status quo will be changed based on the updated acts and it will certainly affect the path forward for designated governments.

Therefore, by understanding both the information available for revenue breakdown and the most updated systems, a good guideline is expected to be framed for policy improvement for governments.

Chapter 2. General Methodology

A comprehensive introduction on the topic will be given with data and research results from prior studies that have conducted on the subject. The importance of carbon reduction will be illustrated with graphs and data that show the linear relationship between carbon dioxide concentration and climate change. The carbon pricing system in Alberta will be fully explained using the information posted by the provincial and federal governments.

To answer our research questions, our methodology includes the analysis of the revenue breakdown from carbon tax and the comparison of unemployment rates in Alberta. The data needed to analyze the revenue breakdown will be gathered through government-released data, including data from both federal and provincial government. The raw data will be analyzed and organized into graphs that will better display the expenditure of the revenue generated. Data on the growth of GDP will also be gathered through government websites and reports. By comparing the data before and after the implementation of the carbon tax, we hope to gain a better understanding on where the revenue went and how effective the carbon tax is in shaping the economy of Alberta. Through the examination of the various sectors in Alberta's economy, the growth of each sector under the influence of the carbon tax can be seen. This part of the paper includes the collection of data from the annual reports of different companies and corporations. This helps us to understand the effects of economic diversification induced by a zero-emission economy.

The unemployment rates of Alberta from 2004 to 2019 will be examined using government released data. The unemployment rates before and after the implementation of carbon pricing policies will be compared.

The effects of the carbon tax will be investigated and discussed using conclusions and suggestions from other primary research papers. By having comprehensive reviews on previous studies, our own conclusions will be derived.

Chapter 3. Past Alberta Carbon Policies

3.1 SGER

SGER stands for Specified Gas Emitters Regulation. It became operational in 2007 and was replaced by Carbon Competitiveness Incentive Regulation (CCIR) in 2018. It was based on an intensity-based approach, and as a result, companies that emitted more than 100,000 tonnes of carbon dioxide annually were required to reduce their emissions intensity by 12 percent.

Various compliance options exist under the SGER. Companies could choose to reduce their emissions intensity by 12 percent through improvements on operational procedures. They could also buy offsets from projects that followed provincial protocols. Lastly, companies could choose to make deposits to Climate Change and Emissions Management Fund, which had a set price of $15 per tonne of emissions. The fund was used to fund energy projects or technologies that would reduce carbon emissions in the future.

Table 1. Emission reduction from 2007-2017.

	Emission reduction (Mt CO2e)
2007	3.4
2008	6.6
2009	7.1
2010	6.8
2011	10
2012	7.9
2013	7.3
2014	10.2
2015	7.5
2016	9.6
2017	19
Total	95.4

(SGER, 2007-2017)

By January 2018, a total reduction of 95 million tonnes of carbon emissions had been achieved under the SGER (Government of Alberta, 2018d). The following table also illustrates the total fund payment received by the government under the governance of SGER. Based on Table , it is clear that SGER had reduced the amount of carbon emissions in the province, along with raising funding for the development of technologies that help carbon emissions reduction in the future. Companies were also changing their operational procedures to meet their annual reduction target, which had helped Alberta to shift toward a less carbon-intense economy faster.

Despite its merits, insufficient data on the breakdown of the spending of Climate Change and Emissions Management Fund had prevented us to further investigate its effects on the economy. However, the Climate Leadership Plan(CLP) initiated in 2015 could help us to gain a deeper understanding on the combined effects of SGER and CLP on the economy.

3.2 Climate Leadership Plan

The Climate Leadership Plan(CLP) was introduced by the Government of Alberta in November 2015. Its goals are to reduce the emissions of carbon dioxide within the province, to enhance diversification of the economy, to create jobs and to protect and conserve our environment. Under the CLP, emissions reductions were accelerated by launching carbon levy in 2017, which increased from $15 per tonne to $20 per tonne (Government of Alberta, 2018c). In 2018, this carbon levy was increased again to $30 per tonne CO2e, including fuels used for heating and transportation (Government of Alberta, 2018c).

The CLP pledges to phase-out the emissions from coal-fired electricity. This was done by entering funding agreements with three affected companies. It is hoped that by 2030, 30 percent of electricity generation capacity would come from renewable sources (Government of Alberta, 2018c). Starting 2017, emissions from oil sands are to become capped at 10 mega tonnes (Mt)

per year (Government of Alberta, 2018c). In addition, the CLP also pushes for a reduction of 45% on methane emissions from upstream oil and gas production by 2025 (based on 2014 levels) (Government of Alberta, 2018c).

A large portion of revenue generated from the carbon levy and CCIR will be distributed to lower and middle-income Albertan families, and the rest will be reinvested into the economy as funds and projects (Government of Alberta, 2018b). Programs that focus on companies and businesses that have demonstrated leadership in clean technology innovation are highly encouraged under CLP. Increasing the funding for public infrastructure and transportation system is also an objective for CLP, since public transit tends to decrease the number of private vehicles on the road, which in turn reduces total CO2 emissions.

Indigenous communities and organizations will receive funding from the government to improve and develop community buildings and facilities (Government of Alberta, 2018b). At the same time, jobs related to green energy are being offered to Indigenous peoples to help them better adapt to the transition. Although the CLP has multiple specific objectives, its main goal is to aid Alberta's transition to a greener economy.

3.3 CCIR

CCIR stands for Carbon Competitiveness Incentive Regulation, and it had replaced SGER on January 1, 2018. The eligibility threshold is 100,000 tonnes of carbon dioxide equivalent greenhouse gases (Government of Alberta, 2018b). Any facility that reaches or surpasses this threshold in 2003 or later years will be eligible for CCIR. Additionally, facilities with smaller emissions may choose to opt-in to CCIR if they emit more than 50,000 tonnes of CO2e greenhouse gases annually and are competing with other facilities that are regulated by CCIR.

CCIR has adopted product-based benchmarks to regulate facilities within each sector. Each specific product will have its own emission benchmark, and facilities can use various methods for manufacturing. This ensures fairness in each sector and allows companies to compete for finding the most cost-effective method for manufacturing. Companies that exceed the benchmarks will need to reduce their emissions either by purchasing carbon offsets or emission credits. Making payments to the Climate Change and Emissions Management Fund at $30 per tonne of CO2e also helps companies to not go over their benchmarks.

Chapter 4. Effects of Carbon Policies on Unemployment Rate

4.1 Methods

To gain an understanding on the effects of carbon pricing on employment rate in Alberta, we looked at the unemployment rates of Alberta between the years 2004 and 2019. The data was obtained from Statistics Canada. From 2004 to 2006, carbon pricing did not exist in Alberta, and SGER did not become operational until 2007. Thus, unemployment rates in the years 2004, 2005 and 2006 were used as controlled variables, and were grouped together to be named "Control".

From 2007 to 2017, both SGER and CLP were in operation. The unemployment rates of Alberta in the years 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016 and 2017 were grouped together to be named "Observed". From 2018 to 2019, CCIR had replaced SGER as the new carbon policy in Alberta. The unemployment rates of these two years were also grouped together to be named "Observed".

After assigning the unemployment rates of different years to separate groups, the "Control" group was compared with both "Observed" groups using an independent t-test. This was to see if the unemployment rates had any significant changes under the influence of carbon pricing policies. A 95% confidence interval was deemed appropriate for the significance test. This means that a p-value lower than 0.05 indicates a significance, while a p-value higher than 0.05 does not indicate a significance.

The t-tests were conducted to compare the unemployment rates in Alberta from 2004 to 2019. Independent t-tests were chosen because we would like to determine whether there was a statistical significance between the means of unemployment rates in the compared groups. The parameter of the t-tests is the true change of the unemployment rates in Alberta from 2004 to 2019 under the influence of carbon pricing policies. The null hypothesis is that there is no

significant difference in unemployment rates before and after the implementation of carbon pricing policies. The alternative hypothesis is that there is a significant difference in unemployment rates before and after the implementation of carbon policies. By comparing the unemployment rates of the years before and after the implementation of the carbon pricing policies, we might be able to see if there is a relationship between the unemployment rates and the carbon pricing policies. If the t-tests have p-values that are lower than 0.05, then we would say that there is significant difference in unemployment rates before and after the implementation of carbon pricing policies. In addition, if the unemployment rates after the implementation of carbon policies are significantly higher than before, then it is likely that the carbon policies have contributed to the difference. The t-tests were conducted through the use of R. However, the following formula can also be used:

$$t = \frac{M_{Control} - M_{Observed}}{\sqrt{\frac{S^2_{Control}}{N_{Control}} + \frac{S^2_{Observed}}{N_{Observed}}}}$$

For Figure 1 and 2, $M_{Control}$ represents the mean of employment rates in 2004, 2005, 2006. For Figure 4, $M_{Control}$ represents the mean of employment rates for years 2007 to 2014. For Figure 1, $M_{Observed}$ represents the mean of employment rates for years 2007 to 2017. For Figure 2, $M_{Observed}$ represents the mean of employment rates for years 2018 and 2019. For Figure 4, $M_{Observed}$ represents the mean of employment rates for years 2015 to 2017. $N_{Control}$ and $N_{Observed}$ represent the sizes of the two samples. For Figure 1 and 2, $N_{Control}$ is 3. For Figure 4, $N_{Control}$ is 8. For Figure 1, $N_{Observed}$ is 11. For Figure 2, $N_{Observed}$ is 2. For Figure 4, $N_{Observed}$ is 3. S represents the standard of deviation of each sample group (Control and Observed).

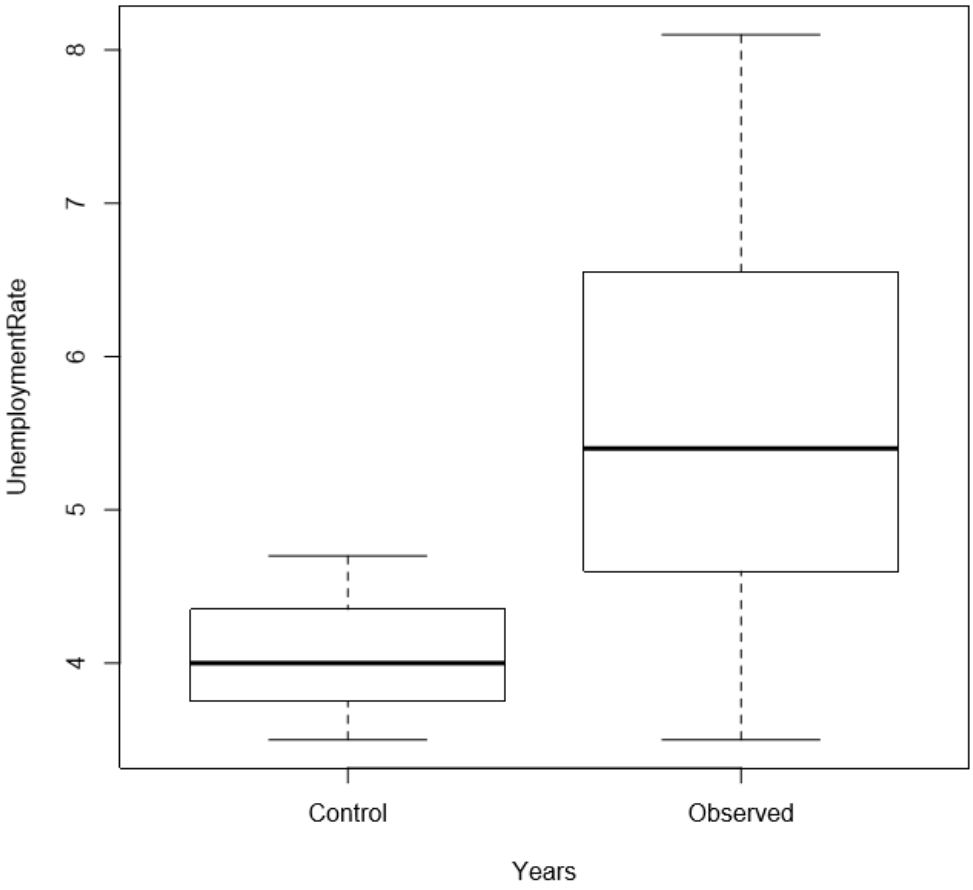
From 2004 to 2006, no carbon pricing policies were in effect, so the unemployment rates in these three years were used as references. From 2007 and onwards, various carbon pricing policies have been implemented. Thus, the unemployment rates in these years were viewed as the results of the implementation of carbon policies. Under the assumption that no other major policies have affected the unemployment rates from 2007 to 2019, any changes in the unemployment rates in the province would be directly affected by the carbon policies. Whether there is an increase or decrease in the unemployment rates in Alberta since 2007, the carbon policies play a direct role.

4.2 Results

Independent t-tests were performed individually for the two "Observed" groups against the "Control" group. For the "Observed" group with years 2007 to 2017, the P value is 0.067. For the other "Observed" group with years 2018 and 2019, the P value is 0.005. Based on the P values of the t-tests, we conclude that the unemployment rates in Alberta from years 2007 to 2017 were not significantly higher than the unemployment rates from years 2004 to 2006 (Figure 1). We also conclude that the unemployment rates in Alberta from years 2018 to 2019 were significantly higher than the unemployment rates from years 2004 to 2006 (Figure 2).

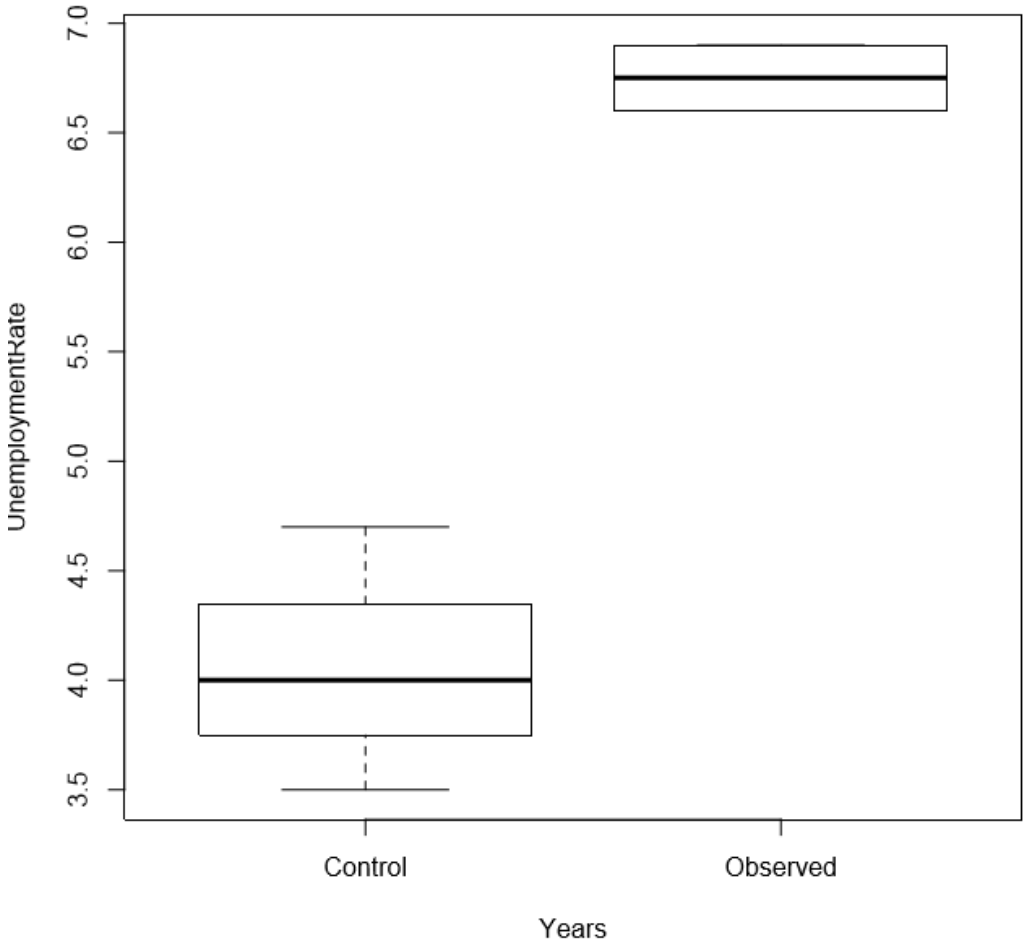
If we are to look at the mean values of the unemployment rates across all three groups, we can see that both "Observed" groups had higher values than the "Control" group (Figures 1 and 2).

Figure 1. T-test showing unemployment rates in Alberta from years 2004 to 2006 (Control) and unemployment rates in Alberta from years 2007 to 2017 (Observed).



(Government of Alberta, 2004-2017)

Figure 2. T-test showing unemployment rates in Alberta from years 2004 to 2006 (Control) and unemployment rates in Alberta from years 2018 to 2019 (Observed).

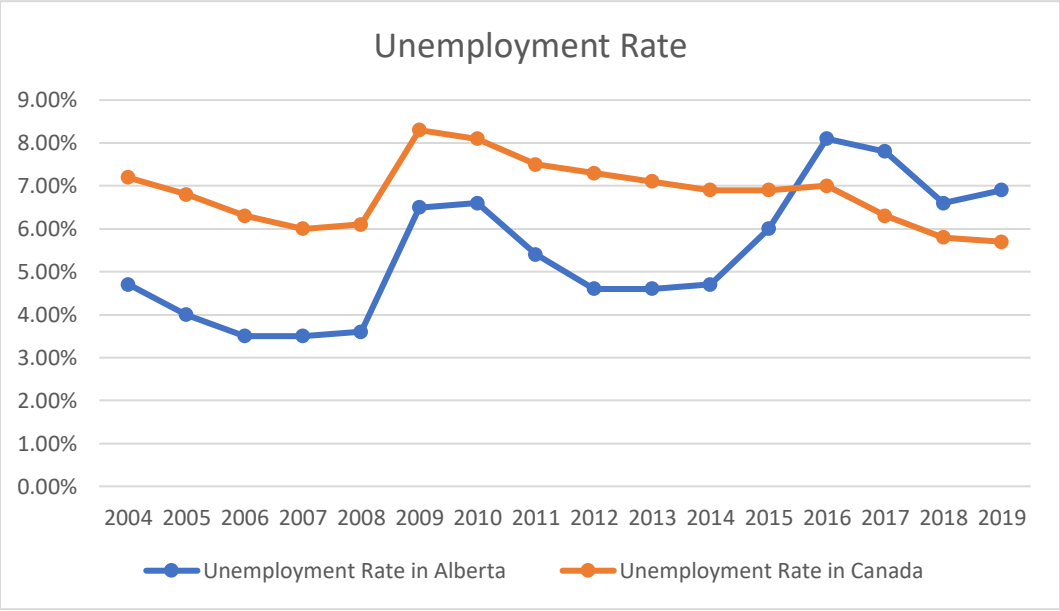


(Government of Alberta, 2004-2019)

4.3 Analysis

If we are to compare the trend of unemployment rates of Alberta with that of Canada (including Alberta), we can see that the trends do not match perfectly (see Figure 3). This indicates that the unemployment rate in Alberta is not fully influenced by federal policies. If federal policies and other national influences had played a significant and dominating role in the changes of unemployment rate in Alberta, then we would expect to see the trends overlap. According to Figure 3, the two lines had followed a very similar trend all the way until 2015. After 2015, the unemployment rate in Alberta had steadily increased while the unemployment rate of Canada steadily decreased. What happened in 2015? In 2015, the Albertan government introduced the Climate Leadership Plan, which broadened the scope of the carbon tax.

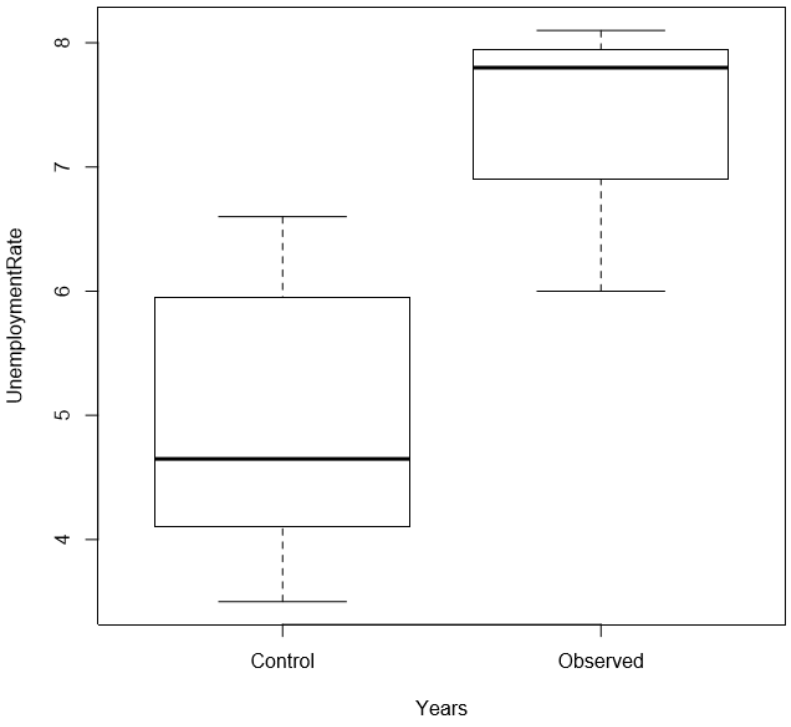
Figure 3. Unemployment rate in Alberta and Canada.



(Government of Alberta, 2004-2019)

If we look at the unemployment rates in Alberta from 2007 to 2017, we can see that the unemployment rates in the years under the influence of the CLP are much higher than other years (Figure 4). In Figure 3, the unemployment rates of Alberta in the years 2007, 2008, 2009, 2010, 2011, 2012, 2013 and 2014 were grouped together to be named “Control”. On the other hand, the unemployment rates of Alberta in the years 2015, 2016 and 2017 were grouped together to be named “Observed”. From 2007 to 2014, only SGER was effective and from 2015 to 2017, CLP was added. Figure 4 was graphed to see whether the introduction of CLP had caused any significant changes in unemployment rates. The p-value of the t-test is 0.0074, which indicates a significant increase in the unemployment rates in Alberta after the introduction of CLP.

Figure 4. T-test showing unemployment rates in Alberta from years 2007 to 2014 (Control) and unemployment rates in Alberta from years 2015 to 2017 (Observed).



(Government of Alberta, 2007-2017)

Employment rate is a crucial indicator to the prosperity of an economy. A research that studied the employment rate and economic growth in Costa Rica had showed that when real per capita income declined, unemployment rate had doubled (Fields, 1988). Economic growth and labor market conditions are directly related (Fields, 1988). Carbon pricing policies and regulations such as the CLP in Alberta had all promised job creation and improvements to people's wellbeing (Government of Alberta, 2018c). These policies had misled people to believe that they would increase the employment rate in the province while reducing carbon emissions. However, upon analyzing the unemployment rates in Alberta from 2004 to 2019, it was found that unemployment rates were much higher when carbon policies were in effect. With higher unemployment rates, many families in Alberta may suffer from reduced annual income, thus lowering their standard of living and quality of life. The results of our research had contradicted the promises of the carbon policies.

The extra costs that carbon tax adds to industrial goods and processes can potentially be passed on to consumers. Depending on the age, income and education of the consumers, the willingness to buy low-carbon products varies significantly (Li, Long, & Chen, 2017). Although it is a global census to reduce carbon emissions, not all people have the financial status to contribute. Consumers with lower income were shown to be more responsive to the price changes of goods like gasoline (West & Williams, 2004). This shows that as the price of a product increases, people become reluctant to buy that specific product. This can be explained by basic economic principles. As price increases, the demand tends to fall. With consumers buying less from the producers, the producers earn less profits. If this is to happen, then the product-producing companies may choose to hire less employees or even layoff its current ones. Due to the carbon tax, consumers have a lower willingness to purchase products and this causes

companies to halt their expansions. As a result, the unemployment rate in the province can potentially increase. Under the carbon pricing policies, companies are required to reduce their annual carbon emissions. This can be done either by improving their operational procedures, or by depositing to the Climate Change and Emissions Management Fund. Both options increase the cost of production for the companies. Due to this reason, existing companies may simply choose to produce less of its products. A decrease in production also decreases a company's need of labor.

Carbon pricing policies and regulations could have made Alberta unattractive to investors and hard for new companies to enter the field. Compliance to the carbon pricing policies raises the cost of production, and therefore, smaller companies do not have the financial capability to compete with existing companies. The policies have raised the barrier to entry for many small businesses in Alberta. When there is a decrease in the amount of small businesses, there tends to be a decrease in the amount of employment available. The employment dynamics of the United States from 1978 to 1980 in the private sector had showed that 78% of employment increase had occurred in businesses with less than 100 employees (Armington & Odle, 1982). Based on a panel analysis of 48 U.S. States, a study had found that the states with higher number of small businesses had lower unemployment rates and larger growth in Gross State Product (Robbins, Pantuosco, Parker, & Fuller, 2000). Both studies show that small businesses create employment opportunities, along with economic growth. Furthermore, the raised production costs due to carbon pricing policies have prevented investors from investing in Alberta. Among 20 jurisdictions in North American, Alberta was ranked 16th for investment attractiveness (Stedman & Aliakbari, 2019). It is no coincidence that the unemployment rates had increased substantially while the investment attractiveness ranking is low. With less investment in the province, cash

flow into the province will stay low and this in turn can cost the province many employment opportunities. Employment opportunities only increase if there is a need of labor in the market. When there is no demand for labor in the market due to the lack of investment, the unemployment rate stays high.

We recognize the fact that Alberta had experienced recessions in the years 2008 and 2014, which may have raised the unemployment rates in the province. The higher unemployment rates from 2007 to 2019 may be due to the combination effects of recession and the implementation of carbon pricing policies. While we cannot conclusively say that the carbon pricing policies have directly caused the increasing unemployment rate of Alberta, we do believe that they are a contributing factor.

Chapter 5. Economy Diversification

5.1 Methods

To gain a better understanding of the correlation between carbon pricing policies and economy diversification, we collected data from varies places in different steps. Data from Statistics Canada was first collected to gather the information of the percentage that each industry had contributed to GDP from 2004 to 2019. In this case, data from 2019 is the most recent data we can get. Then we reviewed Government of Alberta's annual reports from 2004 to 2018 (most recent) to get the specific data in Alberta's unemployment rate by industry. Industries are later to be listed associated with their unemployment rates.

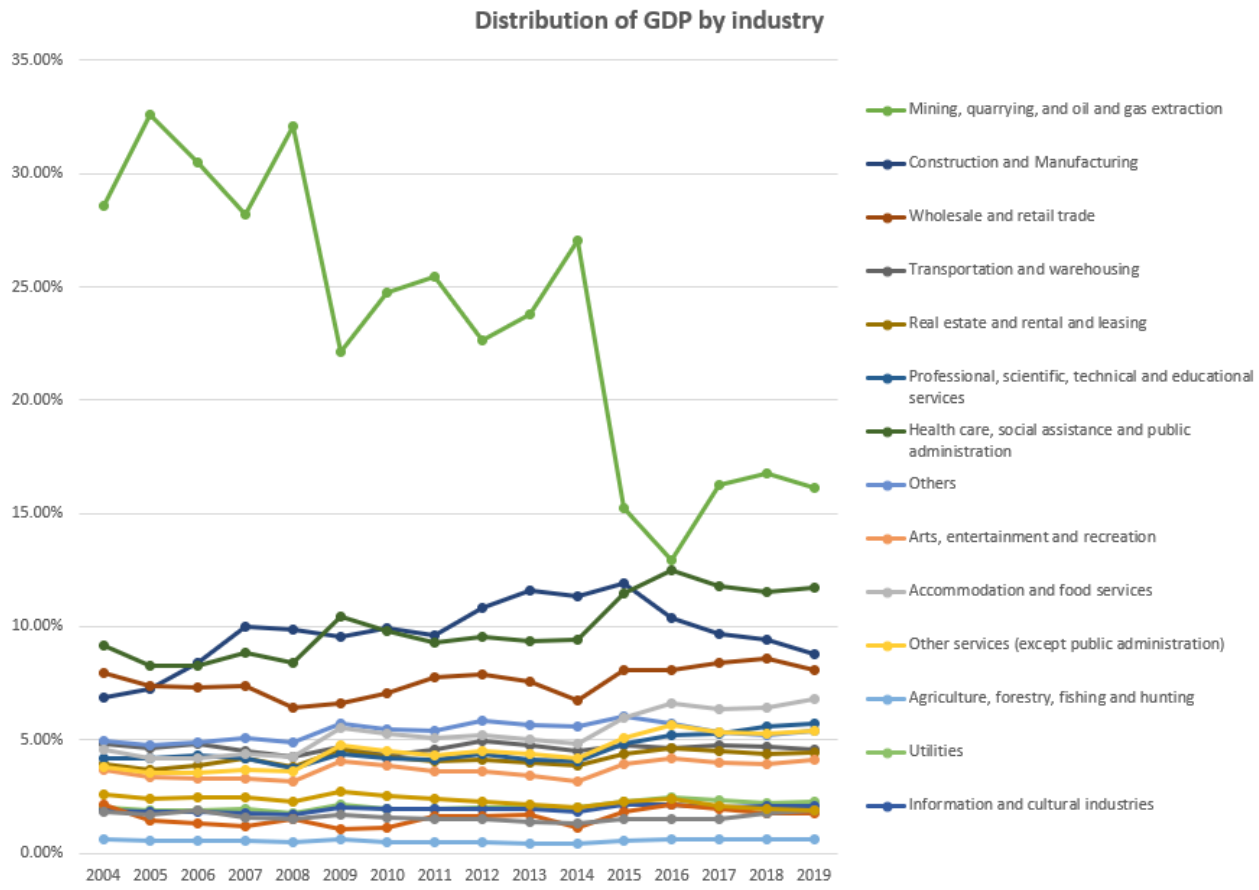
After generating the graph of unemployment rate in Alberta, it was compared with the GDP distribution. The graph was simplified with the areas we want to highlight. Main industries that have higher percentage shares in GDP are then being listed out and combined as they share similar characteristics. We combined health care, social assistance with public administration, wholesale trade with retail trade, and construction with manufacturing in order to get a more simplified graph in unemployment rate in these sectors.

Lastly, we extracted the data from Government of Alberta's annual report under their highlight for carbon levy revenue to have a better comprehension in how the carbon levy revenue has been breakdown. However, there was not sufficient data in other years except year 2016-2017 and year 2017-2018. To further analyze, we got data from ERA for their financial statements since 2009, and the table has then generated after we went through all the statements. According to the funded project areas ERA are covering, we went back to the GDP distribution graph and selected the related area to the project. The result shows GDP distribution in

highlighted areas where ERA has projects in. We will compare all the data to see if there are significant change in GDP distribution in the areas where ERA's funded projects at.

5.2 Alberta's GDP Distribution

Figure 5. Distribution of GDP by industry, Alberta.



(Government of Alberta, 2004-2019)

Figure 3 is the distribution of GDP by industry from 2004 to 2019, there is a significant trend of decreasing in mining, quarrying, and oil and gas extraction industry with two sharp drops showed around 2008 and 2014. It both happened around the economy recession time where the oil price crushed, and local businesses have been severely affected. Energy transition is also a trend that affected mining, quarrying, and oil and gas extraction industry's GDP share

percentage. SGER and CCIR, being as energy transition derived policies, are no doubt making difference in industries' behaviour in order to help Alberta achieve Canada's 2030 goal.

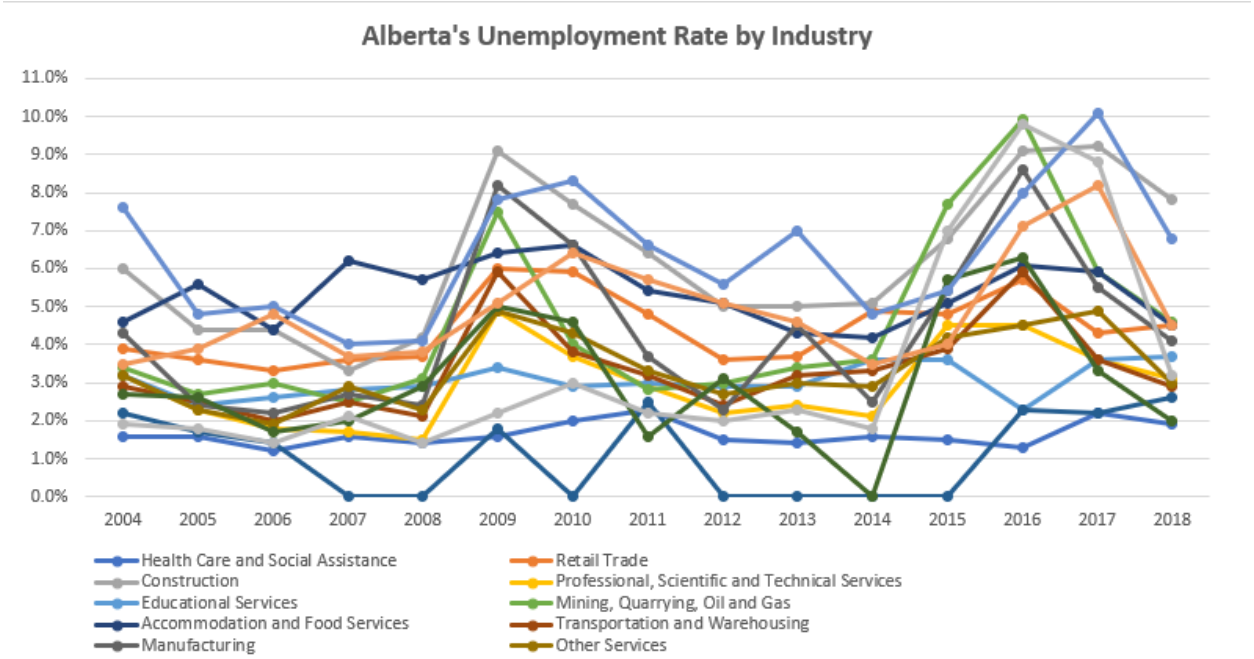
Similar to the change in mining, quarrying, and oil and gas extraction industry, construction and manufacturing industry experienced a decrease in 2015 after a relative steady increase before. Construction and manufacturing industries are still making main contribution to Alberta's GDP growth without big fluctuation in relation to mining industry, in fact, there was even a small increase around 2014 recession period. The reason being is that Government of Alberta have particularly stressed on public infrastructure investment in recent years to stimulate its economy in response to recessions, while it is not really an effective method as the decision and implementation process take time along with the high possibility of misplace project funding (Poschmann, 2020). It appears to be in a decreasing trend as the manufacturing part is related to oil refineries, pul mills, chemical plants etc.

However, different than the change in above industries, health care, social assistance and public administration have an increase that put itself out of the other smaller share percentage industries' league after being under 10% for long time. Apparently, with the help of government's attention to resident's mental health, health care, social assistance and public administration industry has been increasing its GDP share percentage after the two period of recessions in the recent decade.

5.3 Alberta's Unemployment Rate

This raise the concern of need of change for Alberta. Economy diversification is needed under the current trend of energy transition and raising awareness of being environmentally friendly. To be more specifically, the unemployment rate by industry (Figure 4) shows the percentage of unemployment people in Alberta from 2004-2018 (the most recent updated data).

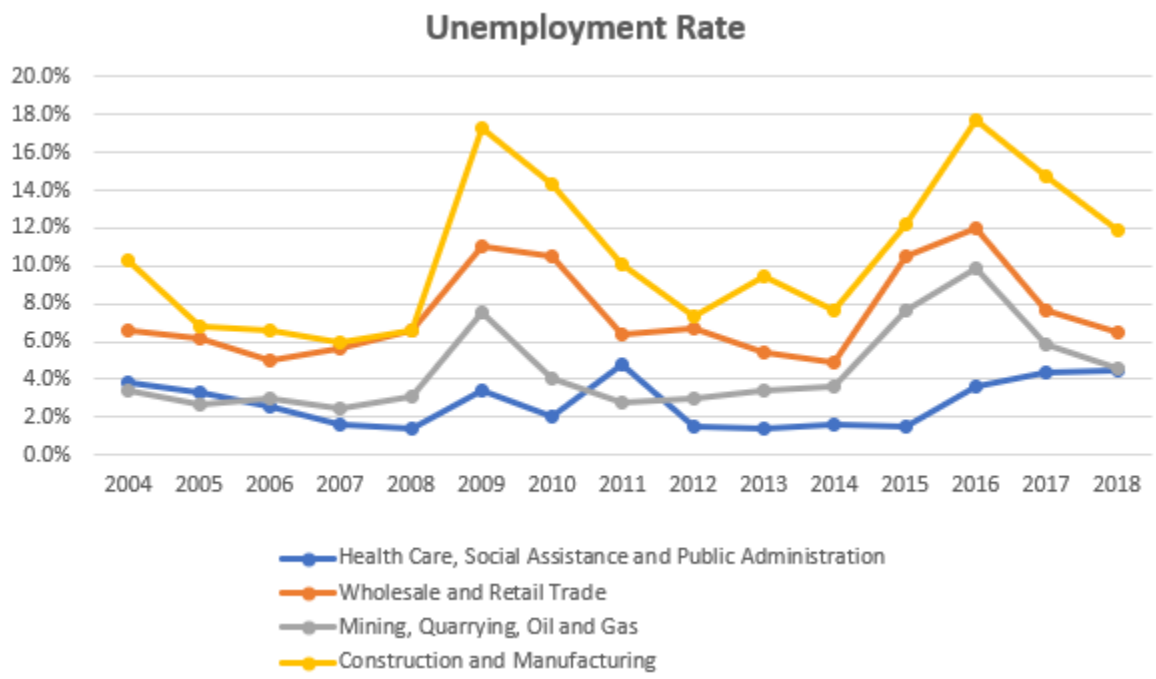
Figure 6. Alberta's Unemployment Rate by Industry.



(Government of Alberta, 2004-2018)

After simplifying the data and highlight the unemployment rate in the sectors which holds bigger percentage shares of GDP, figure 5 has been generated and listed below.

Figure 7. Unemployment Rate in Specific Industry.

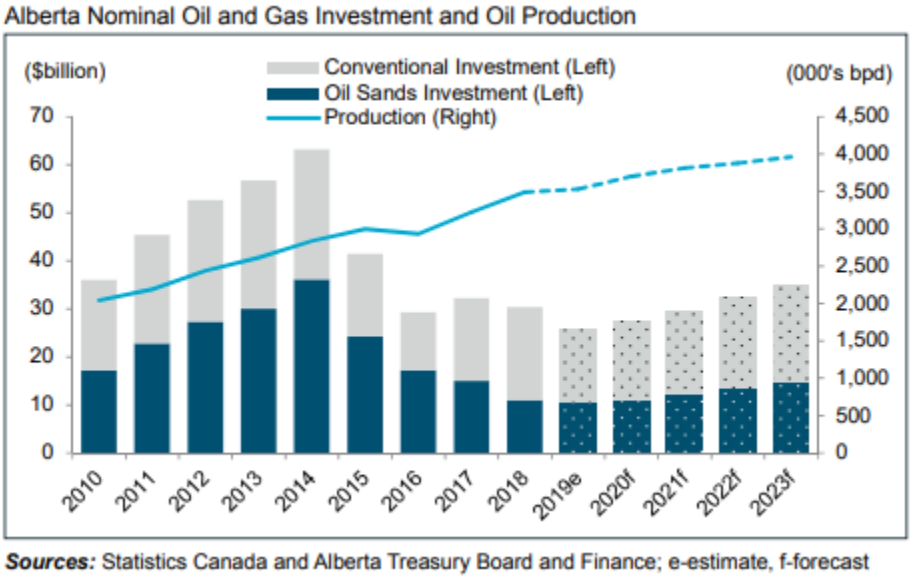


(Government of Alberta, 2004-2018)

Four main industries have been taken out and while comparing these industries' unemployment rate with their GDP contribution, economy diversification is undoubtedly needed as the rate of unemployment in those industries are having bigger effect in Alberta's GDP growth. In the past decades, oil price crushes and recessions brought to increased unemployment rate especially on high-wage employments industries such as mining, oil and gas, construction and manufacturing, wholesale, and retail trade industries. It is very unlikely for Alberta to get back to where it was before the recession in a short time, in addition, the trend of energy transition is not helping in flattening the unemployment rate in oil and gas industry if Alberta is not taking actions to change its focus of development. Both SGER and CCIR are showing gestures of changing and encourage in developing renewables while reducing emissions. However, this is not enough as there are still need of economy diversification.

Even with the policy and legislations in the past to help Alberta achieving its goal of emission reduction, Alberta energy producers still faced fierce competition in other North American markets due to the rapid growth of U.S. oil and gas industry (Government of Alberta, 2020a). Figure 6 indicates that the investment on oil and gas was decreasing after 2014 recession. Combining this data with the unemployment rate in oil and gas industry these years, it is not hard to see that as one of Alberta's main industries in GDP growth, the crush in oil price and increase in number of competitors are not making Alberta's economy being any better. Energy diversification is needed in order to help with Alberta's long-term growth in a more diverse market.

Figure 8. Alberta Nominal Oil and Gas Investment and Oil Production.



(Statistics Canada, 2010-2023)

Economy diversification is an inevitable trend and with the evolving technology that fewer people are needed at some traditional work position while other new career opportunities will appear any time soon. Taking this year as an example, by April 2020, 5.5 million Canadians

have been impacted by COVID-19 either on job loss or reduced hours (Statistics Canada, 2020a). Most companies especially retails have been suffering from the pandemic, however Zoom, a communication technology company, has been booming due to the COVID-19 pandemic. It is a good lesson for Alberta that having diversified economy will be helpful for its future development. Similar to energy security, having a variety of job options available and encouraging people being more open to study in other areas than just focus on oil and gas would help people to have a better choice when facing same issue again. The status change in oil and gas industry along with booming of IT and renewable industries are changing people's focus as well as working habit. To answer the question raised earlier in introduction, under the inevitable trend of energy transition, being economy diversified along with the policies and regulation on carbon would be a good change to help Alberta achieving its own goal as well as Canada's 2030 climate goal while also provide more alternatives in job market.

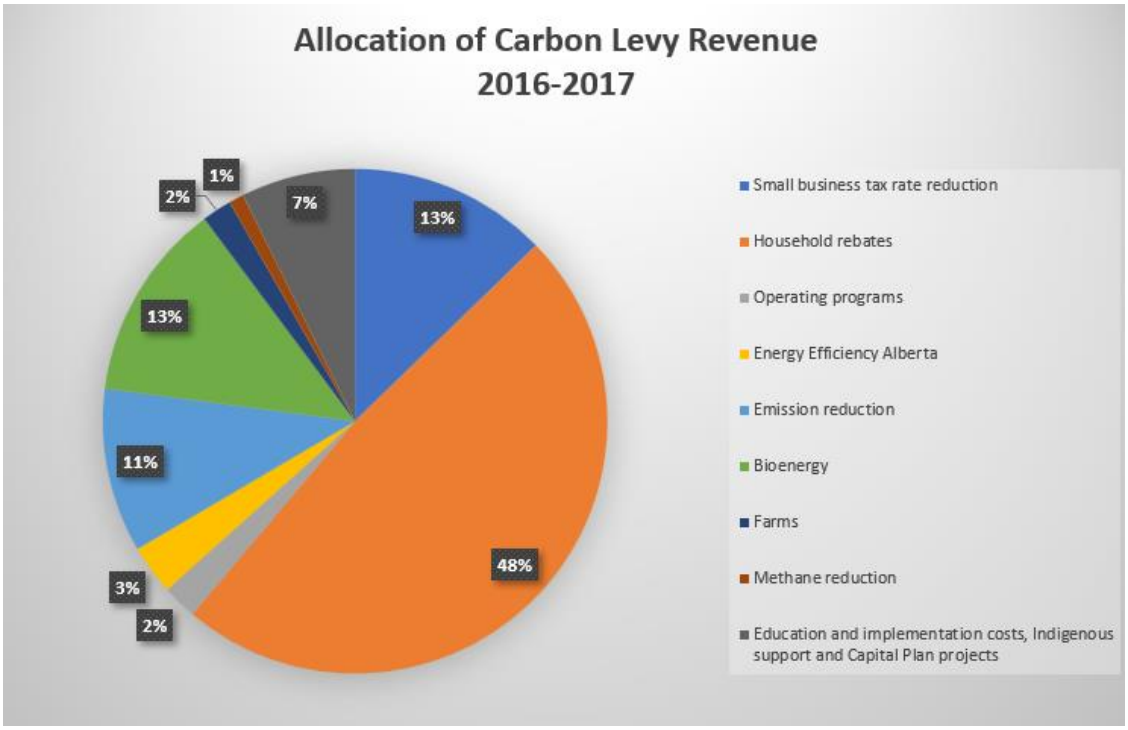
5.4 Revenue Breakdown

Allocating carbon levy into other sectors is one of the good methods to help with economy diversification as well as energy transition. Revenue from the carbon levy was intended to mostly allocate on household rebates, small business tax rate reduction, energy efficiency, renewable energy development and emission reductions (Government of Alberta, 2017). From data in Government of Alberta's annual reports, most of the carbon levy revenue has been directed to household rebates and small business tax rate reduction.

Figure 7 and 8 presents the data of carbon levy revenue breakdown in period 2016 to 2017 and 2017 to 2018 from CLP, data is extracted from Government of Alberta's annual reports, which shows the determination from the government on reducing the emission and give back to residents as well as moving Alberta to a direction with more diversified options. Policies

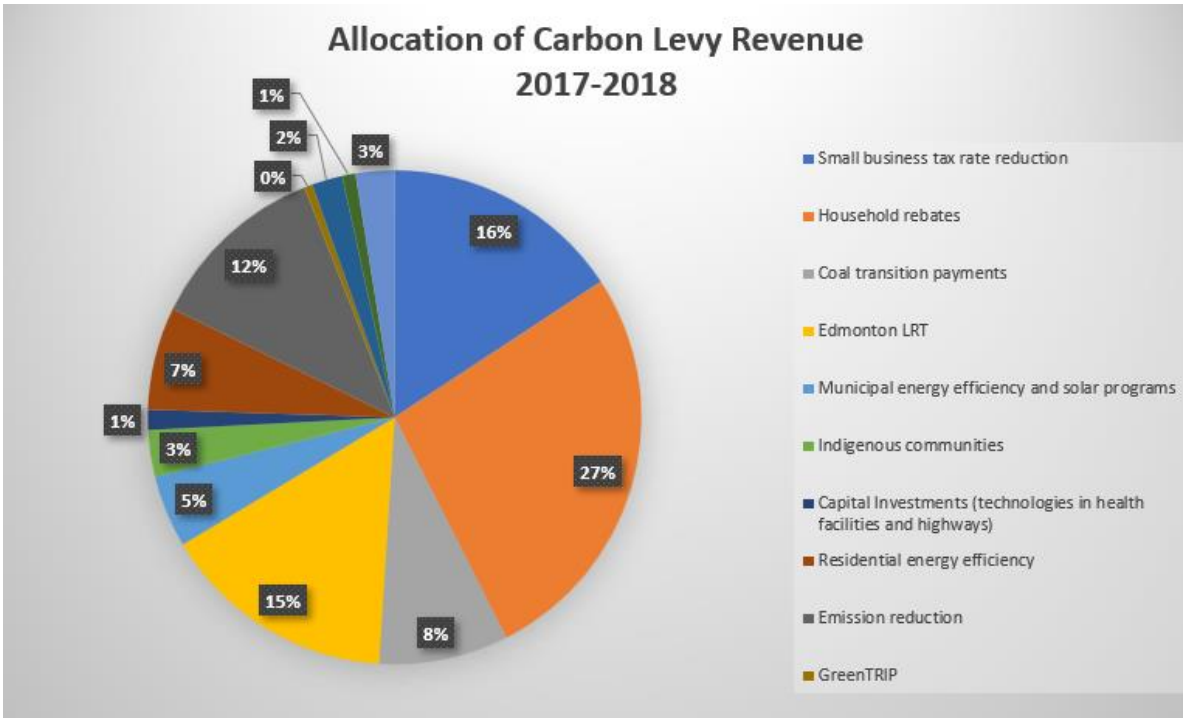
and regulations such as SGER, CCIR and CLP are helping with it as the tax revenue are allocated into household rebate , green tech, innovation, and other sectors. For example, carbon price was increased from $20/tonne of CO2 equivalent to $30/tonne of CO2 equivalent on January 1st, 2018, which lead to a higher household rebate (Government of Alberta, 2018a).

Figure 9. Allocation of Carbon Levy Revenue 2016-2017.



(Climate Leadership Plan, 2016-2017)

Figure 10. Allocation of Carbon Levy Revenue 2017-2018.



(Climate Leadership Plan, 2017-2018)

The Climate Change and Emissions Management Funds mentioned in Chapter 3 was collected by the Climate Change and Emissions Management Corporation (CCEMC), and Emissions Reduction Alberta (ERA) is the roots of the CCEMC. ERA was established for the purpose of using revenues gained from SGER to help keep up to achieve the Alberta government's climate change strategy (Emissions Reduction Alberta, 2019). Table 2 shows the total revenues and expenses they had since 2009.

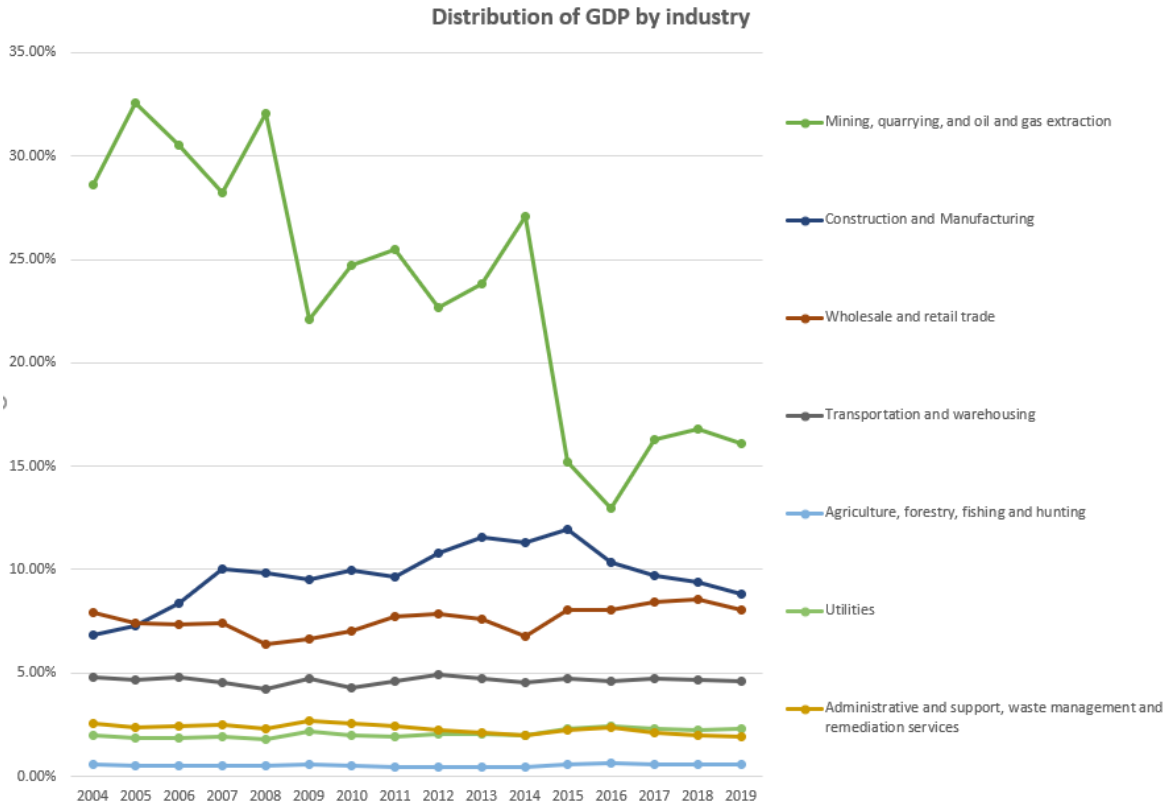
Table 2. Total Revenues and Expenses of ERA Since 2009.

Operation Year	Time Period	Grant Revenue from Government of Alberta	Income Generated from Grant Revenue	Conference Revenue and Sponsorship	Total Revenue	Project Expenses	Operating Expenses	(Deficiency) Excess of Revenues Over Expenses	Grant Re-allocation	(Deficiency) Excess of Revenue Over Expenses for the Year
1	2009-2010	$ 126,157,000.00	$ 371,255.00	$ -	$ 126,528,255.00	$ 3,221,416.00		$ 123,306,839.00	$ -	$ 123,306,839.00
2	2010-2011	$ 62,781,105.00	$ 1,711,549.00	$ 251,530.00	$ 64,744,184.00	$ 142,601.00	$ 4,321,887.00	$ 64,601,583.00	$ -	$ 60,279,696.00
3	2011-2012	$ 72,821,928.00	$ 2,974,262.00	$ -	$ 75,796,190.00	$ 23,008,878.00	$ 4,897,157.00	$ 52,787,312.00	$ -	$ 47,890,155.00
4	2012-2013	$ 54,628,905.00	$ 3,681,373.00	$ -	$ 58,310,278.00	$ 21,980,590.00	$ 7,609,628.00	$ 36,329,688.00	$ -	$ 28,720,060.00
5	2013-2014	$ 64,117,000.00	$ 4,316,523.00	$ 456,002.00	$ 68,889,525.00	$ 37,129,851.00	$ 9,827,789.00	$ 31,759,674.00	$ -	$ 21,931,885.00
6	2014-2015	$ 50,000,000.00	$ 4,446,374.00	$ -	$ 54,446,374.00	$ 33,034,492.00	$ 7,075,962.00	$ 21,411,882.00	$ -	$ 14,335,920.00
7	2015-2016	$ -	$ 3,465,228.00	$ -	$ 3,465,228.00	$ 27,992,007.00	$ 6,000,937.00	-$ 24,526,779.00	$ -	-$ 30,527,716.00
8	2016-2017	$ 33,000,000.00	$ 3,057,450.00	$ -	$ 36,057,450.00	$ 21,654,278.00	$ 5,348,585.00	$ 14,403,172.00	$ -	$ 9,054,587.00
9	2017-2018	$ 164,500,000.00	$ 4,694,781.00	$ 435,065.00	$ 169,629,846.00	$ 34,084,578.00	$ 4,090,066.00	$ 135,545,268.00	$ -	$ 131,455,202.00
10	2018-2019	$ 31,150,000.00	$ 8,700,365.00	$ -	$ 39,850,365.00	$ 33,619,127.00	$ 5,105,921.00	$ 6,231,238.00	$ 5,000,000.00	-$ 3,874,683.00

(Emission Reduction Alberta, 2009-2019)

From Table 2, we can see that overall revenue gained from carbon mechanism along with government grant has generated a good amount of excess revenue after all the operation and project expenses. From these funding, 161 projects have been funded in order to help with developing innovative technologies and reducing emission (Emissions Reduction Alberta, 2019). And according to ERA, the funded projects are covering a good variety in cleaner oil and gas, low emitting electricity supply, food, fiber and bioindustries, and low carbon industrial processes and products (Emissions Reduction Alberta, 2019). The good range of variety the funded projects are mainly aiming at diversifying Alberta's low carbon economy while creating more jobs.

Figure 11. Distribution of GDP in the Industry where ERA approved projects are.



(Government of Alberta, 2004-2019)

While filtering the related industries where ERA approved projects into GDP distribution by industry (Figure 9), there is an apparent decline in mining quarrying and oil and gas extraction industry since 2007. Even though recessions mentioned before may have played a role in the decline, but the projects of ERA are also likely to have contributed. Since there are no major changes in the percentage share of GDP distribution from other related industries, our research concludes that the ERA projects are insufficient in driving the diversification of the Albertan economy.

Chapter 6. Socio-economic impact on Carbon Pricing

6.1 Social Impact

Currently, Canada's emission efforts have been classified as "insufficient", which indicates that Canada is in the least stringent part of its fair share range (Climate Action Tracker Analysis, 2019). This means that Canada also fail to keep warming degree under 2°C, which is the Paris Agreement's standard.

So, to combat the rising CO2 concentration and adverse effects of global warming, Canada is trying to lower its CO2 through varies means. Alberta, as one of the leading jurisdictions in Canada, also has the responsibilities to do actions to reduce GHG emissions. According to IRENA analysis, reducing global GHG emissions together with the support of Paris Agreement would boost GDP by 0.8% in 2050 (IRENA, 2017). Carbon policy is one of the methods that can help with GHG emission while maintain economy prosperity.

In Alberta, the revenue generated from carbon policy has been spent in different areas to help stimulate economic growth as well as bringing social benefits. Taking CLP as an example, there are six main action areas it focuses on, which are policy and legislation, energy efficiency, innovation and clean technology, transit and infrastructure, electricity transition, and indigenous communities (Government of Alberta, 2018c).

Social welfare gains are the result of reduced negative externalities such as pressure on ecosystems and impacts on human health (IRENA, 2017), because there will be less mining of coal, less drilling for oil and gas and lower exposure to air and water pollutants stemming from fossil-fuel use. Indigenous community development is under carbon policy revenue spending's consideration as well. Numerous programs were launched to help with indigenous communities' energy efficiency, employment opportunities, and adapting to this changing environment. For

example, Alberta Indigenous Climate Capacity Program (AICCP), Green Employment Program (AIGEP), Climate Planning Program (AICPP), and Energy Efficiency Retrofit Program (AIEERP), and the Alberta Indigenous Community Energy Program (AICEP) are offered under carbon levy fund (Environmental Defense, 2018). These programs are helping Aboriginals to gain skills and knowledges in order to find opportunities in this new economy pattern while also bridging good relationship between Aboriginals and non-Aboriginals.

6.1.1 Health Impact

Health risk associated with emissions that will eventually let the society pay in terms of climate change and health impacts. According to Health Canada, there will be raising burdens of climate-related health issues to Canadian if there are no effective methods been implemented (Séguin, 2008). While there is not a lot of data available to the health impacts of climate change in Alberta, it is undeniable that human health is affected by it. Air pollution is one of the derivatives from climate change since climate change can increase smog formation, wildfires, and pollen formation (Anderson, et al., 2013). Health Canada has started an assessment in order to obtain a better understanding in how climate chage could impacts the health and well-being of Canadians. In the assessment model, air quality was proved to be effected by climate change as the increase in global average temperature has influence to key air quality indicators such as ozone (O3) and particulate matter (PM2.5) in Canada (Séguin, 2008). With the growing oil sands activities in the past years, increased pollutants that are carcinogens have been generated near Fort McMurray and outside of Edmonton (NRDC, 2014). Communities were serioysly affected by the hazardous air pollutants that generated from the oil sands sites that are causing leukemia and other cancers (Simpson, et al., 2013). For example, the nearby community residents around

Edmonton as well as communities that lives downwind of the sites are the victims for the oil and sands activities (Simpson, et al., 2013).

Reproductive issue in animals is another concern to the result of mining and other oil and gas processes. A study took an oil sands site in north eastern Alberta as a test area and got the conclusion that oil sands procesing activities can have potential to disruptive issue in reproductive functioning to goldfish (Lister, Nero, Farwell, Dixon, & Van Der Kraak, 2008) and the other native species such as yellow perch (van den Heuvel, et al., 1999). While contaminated water from oil sands development can effect fish in different ways, the further concern is the consequence when human consume the contaminated fish. A study showed that the cancer rate increased 30% from 1995 to 2006 in a small community in Fort McMurray near where the major oil sands development at (NRDC, 2014). In the study, certain cancers occurred in a higher rate than expected and the specific cancers have been tested to have a relation with petroleum products development (NRDC, 2014).

As chapter 3 mentioned, there is a total of 95 million tonnes of carbon emission reduction under SGER from 2007 to Januarary 2018. Therefore, adaptive methods such as carbon policies that can helps reduce GHG emission and limit the oil sands activities are good for lighten the burden of health issues that is related to oil sands development.

6.1.2. Impact to Indigenous Community

Some past oil and gas projects have been proven to have adverse impact on indigenous communities that can affects Indigenous People's culture and their way of life while also leaves health impact to people from the cumulative impacts of urban development and oil and gas projects (Chen, 2009). Ongoing natural resource extraction activities such as mining are also affecting the function ability of Canada's boreal zone where there are around 3.7 million people

and Indigenous people are taking a large portion in it (Serran, et al., 2018). By 2019, there are around 250 remote communities (about 185,000 people) in Canada that are off-grid (Lovekin & Heerema, 2019). While they are heavily rely on diesel generators or other carbon intensive technologies for generating power, the impacts they are making on climate change are large. In Alberta, over 58% of its landbase is covered by boreal forest, where there are 7 active remote communities in total with the population of approximately 6131 (Energy and Mines Ministers' Conference, 2018). According to the report, the annual diesel generation of the remote communities in Alberta is 10,930,862 MWh per year (Energy and Mines Ministers' Conference, 2018).

As mentioned in beginning of this chapter, numerous programs have been funded with the support of carbon pricing revenue to help Aboriginals gain skills, knowledges and competencies in order to find opportunities in this new economy pattern while also bridging good relationship between Aboriginals and non-Aboriginals. The initiatives such as AICCP, AIGEP, AICPP, AIEERP and AICEP that funded by carbon levy are making their moves to help reduce diesel in remote communities. Reducing the number of oil and gas developments can help narrowing down the projects that also bring benefit for minority stakeholders such as indigenous community. Programs that support implementing solar panels in indigenous communities also helps them adapt with the energy transition trend.

6.2 Economic Impact

Carbon pricing can help with the GHG emission in some way as the policy limiting the activities of GHG emissions. Comparing the time when carbon pricing has been implemented in Alberta, which is 2007, there is a trend of steady increase in GDP growth even with two recessions happened in 2008 and 2014. While it cannot indicate that carbon pricing has a direct

positive relationship with GDP growth, it does provide evidence to show that carbon pricing is a contributing factor to GDP growth.

Even though the carbon pricing policies does not appear to be affecting Alberta's GDP growth very much in some industries, it is still undeniable that ERA is making an effort towards creating a more diverse environment for Alberta's economy growth. The 161 projects ERA funded are in varies industries that brings more employment opportunities to people. By end of 2018, the projects ERA funded have added $1.8 billion to Alberta's GDP and created 1400 jobs each year (Environmental Defence, 2018). The clean energy projects that contribute to the growth of Alberta's economy by creating jobs and investment opportunities, which highlights numbers of new energy projects operating or under construction in Alberta from 2012 to 2017, lead to 10,650 jobs that time and more coming in the future (Pembina Institute, 2017).

In addition, the implementation of carbon policies is a good way to stimulate the deployment of renewable energy. With current global trend of energy transition, renewable energy has been recognized as an excellent opportunity that helps to diversify a country's skill base, while also boost its industrial development and support societies' broad developmental priorities at the same time (IRENA, 2017). Taking Alberta as an example, under the current background of energy transition along with carbon policies, the result of total 95.4 million tonnes of CO2 emission reduction since 2007 to 2018 under SGER (Government of Alberta, 2018d), in which lighten the tension on ecosystems and human health. Under Alberta emission offset system, the offset credits are firstly used to renewable energy, agricultural projects, and waste projects, which renewable energy takes 31% of all coverage areas (World Bank, 2020). The amount of CO2 emission reduction builds a positive social profile for Alberta as well as encourage more investment and research on clean energy development. For example, $10 million

went into Alberta Innovates in 2017 to help with research and technology sector in diversifying Alberta's economy (Environmental Defence, 2018). The development and implementation of technologies will no doubt play a key role in helping Alberta moves towards a low-carbon economy.

Chapter 7. Conclusion and Recommendation

7.1 Limitation

As with all research projects, we do recognize that our research has its limitations.

First, we cannot make a conclusive statement saying that the increase of unemployment rate in Alberta is a direct result of the implementation of carbon policies. Based on our research, carbon policies are likely to be a contributing factor, but many other factors are in play. For example, the two recessions in the year 2008 and 2014 may also have contributed to the increase of unemployment in the province. It is out of the scope of our research to say which factor is the main culprit for the increasing unemployment rate in the province from 2007 to 2019. Our research is only presenting the evidence gathered through interpretation of government released data. Although it is impossible to determine whether carbon policies have directly caused the rising unemployment rate in the province, it is clear that any employment created by the policies is unable to off-set the increase. For example, if 50 jobs were created under the implementation of the carbon policy and 100 jobs were lost because of the recessions, then we could say that the jobs created through the implementation of the carbon policy could not neutralize the loss of jobs. This means that even though the carbon policies may create employment opportunities, we still see an increase in unemployment rate.

Second, the diversification of the economy was analyzed through comparing the GDP distribution of each industry with the revenue breakdown of the carbon policies. The revenue generated under the carbon policies was funded to various projects in different sectors. By comparing the sectors' growth before and after receiving the funding from the government, we were able to see if the funding had an impact or not. However, again we cannot make a conclusive statement saying that the funding from the government is the only contributing factor

and is directly responsible for the growth of the different sectors. We can only say that the funding has potentially contributed to the sectors' growth and it is a gesture from the government to show its determination in moving towards a more diversified economy.

Third, the raw data used in our research mostly came from sources other than ourselves. The reliability of the data may have to be considered when analyzing the data.

7.2 Future Outlooks

TIER Regulation stands for Technology Innovation Emissions Reduction, and it applies to any facility that has emitted 100,000 tonnes or more of carbon dioxide equivalent greenhouse gases since 2016 (Fiorillo, 2019). TIER Regulation is currently the newest regulation in Alberta, and it had just become effective since January 1, 2020. This means that it is still too early to determine its effects on the society and economy, especially now with the pandemic of COVID-19.

Based on the released details of the TIER Regulation, it is predicted to have the following possible positive and negative effects. Not only large emitters, but small emitters can also opt-in to be regulated under TIER. Small emitters can join either as an aggregate (under common Person Responsible) or individually (if it competes with a facility that is regulated under TIER or has an emission over 10,000 tonnes in an emission-intensive sector) (Fiorillo, 2019). By being regulated under TIER Regulation, companies will be protected from the full costs of the GGPPA (Greenhouse Gas Pollution Pricing Act), which is a federal fuel charge applying to fossil fuel usages. This provides incentives for both large and small emitters to become regulated under TIER and may further reduce GHG emissions. Also, new companies regulated under TIER will be provided with a three-year relief from compliance, which can promote new companies to become regulated under TIER. The more companies to become regulated under TIER, the more

effective TIER will become. TIER uses facility-specific benchmark methodology, which means that each facility is required to reduce emissions intensity by 10 per cent relative to its own average emissions intensity. Each facility operates differently and have different rates of emission. With facility-specific benchmark methodology, the uniqueness of every facility has been considered. However, facility-specific benchmark methodology discourages small emitters to adopt the best technologies available, since they have low limits on emission.

Under TIER, a tightening rate of 1% will be added to facilities starting 2021 (Fiorillo, 2019). A tightening rate encourages companies to invest in innovative technologies to keep up with the reduction requirements, but 1% may be too little for large emitters. If we are to make the transition from fossil fuels to green energy faster, then a higher tightening rate is recommended. At the same time, the tightening rate of 1% each year is not applied to Industrial Process (IP) emissions. Setting a price to IP emissions will provide less financial motivation to identify and capture low-cost IP emission sources. It will also promote companies to find new ways or innovations to reduce emissions. Finally, the three-year relief period mentioned above may also be shortened to promote more rapid innovation developments. A long relief period may cause companies to be stagnant in their innovation developments. A sense of urgency is often needed in the market to make the market itself more competitive with new technologies.

7.2.1 Post-Pandemic Influence

In December 2019, a novel coronavirus, which was later to be named COVID-19, was identified in Wuhan, China. Like a wildfire, the virus quickly spread to the rest of China and later, the whole world. It had become a global pandemic in less than three months. Unfortunately, Canada was not exempted from the pandemic.

Due to the severity of the pandemic, many countries, including Canada have decided to put their citizens on various forms of lockdown. This had affected the global economy greatly. Since both the evolution of the virus and the duration of the pandemic are uncertain, the impact of the pandemic can only be studied through scenarios. In some scenarios, it was estimated that the GDP of certain countries would fall from 10% to 15% in 2020 (Fernandes, 2020). In the short term, the pandemic could still have a significant impact on the global economy even with containment measures (McKibbin & Fernando, 2020). According to Statistics Canada, the unemployment rate in Alberta in April 2020 had reached 13.4% (Statistics Canada, 2020b).

In addition to the high unemployment rate in Alberta, people were told to stay home and to practice social distancing. This can cause various industries to face either supply or demand shocks, and in some cases, both (del Rio-Chanona, Mealy, Pichler, Lafond, & Farmer, 2020). Temporary supply and demand shocks created by the pandemic makes the effects of the TIER regulation ambiguous. Thus, due to the special circumstance, it is our prediction that the full effects and impact of TIER on the economy will not be seen even in 2021. This is because that the economy needs time to recover, and the unemployment rate also needs time to stabilize. This process may take longer than just one year.

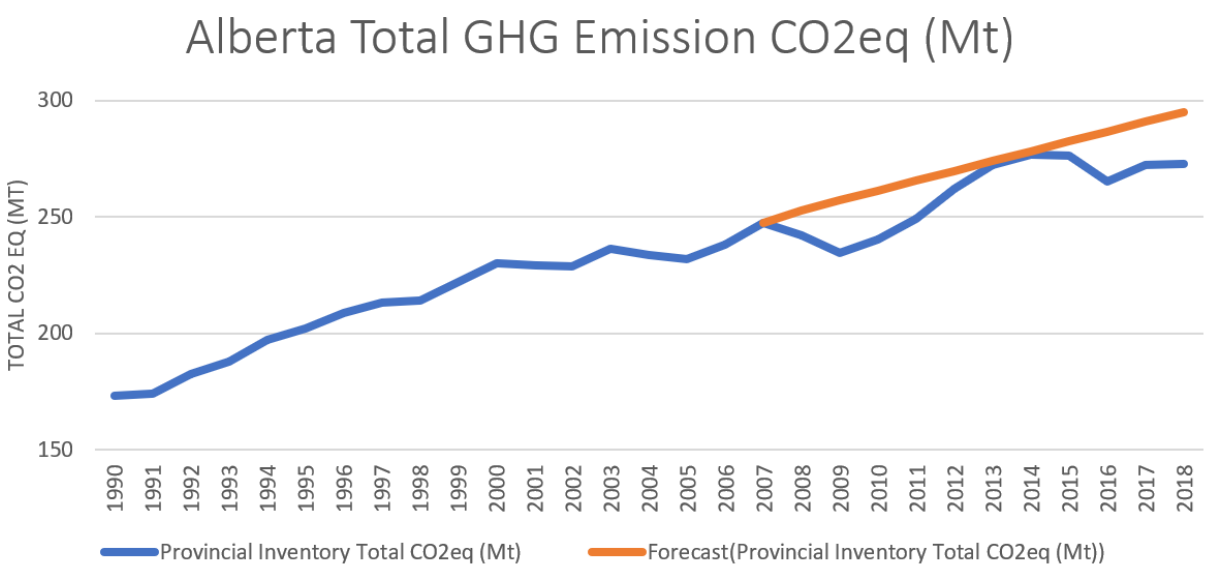
7.3 Conclusions

Based on the emission pattern from the years 1990 to 2006 (Government of Canada, 2020), greenhouse gas emission projections were made for the year 2007 and onwards (Figure 12). The orange line represents the expected emission total, while the blue line is the actual annual emission total. From this graph, we can see that the actual emission total for years 2007 to 2018 had never surpassed the expected emission total. This indicates that the carbon policies

were in fact contributing to the reduction of greenhouse gases being released into the atmosphere.

In addition to the projections made based on the emission pattern from years 1990 to 2006, the provincial government had also set targets for GHG emissions in Alberta. The GHG emission target will be 277 Mt by 2020 and 270 Mt by 2030 (Boothe & Boundreault, 2016). From Figure 12, we can see that the most updated data shows that the total emission of GHG in 2018 is 272.554378 Mt, which is below Government of Alberta's 2020 target. PC (Progressive Conservative) was in charge for couple of decades until NDP (New Democratic Party) was elected in 2015. Data about the details of results from carbon mechanisms were not transparent enough to collect until NDP introduced CLP to make some changes addressing on GHG emission. Even though CLP did make its reports more transparent and easier to access, it did not set a target for total GHG emission. Despite Alberta's efforts in reducing GHG emissions in the province, it is still obvious to see that there is an increasing trend of emission production since 1990 (see Figure 12). The carbon policies implemented by the Alberta government had kept the GHG emissions below its provincial target but were unable to make a change to the general trend of GHG emissions.

Figure 12. Graph showing the actual and forecasted provincial emission of CO2eq from 2007 to 2018. Calculated from Canada's Official GHG inventory, Government of Canada.



(Government of Alberta, 1990-2018)

While not denying the contribution of the carbon policies in the reduction of greenhouse gas emissions, the policies do have their shortcomings. After the implementation of the carbon policies, we can see an increase of the unemployment rates in Alberta from 2007 to 2019. This increase of unemployment rate in the province is likely to be affected by the carbon policies. Even though part of the carbon levy revenue has been spent to small business tax reduction, the barrier has still been raised to entry for small businesses. Small businesses play a vital in the economy because they provide and create employment opportunities. Carbon policies have also raised the production cost of industrial goods and services, and this causes companies to reduce their output. With a reduction of output, the demand for labor will be affected. Due to the added price of carbon tax on consumer goods, families, especially those with lower income, may choose to cut their spending. Less demand causes supply to fall, which again leads to

manufacturing companies reducing their output. The recessions in 2008 and 2014 may also have played a role in the increase of unemployment rates in Alberta, but it is out of the scope of this study. Although we recognize that the recessions may have played a role in the increase of unemployment rates in Alberta, carbon pricing policies are still a major contributing factor.

It is understandable that as Alberta is adjusting from the past recession and oil price crushes, it is still finding a new way for development growth. While trying to adapt with the current energy trend is not easy, there are still evident effort put in by government and organizations. The GDP growth in mining, quarrying, oil, and gas industry has a trend of decline since 2007, while health care, social assistance and public administration on the other hand has an incline through 2007. Unemployment rates increased along with the trend, especially in oil and gas industry which typically has a higher wage. Although there is no major change of GDP growth in other non-oil and gas industries, it is still undeniable that projects and programs have been funded to help Alberta to diversify its economy. Approximately 161 projects that cover cleaner oil and gas, low emitting electricity supply, food, fiber and bioindustries, and low carbon industrial processes and products have been funded by ERA from government funding and with revenue generated from carbon levy. Carbon polices have played an important role in supporting these projects with the revenue it generated.

Taking the benefits that carbon policies can bring, such as spending the carbon levy revenue into energy efficiency, innovation and clean technology, transit and infrastructure, and electricity transition, Alberta is on the direction of moving itself towards a low-carbon economy. It is also helping indigenous communities to adapt to the changing environment as well. While the carbon policies help GHG reduction, the rise of renewable energy that stimulated by

implementing carbon policies are creating more potential and opportunities for a diverse environment.

Therefore, we conclude that the implementation of carbon policy is working on its way of helping Alberta to move toward a low-carbon future. However, despite their efforts, the carbon policies in Alberta are insufficient in job creation and economy diversification because it was followed by a significant increase of unemployment rate within the province after implementation. Any jobs created by the carbon policies were unable to offset the observed increase of unemployment rate.

7.4 Recommendations and Future Research

To further diversify Alberta's economy, decision makers need to focus on how to maximize the utility of existing solutions on climate change, such as carbon pricing policies, rather than keep making new regulations to temporarily meet the climate change standard. The performance of past carbon pricing policies shows Alberta's determination to make a change. Although the outcome may not be satisfactory, it does take time and effort to get a more significant result from placing carbon pricing policies. Patience and consistency are needed in order to improve the policy. The goal to reduce GHG emissions is just a beginning, more areas need to be covered along with the improvements to the policy. Policy improvement on rural area is also needed as they have bigger impact on climate change with bigger percentage of using diesel. Green technology implementation needs to be taken into consideration. In addition, more clear and transparent data need to be available to the public, so people can have a better idea of the effectiveness of the policies. It is our suggestion that the government should put a feedback system in place.

Furthermore, cumulative impact assessment needs to be improved and implemented to future oil sands developments as the projects may have impacts that cannot be seen in present. In this case, communities that are nearby sites will likely to avoid the chance of having dieseases that caused by the hazardous air pollutants that generated from the oil sands sites. Government needs to have an independent investigation on health impacts from existing oil sands sites as well to make sure the investigation and result on a project is transparent.

Public participation such as Indigenous communities and other minority stakeholder's feedback also need to be heard in order to improve policy. We are living on the same land that activities done by anyone makes a difference to it. Listening and involving people that have been less heard can help us improve and achieve our goal together as a whole.

When the economy is healthy and prosperous, compliance to the carbon policy is not difficult to achieve. The additional cost of the carbon tax is not likely to have a tremendous effect on the operations of businesses. Even though the carbon tax can be passed on to the consumers, but with a low unemployment rate in a healthy economy, the purchasing power and behaviors of the consumers will not necessarily change. This all changes if the economy is in recession with reduced economic activities. The carbon pricing policies heighten the barrier to entry for many small businesses, and with a high unemployment, consumers tend to change their spending behaviors to cope with lowered disposable income. At the same time, demand and supply shocks further complicate the situation by creating an atmosphere of uncertainty in the market.

Thus, it is our recommendation that during times of recession or reduced economic activity, such as the COVID-19 pandemic, it is necessary to extend compliance of carbon policies. It can also be helpful to lower the rate of carbon tax to encourage small businesses to enter the market and for investors to gain confidence in the market. Further research needs to be

done on a threshold-system, where carbon tax will only be imposed when a certain rate of economic growth has been achieved. This makes sure that in times of economic recession, the carbon policy will not become a burden on the economy.

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