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How Investments in Clean Energy Affect Job Creation in Canada Panel Data Analysis

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Abstract: Recent international efforts to foster global sustainability have underscored the pivotal role of renewable energy sources. However, significant transitions within industries, such as the energy sector, often entail challenges, including job displacement and the emergence of new opportunities. In light of these dynamics, this study proposes to examine the relationship between investment in renewable energy and employment levels across ten distinct Canadian provinces. To investigate this relationship comprehensively, we employ panel data analysis, encompassing both the fixed effects and random effects models. Our study aims to shed light on how investments in renewable energy influence employment figures across various job categories. Furthermore, we seek to contrast the shifts in employment patterns between low- and high-skilled workers resulting from such investments. The anticipated findings of this research will contribute to a deeper understanding of the intricate interplay between renewable energy investments and employment dynamics."

Keywords: clean energy, Panel Data Regression Model, employment, investment

1. Introduction

The significance of renewable energy has greatly increased recently as the global community strives to foster a more sustainable world. A pivotal instrument in this endeavor is the Paris Agreement—an international climate change treaty designed to curtail the rise in the global average temperature to levels well below 2 °C above pre-industrial benchmarks [1]. The benefits of renewable energy are widely acknowledged to include a decrease in greenhouse emissions and a reduction in the rate of global warming, which meet the needs of the Paris Agreement. Beyond climate benefits, developing renewable energy sources augments environmental quality and spurs economic growth [2]. Nevertheless, significant shifts within large sectors often provoke complex transitions—similar to historical instances like the Industrial Revolution—ushering in job losses and new opportunities. This prompts us to consider whether investments in renewable energy catalyze job creation, particularly given the substantial and indispensable nature of the energy sector. Until now, a definitive consensus on this matter remains elusive, with outcomes diverging among various countries and regions.

This study aims to establish the relationship between investment in renewable energy and employment in Canada. The focus on Canada is important for a variety of reasons. First of all, 100% of the population in Canada has access to electricity and clean fuels for cooking, which means that when an increasing amount of renewable energy is used to generate electricity, it will affect a wide range of people. Furthermore, the increased investment from Canada has boosted the production of renewable energy, 30.62% of the country's energy came from renewable sources in 2022, which ranked 11th in the world; meanwhile, the share of electricity production from fossil fuels has decreased since 2001. Last but not least, a 2021 report by Clean Energy Canada estimates that by 2030, there will be 639,200 jobs within the clean energy field, an increase of nearly 50 percent compared to 2020, when 430,500 jobs were reported [3]. Thus, in light of the big influence renewable energy has in Canada, it is crucial to determine whether there is a causal relationship between investment in renewable energy and job creation.

To tackle this question, we link investment in the renewable energy sector with employment using panel data analysis. Many studies related to this topic have used the time series model to show whether there is a causal relationship. However, panel data contains more information, variability, and efficiency than pure time series data, facilitating the incorporation of multiple variables. We first use the Fixed Effect model to analyze the relationship. Subsequently, we transition to the Random Effect model, linking renewable energy investment to employment. Finally, we conduct the Hausman test to show the result is significant.

We plan to rely on various datasets from Statistics Canada, a national office of Canada. We obtain measures of the labor force and employment in 10 different provinces in Canada during 1990-2022.

We also obtain total employment, investment in renewable energy, and the Consumer Price Index for Electricity (Cpie) at the provincial level. These observed data sets are introduced into the panel data model for analysis.

We expect our research to contribute to further discussion regarding developing various kinds of renewable energy and job creation in diverse regions. We thrived to figure out if developing renewable energy is a good way to decrease unemployment or create jobs. Our focus is based on the province level, which eliminates several confounding variables and gives a more accurate and specific result compared to analysis at the national level.

Following this introduction, the subsequent section provides an overview of relevant literature on the employment impacts of renewable energy development. We then discuss the usage of panel data analysis in the conceptual framework to show this method is suitable and feasible for the topic. In the next section, we provide an overview of the data and analyze to find the results. We finally conclude the findings and extend a further discussion on closely related areas.

2. Literature Review

In the first literature, Wei, Patadia, and Kammen discuss how many jobs the clean energy industry can generate in the US and build a job creation model for the US power sector from 2009 to 2030 by integrating information from 15 separate studies on employment, encompassing areas such as renewable energy (RE), energy efficiency (EE), carbon capture and storage (CCS), and nuclear power [4]. The analysis takes into account potential job losses in the coal and natural gas industries, ultimately projecting net employment effects. The findings reveal that non-fossil fuel technologies—such as renewable energy, energy efficiency, and low-carbon solutions—exhibit a higher job creation potential per unit of energy generated compared to coal and natural gas. Knowing the relatively higher job creation potential per unit of renewable energy, we want to discover the actual job creation renewable energy could generate.

In the following article, Dalia and Rasha conducted a study to examine the long-term and causal relationships among unemployment, financial development, population, and renewable energy sources in Egypt from 1971 to 2014 [5]. They used auto-regressive distributed lag (ARDL) and vector error correction (VECM). The findings showed that while clean energy resources lead unemployment levels to decrease, population growth and financial development drive unemployment rates to increase. The researchers contend that governmental interventions are required and provide several

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solutions, including increased infrastructure spending and export incentives, to promote the expansion of small and medium-sized businesses. Despite ARDL and VECM being time series models, we consider employing panel data analysis because it contains more information, variability, and efficiency than pure time series data.

Petr, Standa, Dan, Bohumil, and Kamila employ policy document analysis, descriptive statistics, and trend analysis (spatial and temporal) to study the relationship between investments in renewable energy and employment creation during 2008–2013 in the Czech Republic [6]. Their findings demonstrate how heavily dependent employment development is on the persistence of financial incentives. Additionally, they discovered that processing biomass and waste energy provides the most jobs per MWh, which helps to support employment in rural areas (which are economically vulnerable). For the Czech Republic, the relevance of the PV and wind energy subsectors has been lower regarding job creation. The reason is that most jobs are in the development and installation phases, and relatively few jobs are required for maintenance, which can provide long-term work. From the research, we see that financial incentives are important for employment development, which leads us to consider investment in the renewable energy industry. Frondel and other researchers in the study of Economic impacts of the promotion of renewable energy technologies critically evaluate the central element of this initiative, known as the Renewable Energy Sources Act (EEG) [7]. Multiple empirical investigations have consistently indicated that, over the long term, the overall employment impact tends to be neutral or potentially negative. This outcome results from the great opportunity cost of developing renewable energy technologies. Probably, any employment gains facilitated by the promotion of renewable energy will likely disappear once government assistance is withdrawn. We, therefore, want to examine if the renewable energy industry's lack of investment would have a similar outcome.

The last piece of literature by Ingaldi and Tater examines the general public's attitude toward developing renewable energy, specifically hydrogen [8]. The findings indicate a significant lack of understanding regarding hydrogen's potential as an energy source, as well as the safety and storage techniques involved in its production. The findings suggest a lack of societal confidence in the sufficiency of safety measures for energy obtained from hydrogen. We can see from the analysis that the public in places where hydrogen is undeveloped holds a negative attitude towards the technology. This leads us to wonder how countries where renewable energy has been developed are dealing with the development and what job creation is possible under this development. In sum, when all of these studies are reviewed, we believe there is an explicit need for a study to examine the relationship between investment in renewable energy and employment level in Canada.

3. Conceptual framework

At the heart of our research is exploring how investment in renewable energy affects employment across provinces over time. We hypothesize that this relationship is not isolated but intertwined with various factors, such as labor dynamics and electricity prices, each with its importance and impact. The interplay between these variables paves the way for our conceptual framework, promoting a comprehensive understanding of the employment situation in the context of renewable energy investments.

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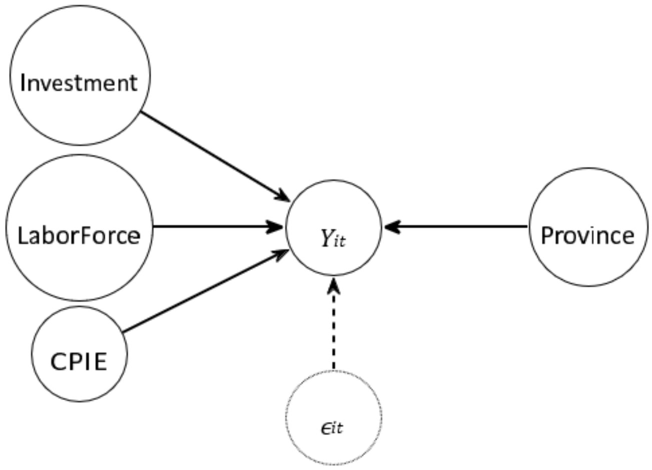

Figure 1: Panel Data Regression Model of Employment (Yit) Influenced by Independent and Control Variables.

This graphical representation provides a visual representation of the regression model, showing how various independent and control variables affect employment (Y_{it}). Dashed arrows indicate the contribution of the error term. The crux of our investigation lies in the panel data regression approach. At its core, panel data methods utilize cross-sectional and time-series data. This approach is powerful because It allows for more complex and granular models that capture variation across entities (e.g., provinces) and over time. It can account for unobserved heterogeneity, ensuring that the error term of the model does not absorb unobserved effects associated with sexual problems. Larger sample sizes (due to multiple observations per entity) increase the degrees of freedom and reduce multicollinearity, improving the efficiency of econometric estimates.

Our specific panel regression model can be formulated as:

$$Y_{\{it\}} = \alpha + \beta_1 \ Investment_{\{it\}} + \beta_2 \ LaborForce_{\{it\}} + \beta_3 \ CPIE_{\{it\}} + \gamma \ Province_{\{i\}} + \epsilon_{\{it\}} \quad (1)$$

Where, $investment_{it}$ represents the amount of renewable energy investment committed by the province i in the year t. Presumably, as provinces invest more in renewable energy, employment levels could surge due to job creation $LaborForce_{it}$ represents the province's active labor force for i years t periods. This is a crucial control variable because a larger labor force may inherently have a higher employment rate regardless of other conditions. $CPIE_{it}$ refers to the consumer price index of $t \ province_i$. This control variable takes into account the overall price level and economic conditions of the province. $Province_i$ represents a fixed effect, capturing unique characteristics inherent to each province that are likely to remain consistent over time—whether cultural factors, geographical advantages, or policy stances. ϵ_{it} is the random error term that captures all omitted variables that could affect employment but were not explicitly included in our model. Through this mathematical model, we attempt to discern the subtle relationship between renewable energy investment and employment while controlling for other key factors. The model is particularly good at resolving consistent impacts over time across provinces, providing robust and granular insights.

4. Data

Data are presented in this section. The data is secondary data sourced from *Statistics Canada*, covering the period from 1990-2022 in 10 provinces of Canada [9-13]. Table 1 shows definitions of the variables used in the study.

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Table 1: Variables description.

Variables	Explain
Year	1990-2022
Employment	1990-2022 Employment by Province
Investment	1990-2022 Investment in wind and solar
CPIE	1990-2022 Consumer Price Index, annual average, not seasonally adjusted on Electricity (2002=100)
Labor	Labor force characteristics by industry, annual

Understanding the relationship between Canadian renewable energy investment and employment dynamics is a delicate one, full of often intertwined variables. To rigorously address our research question, it is imperative to obtain comprehensive and reliable datasets. This brings us to Statistics Canada, a prestigious agency known for its exhaustive statistical insights into all aspects of Canada's socio-economic environment.

At the heart of our research are data sets such as annual labor force characteristics by industry, economic accounts for environmental and clean technology products, and the CPIE (Consumer Price Index for Electricity). The collections provide a panoramic view of the Canadian landscape from 1990 to 2022, revealing provincial employment statistics, wind and solar investment, and electricity-related consumer price index data. The reason behind choosing such a diverse dataset is simple—to understand employment dynamics, the interaction between renewable energy investment, labor statistics, and electricity prices must be considered. They are part of a coherent story, and leaving one out could lead to distorted interpretations.

While digging into the data, we discovered investment patterns in solar and wind energy across Canadian provinces. However, not all provinces show consistent or meaningful data. Therefore, we opted for a 5-year investment threshold, ensuring we capture sustained long-term trends rather than sporadic bursts of activity. This initial screen excludes MB, NB, ON, and PE.

Table 2: Data for various provinces across multiple metrics.

Prov.	Var.	Min.	Max.	Avg.	Std.
AB	Labor	1370.9	2522.6	1964.4	397.1
	Emp.	1276.8	2376.1	1840.8	374.1
	Inv.	4.0	607.0	99.5	147.6
	CPIE	50.2	187.8	103.5	35.1
...	...	...	...	...	...
SK	Labor	486.7	610.6	538.2	48.1
	Emp.	448.0	581.5	507.1	47.4
	Inv.	0.0	274.0	72.6	67.4
	CPIE	63.7	183.2	117.9	36.4

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For a research effort of this size, gaps in the data are to be expected. Not only do we acknowledge these gaps, but we go a step further. By outlining the properties of an "ideal dataset," we hope to convey the broader possibilities and potential future research directions in this field. Capturing higher-resolution or broader datasets can provide further insight into seasonal fluctuations, the impact of historical policies, and the interplay of macroeconomic factors.

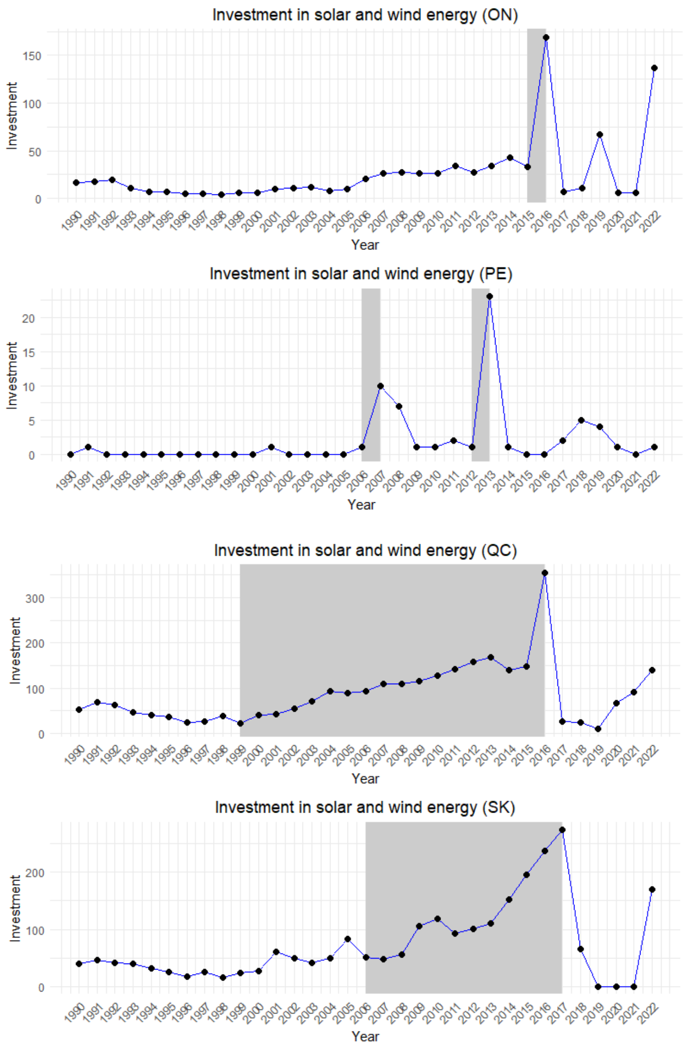

Figure 2: The time series of investment in solar and wind energy by province.

We used panel data analysis to narrow the focus of the analysis to the period 1999-2021. This technique is frequently used in econometric research and is essential for understanding cross-sectional and time-series variation. But before in-depth analysis, there is a daunting task: data integration. Merging disparate datasets requires care to ensure data consistency and structural applicability.

5. Methodology

Our research seeks to illuminate the complex relationship between renewable energy investment and employment dynamics across Canadian provinces. Well-designed survey research that provides valid insights requires a proper methodological foundation. In academia, several approaches have received attention in understanding this relationship, including difference-indifferences, regression-on-

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discontinuity designs, and instrumental variables, among others. For our investigation, a panel data approach is most appropriate.

The choice of panel data method depends on the nature of our dataset. These data span multiple years and provinces and require a method that captures temporal and cross-sectional changes. Panel data methods serve this purpose, providing insight into province-specific temporal trends and addressing inherent provincial heterogeneity, ensuring accurate and consistent estimates.

The precision of the methodological elaboration is crucial. Our data originates from Statistics Canada and is meticulously cleaned to identify and resolve any inconsistencies. When refined, the dataset is integrated using “province” as the primary identifier. This integration ensures the comprehensiveness of our data and the seamless integration of subsequent analyses. In panel data analysis, fixed-effects and random-effects models are at the forefront. For our dataset, the decision between these models was guided by the Hausmann test, ensuring the best model fit.

To further clarify our analytical trajectory, consider our linear regression model:

$$Y_{\{it\}} = \alpha + \beta_1\ Investment_{\{it\}} + \beta_2\ LaborForce_{\{it\}} + \beta_3\ CPIE_{\{it\}} + \gamma\ Province_{\{i\}} + \epsilon_{\{it\}} \quad (2)$$

In this model, Y_{it} signifies employment in province i at time t. Each variable, including $Investment_{it}$, $LaborForce_{it}$, and $CPIE_{it}$, provides a lens into different facets such as renewable investments, labor dynamics, and economic indicators.

Embarking on a methodological endeavor of this nature is seldom linear. The process entails a sequence of critical steps: data preparation, preliminary analysis via descriptive statistics, application of fixed or random-effects models, and, importantly, robustness checks involving diverse model specifications. It’s also pivotal to acknowledge the scholarly works that have steered our approach. Our methodology resonates deeply with foundational studies in energy economics. Works such as Smith, A. & Jones, B.’s research on Panel data methodologies in energy economics have been instrumental in informing our methodological framework.

6. Results

Our analysis highlights a counterintuitive trend: Increased investment in solar and wind energy does not necessarily translate into proportional growth in employment. Using a panel data approach and employing fixed- and random-effects models, our study reveals complex nuances in employment trends relative to renewable energy investment. Surprisingly, the fixed effects model infers that for every unit increase in investment, there is a “0.152” unit decrease in employment. Likewise, the random-effects model records a “0.132” unit reduction. To establish a strong analytical basis, our model incorporates the aggregate labor force, which reflects the entire population, as a control indicator. Table 3 delineates our comprehensive regression outcomes.

Table 3: Regression Analysis of Fixed and Random Effects Models on Employment.

Employment		
	FE	RE
Investment	-0.152*** (0.037)	-0.132*** (0.037)
Laborforce	0.978*** (0.016)	0.939*** (0.007)
CPIE	0.008 (0.119)	0.166 (0.104)

Table 3: (continued).

Constant		-31.459* (18.942)
Observations	138	138
*R*2	0.978	0.993
Adj. R^2	0.977	0.993
F Statistic	1,907.831*** (3; 129)	18,852.110***

Note: *p¡0.1; **p¡0.05; ***p¡0.01.

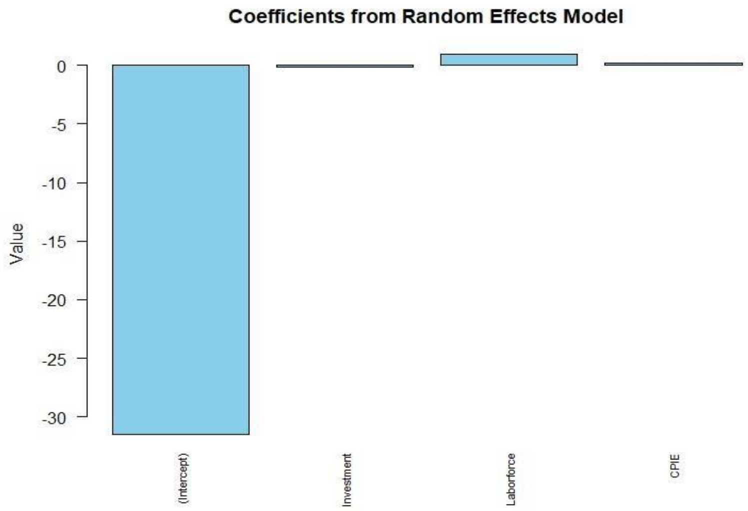

Figure 3: Plot of Coefficients from random effects model.

The unanticipated trajectory of our discoveries compels a deeper reflection on its wider ramifications, notably in policy formulation and sectoral applications.

7. Conclusion

The transition from conventional energy to renewable energy sources is currently taking place due to the escalating concerns of air pollution and greenhouse gas emissions worsening. Historically, significant technological shifts have inevitably introduced fluctuations in the labor market. This study seeks to find whether a causal link exists between Canadian employment patterns and investments in renewable energy.

We employ different models to investigate this question. First, we obtain data sets on the labor markets, renewable energy investment, and CPIE from Statistics Canada, a national agency of Canada. Subsequently, we apply panel data analysis using the Fixed Effect model and Random Effect model without log. Then we use the Hausman Test to show the results of the relationship between investment in renewable energy and employment is statistically significant. In the next step, we apply the panel data analysis using the Fixed Effect model and Random Effect again. Still, this time, we take the logarithm of both sides of the equation in order, enhancing data stability and analytical precision.

All the result of our analysis shows that when investment in renewable energy increase, employment decrease. However, it is vital to note that the study primarily assesses short-term effects, leaving the potential for divergent long-term outcomes unexplored. During the global transition from conventional energy production to renewable alternatives, it is foreseeable that job displacements will be temporary, especially in regions tethered to coal, oil, and gas industries. Moreover, emerging renewable energy sectors might need various skill sets. Even when job openings exist, the existing workforce might struggle to secure new positions if their skills are not adequately aligned through training or retraining initiatives. As a result, the outcomes of the short run and long run may differ.

Our conclusions are based on the assumption that the investment will have a uniform effect on employment throughout all provinces, but this is not always the case. Additionally, despite the numerous types of occupations related to renewable energy, available data on employment figures and educational attainment within these categories are insufficient and sometimes contradictory. As a result, we find it difficult to cover more detailed information in our article. Consequently, our study refrains from making assertions about how investment in renewable energy affects specific job categories or contrasting the shifts in low-skill and high-skill worker employment resulting from such investments.

If there is comprehensive and precise data on workforce demographics and educational backgrounds, future research could analyze the effects of renewable energy investments on diverse job types. Our next step includes an analysis of a more specific interplay between a certain renewable energy investment and its effect on employment dynamics.

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