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Analyzing the Macroeconomic and Supply Chain Impacts of CO_2 Capture Technology: An Input-Output Framework for the Construction Phase

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Abstract

Carbon Capture, Utilization, and Storage (CCUS) is considered as a very important technology for reducing greenhouse gas emissions. While reducing the emissions, it enables the existing industries to continue their operations. Most of the previous studies on this topic focus only on the microeconomic analysis of CCUS and its macroeconomic aspects, in particular its **construction phase** has not been covered. The objective of this paper is to address this gap by evaluating the macroeconomic impact of constructing a CO_2 capture system in Saskatchewan, Canada. This study uses a provincial Input-Output (IO) table for Saskatchewan and the Leontief model to analyze how investment in the construction phase of the capture system, focusing on direct equipment costs, affects industry output, GDP, and employment. The results from this analysis show that an investment of CAD 217.8 million can result in an output increase of approximately $1.83 billion, a GDP impact of $900 million and the creation of about 5,588 jobs. These findings show that the construction of carbon capture projects in a specific region can generate significant benefits across the supply chain and can lead to economic growth in that region. This paper also highlights the steps that should be taken and limitations of such analysis and proposes future directions for addressing these limitations.

Keywords
Carbon Capture, Macroeconomic Impact, Input-Output Analysis, Supply Chain Effects

1. Introduction

Climate Change and the negative impacts of Greenhouse gas (GHG) emissions, in particular CO_2, on the environment is an urgent issue worldwide (Leonzio & Shah, 2024). To address this issue, about 130 countries suggested "zero carbon" climate plans to reduce these emissions (Zhou et al., 2023). Global CO_2 emissions rose by 6% in 2021, and as per one of the reports of the Intergovernmental Panel on Climate Change (IPCC), in order to reach the net-zero emissions target by 2050, the production of greenhouse gases (GHG) must be cut by approximately 45% between 2010 and 2030 (Gowd et al., 2023). Carbon Capture Utilization and Storage (CCUS) is considered one of the solutions that enables the economic growth of industries and, at the same time, tackles environmental challenges (d'Amore & Bezzo, 2020).

CCUS is the process of preventing CO_2 from being emitted into the air by collecting it from the emission sources, storing it permanently, or utilizing it in other industrial processes (Yang et al., 2023). This technology has the effect of making the current industrial plants keep running and, meanwhile, capture their emissions (Fan et al., 2022). It has three main steps: first, Gathering CO_2 from industrial or power plants; second, transporting captured CO_2 via various methods like pipelines or vehicles; and third, injecting it into reservoirs for storage or utilization (Foukolaei et al., 2024). The Global Status of CCS Report mentions that 65 commercial CCUS facilities exist worldwide that can absorb 0.1% of CO_2 emissions, which shows that its development is not fast enough to reach "zero carbon" goals by 2050 (Rakhiemah & Xu, 2022). As a result, it will be very challenging to achieve neutral carbon goals considering current CCUS capacities, and without supporting policies and regulations, its commercialization will not be possible (Yetişkin et al., 2023). Without supporting policies and regulations, CCUS commercialization will not be possible because it is a new technology and is associated with many uncertainties (Jiang et al., 2020).

Another important challenge that can prevent CCUS projects from commercialization is its high costs and financial uncertainties (Yao et al., 2021). To tackle these problems and reduce the uncertainties, careful financial analysis and calculations such as cost-benefit analysis, feasibility studies and evaluation of its environmental, social, and economic aspects, which are the triple bottom line of sustainability, are very important (Fan et al., 2022; Liyanage et al., 2021). Since CCUS is a very important topic worldwide, many countries like Canada encourage their high-emitting industries to adopt them (Wang et al., 2023), and there is no doubt that this huge investment in these technologies will affect the overall supply chain and economy (Chen & Jiang, 2022). Since the majority of previous studies on these technologies mainly focused on their micro-level economic implications through methods like cost-benefit analysis or techno-economic analysis and the broader macroeconomic impacts of CCUS projects have been ignored, this study aims to capture their economic implications on the overall economy and supply chain by using input-output (I-O) analysis in the Canadian context. As a result, this study, which is one of the first studies that explores the macroeconomic implications of CCUS technologies in Canada using the I-O analysis method, can provide valuable insights for business owners and policymakers who are seeking to employ CO_2 capture in their processes. Considering the importance of CCUS technologies and their broader impacts, this study explores to answer the following questions:

1. How can Input-Output (I-O) analysis be used to assess the macroeconomic and supply chain implications of constructing CO_2 capture facilities?
2. What industry classifications and data mapping are required to model the construction phase of CO_2 capture projects in an I-O framework?
3. What are the key considerations and limitations in applying I-O analysis to our case?

After the introduction, the second chapter covers the literature review. The third chapter discusses the methodology and Input-Output framework results of the literature review. Finally, the fourth and fifth chapters cover the application of I-O analysis to CCUS and the conclusion, respectively.

1.1 Objectives

The objective of this study is to develop an Input-Output framework to analyze the economic impacts of a carbon capture project in its early stages on the supply chain. In this analysis, the value of investment in capital expenditures is considered for evaluation of the macroeconomic impacts of constructing a CO_2 capture system in Saskatchewan, Canada. It focuses on capital costs of direct equipment related to a capture facility to estimate changes in industry output, GDP, and employment. It also highlights the steps of developing this IO framework and the limitations related to it for analyzing the construction phase of a carbon capture project.

2. Literature Review

2.1 Micro-Level Studies

CCUS is an emerging technology that addresses climate change problems. The financial viability of these technologies has been widely evaluated through different methods, such as techno-economic analysis, which focuses on its micro-level economic implications. For instance, Zhou et al. (2023) focus on the optimization of the CCUS process as an important requirement for the economic viability of these technologies. Rakhiemah and Xu (2022) and Fan et al. (2020) employ the cost-benefit analysis method for evaluating the economic feasibility of CCUS, considering its utilization in Enhanced Oil Recovery (EOR). (Gowd et al., 2023) assess the viability of CCUS projects, and their findings show that although CCUS is technologically feasible, economic barriers and lack of proper supporting policies can restrict their commercialization. Ye et al. (2022) utilize system dynamics to evaluate the economic feasibility of CCUS projects with a focus on industries like coal-fired power plants and oil extraction. Suicmez (2019) conducted a feasibility study for the deployment of CCUS technologies in the Danish North Sea by introducing oil price, discount rate, CO_2 cost, and tax incentives as key parameters that can influence the economic viability of these technologies. Chauvy et al. (2021) assess the economic viability of CCUS by Techno-economic Analysis (TEA) and, simultaneously, focuses on its environmental performance via cradle-to-gate life cycle assessment and mention that CCUS can become economically viable as CO_2 can be used to create products such as methane, methanol, carbonates, etc.

2.2 Macro-Level Studies

As the implementation of CCUS has economic effects on the entire supply chain, especially in energy-intensive industries such as power plants, it is extremely critical to study its macroeconomic effects. Ostovari et al. (2023) discuss the macroeconomic effect of CCUS through a review of the literature and highlight that substantial investment and enabling policies are needed for the commercialization of CCUS. The macroeconomic studies by Ampomah et al. (2024) show that although CCUS adoption can face different technical and economic challenges, its large-scale adoption and its integration with EOR have the potential to introduce opportunities for economic growth. Basri et al. (2024) discuss that innovations in CO_2 utilization and changing it to economically valuable products can support the circular economy.

2.3 Input-Output Analysis

The input-output (I-O) method is a very important tool in macroeconomic analysis since it can capture the economic interdependencies between different industries and sectors, as well as how changes in one industry can affect other industries (Jung et al., 2024). It has different applications in various studies. For example, Okuyama (2004) used the input-output analysis method to evaluate the economic impact of disasters and highlighted that this method enables them to simulate the economic impacts of earthquakes and help policymakers understand how to tackle this issue. Kim and Kim (2015) assessed the economic contribution of the hospitality sector and measured its direct, indirect, and induced effects on the local economy. Dumas et al. (2008) used the input-output analysis to calculate the economic contribution of the healthcare system and gave suggestions on how their findings could be useful in informing healthcare funding policy.

2.4 Input-Output Applications in Energy and CCUS Studies

The input-output analysis method has also been increasingly used in energy sector studies, including the ones that are relevant to CCUS. Liu et al. (2020) used an Environmentally Extended Input–Output (EEIO) analysis method to evaluate the environmental impact of different energy systems in Canada and Saskatchewan through their lifecycle. This paper incorporates every energy system's emission figure in the IO table for calculating the direct and indirect emissions of various sectors. It supplies information on environmental issues related to various energy systems.

Wimmer et al. (2023) Employed the Input-Output approach to analyze how the shift from fossil fuels to renewable energies can impact the national economy of Japan. They also used historical IO tables to find out how changes in energy consumption can influence economic interdependencies between industries, which is very important for understanding the broader impact of energy transition. Chen and Jiang (2022) use the Input-Output method to analyze CCUS's macroeconomic impacts and mention that investment in these technologies has the potential to create many jobs. They assess the long-term economic and social impacts of CCUS projects, including GDP contribution, job creation, and industry growth.

2.5 Research Gaps

Although there are studies covering the economic analysis of CCUS projects, the majority of studies focused on the microeconomic aspects of these projects and their financial feasibility. However, there is still a large gap in the macroeconomic evaluation of CCUS and its broader impacts on the supply chain and overall economy, in particular in the Canadian context. Moreover, existing literature has not covered the **construction phase** of CO_2 capture projects, which plays a critical role in understanding their initial economic impacts. Therefore, the objective of this paper is to introduce an IO framework for the macroeconomic analysis of CCUS projects in their construction phase in Saskatchewan.

3. Methods

3.1 Scope

In this study, an Input-Output method is employed to evaluate how a Carbon Capture, Utilization, and Storage (CCUS) project can impact the overall supply chain, and it focuses on the CO_2 capture facility only for a Hydrogen refinery plant in Canada Saskatchewan and excludes its transportation, storage, or utilization stage. This is because the capture phase is associated with extensive investment, and it can significantly affect the economy (Lin et al., 2021). In addition, this paper only considers the construction phase of the CCUS plant because this phase has immediate impacts on the economy since extensive investment in equipment and labor can influence GDP and employment rate and evaluating it can provide us with information about the initial economic aspects of these technologies before they are operational (Turner et al., 2019).

3.2 Input-Output Analysis Framework

The Leontief input-output model is basically constructed by considering past economic data from a specific region. It focuses on the activity of different industries and the flow of products between them while they produce outputs for and consume inputs from each other. This information can be shown in a matrix while the rows represent the distribution of outputs by producers, and the columns show the consumption of inputs by user industries. These interindustry relationships are shown in the Intermediate part of the matrix. In contrast, Final Demand is shown in the additional columns and represents the sale of products to final markets such as governments or households. Moreover, there are some additional rows called Value Added and represent non-industrial inputs such as imports, taxes, labor, etc. (Miller & Blair, 2009). According to Miller and Blair (2009), the input-output framework is shown in **Table 1**, and the model is represented as:

Table 1. Input-Output Transaction Table (Miller & Blair, 2009)

		Producers as Consumers								Final Demand			
		Agriculture	Mining	Construction	Manufacturing	Trade	Transportation	Services	Other Industry	Personal Consumption Expenditures	Gross Private Domestic Investment	Govt. Purchases of Goods & Services	Net Exports of Goods and Services
Producers	Agriculture												
	Mining												
	Construction												
	Manufacturing												
	Trade												
	Transportation												
	Services												
	Other Industry												
Value Added	Employees	Employee compensation								Gross Domestic Product (GDP)			
	Business Owners and Capital	Profit-type income and capital consumption allowances											
	Government	Indirect business taxes											

$$x = Ax + f$$

Where:

- x = total output vector ($n \times 1$)
- A = technical coefficient matrix ($n \times n$)
- f = final demand vector ($n \times 1$)

Rearranging the equation:

$$x = (I - A)^{-1} f$$

Here, $(I - A)^{-1}$ is known as the **Leontief inverse** and shows the total output required from each industry to satisfy the final demand. To find the Leontief inverse, first, the **Technical Coefficient Matrix** should be found by using the following equation:

$$a_{ij} = \frac{z_{ij}}{x_j}$$

Where:

- z_{ij}= value of input from industry i to j
- x_j= total output of industry j

This represents the input that is needed from industry i to produce one unit of output in industry j. Then, the Leontief inverse matrix is derived as:

$$L = (I - A)^{-1}$$

It captures the total (direct and indirect) output impact of a one-unit change in final demand across all industries. Once the final demand vector f is found, total output changes are calculated as follows:

$$x = L.f$$

By finding out the total changes in output, changes in GDP and employment rate can also be calculated.

4. Data Collection

This chapter describes the data collection process for our Input-Output analysis of the construction phase of a CO_2 capture system in Saskatchewan, Canada. In the IO table, the final demand vector includes activities like export, household consumption, investments, etc. Since we only consider the construction phase of a capture system, the collected data is used to form the final demand of our input-output table.

4.1 Capital Cost Data for CO_2 Capture

The capital cost (CAPEX) data for this analysis was derived from a publicly available technical report published by the US Department of Energy's National Energy Technology Laboratory (NETL). This report is the primary source for identifying the list of equipment required for a carbon capture plant and the value of each piece of equipment. In this report, the capital cost of a carbon capture plant is estimated, including equipment-level costs and Total Plant Costs (TPC), considering different industries such as cement, steel/iron, and hydrogen refineries (Hughes & Zoelle, 2022). Although the Input-Output model framework can be used for any industry, in this study, hydrogen refinery data was considered for the development of our model because this industry includes a broader list of equipment compared to other industries. The case specifications are shown in **Table 2.**

Table 2. Case Specifications

Case	Refinery H_2
Capacity (ton/year)	87000
Capture Capacity (%)	90%
CAPEX ($)	$160,556,000 USD
Year	2018

4.2 Input-Output Tables and Industry Classification

To develop our input-output model, **provincial input-output (IO) tables for Saskatchewan** were found in **Statistics Canada**. The latest version of IO tables is for the **2021 reference year** and was published in **November 2024**.

Next, each piece of equipment found in the report by Hughes and Zoelle (2022) was assigned to its relevant industry using *the North American Industry Classification System (NAICS) Canada (2022, 2024)*. Industry assignment was done using official NAICS definitions and relevant classification tools provided by Statistics Canada. **Table 3** shows equipment assignments to the industries.

Table 3. Capital Expenditure Assignment to Industries

Item No.	Description	NAICS	Industry
3.1	Feedwater System	BS333300	Commercial and service industry machinery manufacturing
3.2	Water Makeup & Pretreating	BS333300	Commercial and service industry machinery manufacturing
3.3	Other Feedwater Subsystems	BS333300	Commercial and service industry machinery manufacturing
3.4	Industrial Boiler Package w/Deaerator	BS332400	Boiler, tank and shipping container manufacturing
3.5	Other Boiler Plant Systems	BS332400	Boiler, tank and shipping container manufacturing
3.6	NG Pipeline and Start-Up System	BS486200	Pipeline transportation of natural gas
3.7	Waste Water Treatment Equipment	BS333300	Commercial and service industry machinery manufacturing
3.9	Miscellaneous Plant Equipment	BS339900	Other miscellaneous manufacturing
5.1	ADIP-Ultra CO_2 Removal System	BS333900	Other general-purpose machinery manufacturing
5.4	CO_2 Compression & Drying	BS333900	Other general-purpose machinery manufacturing
5.5	CO_2 Compressor Aftercooler	BS333900	Other general-purpose machinery manufacturing
5.12	Gas Cleanup Foundations	BS23C500	Other engineering construction
7.3	Ductwork	BS333400	Ventilation, heating, air-conditioning and commercial refrigeration equipment manufacturing
7.4	Stack	BS332A00	Cutlery, hand tools and other fabricated metal product manufacturing
7.5	Duct & Stack Foundations	BS23C500	Other engineering construction
9.1	Cooling Towers	BS333400	Ventilation, heating, air-conditioning and commercial refrigeration equipment manufacturing
9.2	Circulating Water Pumps	BS333900	Other general-purpose machinery manufacturing
9.3	Circulating Water System Aux.	BS333900	Other general-purpose machinery manufacturing
9.4	Circulating Water Piping	BS332A00	Cutlery, hand tools and other fabricated metal product manufacturing
9.5	Make-up Water System	BS333900	Other general-purpose machinery manufacturing
9.6	Component Cooling Water System	BS333900	Other general-purpose machinery manufacturing
9.7	Circulating Water System Foundations	BS23C500	Other engineering construction
11.2	Station Service Equipment	BS335300	Electrical equipment manufacturing
11.3	Switchgear & Motor Control	BS335300	Electrical equipment manufacturing
11.4	Conduit & Cable Tray	BS335300	Electrical equipment manufacturing
11.5	Wire & Cable	BS335300	Electrical equipment manufacturing
12.8	Instrument Wiring & Tubing	BS335300	Electrical equipment manufacturing
12.9	Other I&C Equipment	BS335300	Electrical equipment manufacturing
13.1	Site Preparation	BS23C500	Other engineering construction
13.2	Site Improvements	BS23C500	Other engineering construction
13.3	Site Facilities	BS23C500	Other engineering construction
14.5	Circulation Water Pumphouse	BS23C500	Other engineering construction

4.3 Final Demand Vector Construction

After each piece of equipment is assigned to an industry using the NAICS system, the total cost of investment in each industry can be found by aggregating the estimated cost of equipment items that fall under that specific industry. These values can be added to the Final Demand vector of our Input-Output table, which shows the value of a new investment in the Saskatchewan economy for the construction of a capture facility.

The cost data found in the NETL report are in **2018 US dollars**. Since our Input-Output tables are in **Canadian dollars** and are for the year **2021**, we need to convert the cost data by following these two steps:

1. **Currency Exchange:** First, the 2018 US dollar values are converted to 2018 Canadian dollars using the average 2018 exchange rate (1 USD = 1.2957 CAD), which is provided by the Bank of Canada (*Table 33-10-0163-01: Monthly Average Foreign Exchange Rates in Canadian Dollars, Bank of Canada*, 2025).
2. **Inflation Factor:** After we find the Canadian dollar value of our costs, we need to adjust it to the 2021 Canadian dollar by applying the inflation factor of Saskatchewan. Based on the Bank of Canada, the inflation factor can be calculated by using the **Consumer Price Index (CPI)**. According to the Statistics Canada (Table 18-10-0004-01 Consumer Price Index, Monthly, Not Seasonally Adjusted, 2025), CPI increased from 135.62 in 2018 to 142.04 in 2021. By having the CPI, the inflation factor is equal to 1.047 by using the following equation:

$$Inflation\ Factor = \frac{CPI_{2021}}{CPI_{2018}}$$

After assigning each piece of equipment to the relevant industry using NAICS and converting the costs to 2021 Canadian dollars, the resulting industry-level values form the final demand vector of our IO table. These values show the amount of investment in each industry to construct a carbon capture facility.

4.4 Key Assumptions

Since the data that is collected for this paper is US-based, for more simplicity, we assumed that the market conditions of the US and Canada are comparable. Therefore, only the exchange rate is used to convert US values to Canadian dollar values. This assumption imposes some limitations on this study, and it is important to acknowledge that some important differences, such as labor costs, taxation, and market dynamics, are not considered, and it can impact the accuracy of the results. As a result, this issue will be addressed in future studies by performing sensitivity analysis and comparing the results under different circumstances.

5. Results and Discussion

This chapter explains how the input-output (IO) model can be employed by using final demand data, which is constructed in Section 4. Although the numerical results are not reported in this paper, the purpose of this chapter is to show how the IO model can be utilized to capture the economic impacts of a carbon capture project in its construction phase. This structure can be used in future studies with real data for any carbon capture project.

5.1 Model Implementation and Results

After the final demand vector is constructed in Section 4, it should be multiplied by the Leontief Inverse, which was found using the Saskatchewan 2021 Input-Output table. The results of this multiplication give us a new total output vector that shows the output value required to support the investment. In this case, the change in output because of investment in a carbon capture project is equal to $1,834,770,000.91. After we find the output value generated by our investment in each industry, we can use this value to determine the gross domestic product (GDP) and employment impact of our investment on Saskatchewan's economy.

5.2 Estimating GDP and Employment Impacts

- **Gross Domestic Product (GDP) Impact**

To find the impact of a CO_2 capture project with assumed specifications on Saskatchewan's GDP, after finding the new total output vector based on (Miller & Blair, 2009), the following equation can be used:

$$GDP\ Impact = \sum_i (\Delta x_i \times VA\ Ratio_i)$$

Where:

- x_i = Total Output of industry i
- $VA\ Ratio_i = \frac{Value\ Added_i}{Output_i}$

In our case, with an investment of USD 160,557,000.21 (2018), equivalent to CAD 217,811,000.57 (2021), the GDP impact is equal to CAD 900,455,000.45, which represents approximately **1% of Saskatchewan's initial GDP**.

- **Employment Impact**

Employment Impact can also be calculated considering the following equation based on (Miller & Blair, 2009):

$$Employment\ Impact = \sum_i (\Delta x_i \times EC_i)$$

Where:

- EC_i = Employment Coefficient = $\frac{Total\ Employment\ in\ Industry_i}{Total\ Output\ of\ Industry}$

In this case, based on Statistics Canada (Table 14-10-0202-01 Employment by Industry, Annual, 2025), total employment in 2021 in Saskatchewan is equal to 466,785 jobs, and the employment impact of this investment is equal to 5,588. This means this investment can create 5,588 jobs in Saskatchewan, which is 1% of the overall existing jobs.

- **Changes in Output by Industry**

In this section, changes in output by industry as a result of a CCUS project construction are found for directly related industries to the project by following the Leontief Inverse steps. Based on the results, the largest effects are concentrated in equipment industries such as general-purpose machinery manufacturing (CAD 182,789,000), commercial and service industry machinery manufacturing (CAD 36,239,000), and electrical equipment manufacturing (CAD 28,694,000). On the other hand, the impacts on construction-related industries (CAD 3,274,000) and natural gas pipeline transportation (CAD 929,000) have the lowest changes.

Table 4. Changes in Output by Industry

Code	Title	change in total output
BS23C500	Other engineering construction	$ 3,274.43
BS332A00	Cutlery, hand tools and other fabricated metal product manufacturing	$ 6,274.83
BS332400	Boiler, tank and shipping container manufacturing	$ 3,799.40
BS333300	Commercial and service industry machinery manufacturing	$ 36,239.44
BS333400	Ventilation, heating, air-conditioning and commercial refrigeration equipment manufacturing	$ 2,683.67
BS333900	Other general-purpose machinery manufacturing	$ 182,788.53
BS335300	Electrical equipment manufacturing	$ 28,693.97
BS339900	Other miscellaneous manufacturing	$ 1,626.14
BS486200	Pipeline transportation of natural gas	$ 928.76
Total		**$ 266,309.17**

This results show the importance of equipment and technology industries in CCUS projects. In total, the directly related industries make up CAD 266,309,000.17 of change in output, while the overall change across all industries is CAD 1,834,770,000.91. This means that the majority of economic gains are in industries that are not directly linked to the project, which shows the importance of indirect supply chain effects. The details of output by industry are shown in Table 4.

5.3 Discussion

In this paper, an Input-Output method is used to find the macroeconomic impacts of constructing a carbon capture plant in Saskatchewan, Canada. This method enables us to understand how capital investment in a CO_2 capture system can affect the economy and overall supply chain. The Leontief Inverse calculations used in the IO analysis can track how investment in a specific project and changes in final demand can spread through the economy by increasing the total output of not only relevant industries but also other industries that are not directly connected to a specific project or industry. By utilizing this method, we could quantify the changes in total output of different industries, GDP impact and employment impact in Saskatchewan, Canada, as a result of investment in a CO_2 capture project. The results show that the construction of a specific Carbon capture project can stimulate different industries, which shows the importance of the clean energy transition and its broad interindustry linkages.

The sectoral breakdown of results provides further insight into how these impacts are distributed across the economy. The largest direct gains are concentrated in machinery and equipment manufacturing, with general-purpose machinery manufacturing (CAD 182,789,000), commercial and service industry machinery manufacturing (CAD 36,239,000), and electrical equipment manufacturing (CAD 28,694) showing the highest output increases. Altogether, directly related industries account for CAD 266,309,000.17 in total output change, compared to an overall provincial output increase of CAD 1,834,770,000.91. This indicates that the majority of benefits accrue to industries not directly tied to the project, underscoring the strength of indirect and supply-chain effects.

6. Conclusion

This study developed an Input-Output (IO) framework to evaluate the macroeconomic and supply chain impacts of constructing a CO_2 capture facility in Saskatchewan, Canada. The focus of the analysis was specifically on the construction phase of the project. It included only the capture process rather than the full CCUS project, which included transportation, storage, and utilization. Unless previous studies focused more on microeconomic analysis of these technologies using methods like cost-benefit analysis or techno-economic analysis, and only a few studies covered the Canadian context, this work focuses on filling the gap in the literature by developing an I-O method for the construction phase of a CCUS plant to capture its broader impacts on Saskatchewan, Canada economy during the early stages of the project.

To identify the value of investment, the costs of direct equipment required for a carbon capture plant were considered. By applying these costs to the 2021 Saskatchewan Input-Output tables and using Leontief Inverse calculations, the model estimated that investment in this hypothetical project could cause an increase of about 1.83 billion in industrial output, an increase of approximately $900 million in GDP, and creation of about 5,588 jobs, accounting for 1% of total provincial employment. These results show that these projects can have a broad economic impact on the overall supply chain and investment injections into these projects can spread through the whole economy.

Another aspect covered in this study is mapping capital expenditures to proper industries using the North American Industry Classification System (NAICS) and converting the costs of the 2018 US dollar to the 2021 CAD dollar by applying the currency exchange rate and inflation rate.

While the findings of this paper show the benefits of investment in these projects, several limitations exist, such as excluding transportation, storage, and utilization processes, as well as focusing only on the construction phase and excluding the operational phase; in addition, US-based costs are considered for the analysis and are converted to Canadian dollars, which might not be able to reflect the exact local conditions. However, the findings of this study can provide a practical framework for the macroeconomic analysis of CCUS projects in both the operational and construction phases since it can capture the changes caused by these projects, like job creation, GDP, and changes in output through the supply chain.

It is important to know that the results of this study are indicative rather than predictive since the analysis relies on several assumptions, such as US-based structures for the costs and market conditions. Therefore, using actual Canadian data will result in more accurate results, and it is essential. However, despite these assumptions and limitations, the results of this study provide valuable insights for Canadian policymakers since it shows the potential of these technologies in job creation and their impact on the economy. These findings support the government's adoption of effective funding mechanisms and the introduction of industrial decarbonization strategies and regional development plans.

6.1 Limitations and Future Research Directions

Due to some limitations in this study, future research should address these limitations. For instance:

- To improve the accuracy of the results, the analysis can be done using real data from CCUS projects in Canada.
- Future studies can cover both the construction and operational phases of a carbon capture facility to provide a more holistic view of how these technologies can impact and stimulate other industries and the overall economy.
- Covering the full CCUS process, including capture, transportation, storage, and utilization, can be very helpful since all these processes can significantly impact the economy in both the operational and construction phases.
- Future studies can utilize this framework to analyze CO_2 capture facilities in other industries, such as cement and steel.
- Future research can enhance the IO model to be more dynamic and capture some changes, such as changes in price or market reactions.

- Broader analysis is needed to capture the impacts of CCUS projects on industries beyond the immediate scope considered in this study.
- Future research should also evaluate the efficiency of CCUS systems under different contexts and compare them with alternative energy technologies to assess their competitiveness.

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