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GREEN FINANCE AND LOW-CARBON ECONOMIC RECOVERY IN THE POST COVID-19 WORLD

Does unionization reduce CO_2 emissions in Canada?

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Abstract

The existing literature is ambivalent on the relationship between unionization and climate change. There is some anecdotal evidence that in some cases, labor unions play a role in implementing climate protection measures. In other cases, unions were more concerned with saving jobs than with reducing emissions. Nonetheless, empirical studies on the relationship between unions and environmental outcomes are limited. The objective of this study is to fill the gap in the literature by examining if unionization has any impact on CO_2 emissions in Canada, after controlling for energy consumption, unemployment rate, and real GDP per capita. Cointegration techniques including Johansen methods and autoregressive distributed lag (ARDL) techniques are applied to a dataset that covers the period from 1969 to 2016. The results suggest that, on average, a 1% increase in unionization reduces CO_2 emissions by approximately 0.25%. This is the first study that examines the union-climate dynamics for Canada. One policy implication of the finding is that the governments should develop incentives for industries to implement climate measures through collective bargaining.

Keywords Unionization · CO_2 emissions · Cointegration · Canada

Introduction

The most recent report of the Intergovernmental Panel on Climate Change (IPCC 2021) noted that carbon dioxide (CO_2) emissions are the main cause of acidification of the open ocean and of total warming. The report gave a stark warning that the temperatures are likely to rise by 1.5 °C within the next two decades. This increase in temperature will cause severe conditions including frequent extreme weather events. The ultimate outcome is loss of life, income, and property. In a recent report, ILO (2019) projected that approximately 2.2% of total working hours will be lost due to climate change by 2030. This accounts for a productivity loss of almost 80 million full time jobs. Not surprisingly, the issue of climate change has become an important political priority at least among the parties on the center and the left. At the same time, a growing number of trade unions have felt the pressure from their members to negotiate health and safety standards at the bargaining table. Sarah Pearce of the public service union of the UK, Unison, made a series of compelling arguments for why climate change is a trade union issue (Pearce 2012). The author noted that union members have progressively become more concerned about the consequences of climate change, and they want their unions to address environmental issues. Pearce (2012) further argued that unions' involvement with climate change issues would ensure compliance with environmental regulations, safer and healthier workplace, and save money and jobs by making workplaces sustainable. Recently, Hampton (2018) suggested that in the UK, climate actors and trade unions' green representatives independently contributed to developing climate policies and adapting workplace strategies. Hampton (2018) also noted that "workers have the interest and collective capacity to reduce greenhouse gas emissions, to address the differential impacts of climate and climate policy, and to coalesce workers to tackle climate change" (pp. 470).

In Canada, unions regularly fought for occupational safety measures and held strikes on these issues throughout the 1970s and 1980s (Harter 2015). More recently, several Canadian unions including Canadian Labour Congress,

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Toronto Labour Council, Canadian Union of Postal Workers, Canadian Union of Public Employees, Unifor, BC Teachers' Federation, and Canadian Association of University Teachers expressed their solidarity with the Global Climate Strike which was started in 2018 by Swedish activist Greta Thurnberg. Thus, to a certain extent, the labor unions and environmental organizations are making an effort to jointly tackle the environmental crisis and protect working conditions. There is some anecdotal evidence that Canadian labor unions are playing a direct role in protecting the climate. For example, the Canadian Union of Public Employees developed a national environmental policy entitled, *Working Harmoniously on the Earth* which called for green bargaining language and workplace environmental policies (CUPE 2013). Similarly, Public Service Alliance of Canada recognized the climate crisis as a social crisis and argued that unions can make an impact by including environmental clauses in collective agreements (PISAC 2020a). However, researchers have not yet studied the nexus between unionization and environmental outcomes in Canada using empirical models. The aim of this article is to fill the vacuum in the literature by answering the following questions: (1) does unionization have any significant impact on climate change in Canada? (2) If there is any impact, does it hold in the long run? In this study, unionization is measured as the collective bargaining coverage, while per capita CO_2 emissions represent the climate change. To answer these questions, I apply the Johansen cointegration technique and autoregressive distributed lag (ARDL) approach to cointegration to a Canadian time series dataset that covers the period from 1969 to 2016.

This study produces two key results. First, I find evidence of long-run cointegrating relationships between unionization, climate change, and other macroeconomic variables. Second, a 1% increase in the collective bargaining coverage reduces per capita CO_2 emissions by 0.25%. The novelty of this study is as follows. First, this study contributes to the existing literature on mostly unexplored area of unionization and environmental outcomes. Second, while examining the relationship, I control for important factors including energy consumption, unemployment, and GDP—all of which potentially impact environmental outcomes. Third, I apply advanced time series techniques to identify long-run associations between unionization and climate change. To my knowledge, this study is the first of its kind in Canada. It should be noted that at the micro-level, the association between unionization and environmental outcome may vary due to the heterogeneity of union structure. Nonetheless, the goal of this study is to take the first step to understand the macro-level dynamics between unionization and climate change in Canada.

To that end, the remainder of the paper is organized as follows. In "Literature review" section, I discuss the evolution of unionization in Canada and how unions have been responding to the climate crisis. In the same section, I review the existing empirical evidence on the impact of unionization on different socio-economic and environmental variables. "Data and methods" section discusses the data and methods used in the study. "Results" section presents the results. "Discussion, future research, and concluding remarks" section provides a discussion of the findings, sheds some lights on potential research, and makes concluding remarks.

Literature review

Unionization in Canada

Canada has a long history of unionization. The largest strike in Canadian history, the Winnipeg General Strike, took place between May 15, 1919, and June 25, 1919. Over 30,000 workers left jobs and shut down factories, shops, and trains to protest high unemployment and high inflation. Between 1920s and 1980s, union density exhibited a positive trend in Canada. Union membership as a percentage of non-agricultural paid workers rose from a modest 28.4% in 1950 to 37.1% in 1980 (Riddell 1993). However, the overall rate of unionization declined from 38% in 1981 to 30% in 2012 (Galarneau and Sohn 2013). Not surprisingly, the data on the rate of collective bargaining coverage exhibited a similar trend. For the period of this study, the collective bargaining coverage rate initially rose from 32.8% in 1969 to 38.4% in 1984 but then declined to 30.3% in 2016 (OECD 2021). Yet, as noted by Jim Stanford of the Centre for Future Work, "… there is empirical evidence that Canada's labor movement has performed better than its peers in most other industrial countries, at a time when trade unions are on the defensive in most jurisdictions" (Stanford 2020). For the last 10 years, Canadian union density has been relatively more stable than other industrial nations (Stanford 2020). Figure 1 shows the historical trend of the collective bargaining coverage rate in Canada.

The decline in unionization in the 1980s and 1990s can be partly attributed to the fact that a significant portion of the labor force shifted from more unionized industrial, construction, and manufacturing sectors to less unionized retail and professional services (Statistics Canada 2018). But there were also deliberate efforts by the governments to curb union activities in Canada. For example, Bill C-377[1] attacked the right to freedom of association and free speech (CUPE 2014). Bill C-525[2] made it more difficult to join a

[1] Introduced on December 5, 2011

[2] Introduced on October 6, 2013

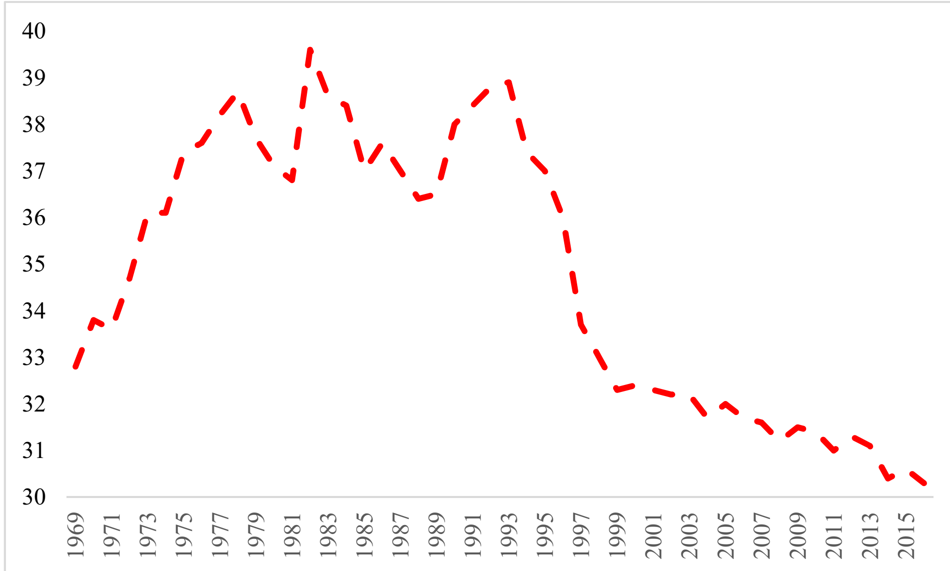


Fig. 1 Collective bargaining coverage (1969–2016)

union by requiring a majority of employees to vote in secret ballots before a union can be certified (Unifor 2015). With the adoption of Bill C-4, both Bills C-377 and C-525 were eventually repealed in 2017. However, similar anti-union initiatives continued at the provincial level. In recent years, several bills including Bill 32 in Alberta, Bill 124 in Ontario, Bill 16 in Manitoba, and Bill 85 in Saskatchewan were introduced to across Canadian provinces (CUPW 2020; PISAC 2020b; SUN 2013).

The evidence shows that, over the last few decades, unionization in Canada exhibited a declining trend before becoming stable in recent years. Nonetheless, unions have remained at the forefront of most social issues of significance such as promoting health care, the fight against discrimination, and improvements to minimum wages and labor standards (Jacobs 2005). And the unions have been vocal on how these social issues impacted the labor force. The following section presents an overview of intersection between unionization and the green movement.

Unions and the green movement

The literature on how labor unions adopted climate change policies is meager. There is evidence that, in some cases, due to their interest in saving jobs, the unions have been slow in identifying climate change as a priority in their mandate. From a theoretical perspective, the capitalist system encourages profit expansion through technological innovation and environmental degradation. This causes loss of employment which in turn necessitates further production, creation of new jobs, and, eventually, generating extra funds to clean up the environment (Schnaiberg 1980; Gould et al. 2008; Alvarez et al. 2019). This is known as the *treadmill of production*, where labor plays a crucial role in accelerating the process of production and accumulation. In addition to loss of employment, other factors including disagreement and coordination failure among unions may contribute to unsuccessful outcomes at the bargaining table (Thomas 2021; Galgóczi 2020; Stevis and Felli 2015). Thomas (2021) used the European Union Emissions Trading System as a case study and argued that an imbalance of power due to unions' lack of expertise on the complex legalities on emission policies was partly responsible for trade unions to not successfully develop and carry out emission reduction policies.

Nonetheless, many unions have included environmental concerns as part of their political mandates. After surveying labor leaders and environmental leaders in the USA between 1997 and 1999 and applying the ordinary least square technique to the survey dataset, Obach (2002) arrived at the conclusion that there is no conflict between environmentalists and union leaders, even in industries where job loss was a real possibility due to environmental measures. In a later study, Obach (2004) argued that the strategic behavior of American labor unions changed with globalization and neoliberal policies that allowed corporate attacks on labor and changes in employment patterns. New labor leaders are more likely to work cooperatively with environmentalists.

The existing literature is ambivalent on how green labor is in Canada. Perhaps, this is due to structural heterogeneity among unions in Canada. For example, Nugent (2011) discussed the strategic response of Canada's two largest private unions—the Canadian Auto Workers (CAW) and the United Steelworkers (USW)—to climate change in the early 2000s. After the ratification of the Kyoto protocol in 2002, the CAW was more concerned with saving jobs than with reducing emissions. On the other hand, the USW was in favor of emission regulations to protect jobs that were threatened by the supply of carbon-intensive imported steel.

Although the association between unionization and CO_2 emissions is not immediately clear in the existing literature, one could hypothesize two potential causal links between these variables. The first one is the *bargaining hypothesis*. In this hypothesis, I argue that unions' involvement in climate actions is through collective bargaining. Adapting Canadian Work and Workplace (2021) complied *green* clauses from Canadian collective agreements to facilitate unions which intend to negotiate environmental clauses at the bargaining table. A survey of these collective agreements suggests that there are 121 collective agreements which have *green* clauses related to commuting, extreme weather and disasters, green procurements, recycling and conservations, social responsibilities, training and education, and workplace adjustments[3]. Therefore, there is some anecdotal evidence that Canadian unions played a favorable role in bargaining environmental clauses. The second hypothesis is the *advocacy hypothesis.* I contend that unions engage in political advocacy and push for emission reduction and fight climate change. In a recent article, Stanford (2021) discussed the long history of Canadian unions taking principled positions against emissions. He gave several examples of how Canadian unions (including unions that represent workers from the energy or energy-related sectors) actively advocated initiatives related to emissions reduction in Canada. For instance, the Canadian Labour Congress pushed for phasing out coal-fired power, Alberta Federation of Labour campaigned for regulating greenhouse gas emissions, and the Communications, Energy and Paperworkers Union of Canada (before merging with the CAW and forming Unifor) advocated for value-added energy refining (Stanford 2021). Other union members whose jobs are not directly impacted by environmental degradation have become more concerned about climate change. For instance, the Canadian Association for University Teachers (CAUT) has called for active participation of university educators to apply critical inquiry and evidence-based decision making to create a sustainable future (CAUT 2017). The CAUT proposed a three-step action plan for academic staff associations in Canada. Their proposal includes improving building energy efficient buildings and transportation and, thereby, reducing emissions, undertaking climate change research and scholarship, and empowering bargaining teams to that the collective agreements can help build sustainable campuses. These examples show that unions have taken effective positions and advocated for measures to fight emissions and climate change. What is not clear in the existing literature is whether unions in general were successful in achieving environmental outcomes.

[3] The full list of the collective agreements can be found at: https://www.zotero.org/green_agreements/items/63HFQQ83/library. The database includes collective agreements from 1970 to 2021.

Unionization and CO_2 emissions: current literature within the econometric framework

Several studies employed econometric frameworks to examine the impacts of unionization on income inequality. Herzer (2014) applied a bivariate behavioral function to estimate a relationship between union density (unionization) and Gini coefficient (inequality) in Ireland for the 1963 to 2000 period. They used cointegration, dynamic ordinary least square, and long-run causality tests and found evidence of a negative relationship between unionization and income inequality. The causal relationship in this case was bidirectional. However, for the USA, Herzer (2016) found a unidirectional causality from unionization to inequality. The association between the two variables was still negative. In this study, Herzer (2016) used panel data models for 50 states from 1964 to 2012. Similar results were established by Meszaros (2018) for the USA. In this study, Meszaros (2018) used the same dataset as Herzer (2016).

In one of the studies on Korea, Kim (2005) found that the impact of unionization on employment and economic growth was negative. Kim (2005) applied the Johansen cointegration technique, vector error correction models, and Granger causality. The period of study was from 1970 to 2002. However, Mah (2012) examined how foreign direct investment (FDI) and unionization impacted income inequality. Mah (2012) applied cointegration tests and the error correction model to a Korean time series dataset that covered the period 1982–2008 and found that increasing FDI inflows and decreasing unionization rate worsened income inequality in Korea.

Reducing CO_2 emissions and achieving carbon neutrality have been at the forefront in the policy debate over the last two decades. With the availability of sufficient time series observations, several studies have explored how CO_2 emissions are associated with economic growth (Abbasi and Adedoyin 2021; Abbasi et al. 2021a, b, c; Brown et al. 2020, 2021; Das 2018). The other set of studies that received attractions from academics and policy makers has explored how energy related policies can achieve carbon neutrality in developed and developing countries (Abbasi et al. 2021d; Tao et al. 2021; Shao et al. 2021; Li et al. 2021; Iqbal et al. 2021). Although labor unions have a long history of fighting for social outcomes, empirical analysis on the impact of labor unions on climate actions to achieve carbon neutrality is mostly absent. Recently, one study used panel techniques to assess the impacts of unionization on climate change. In this study, Alvarez et al. (2019) used data on OECD member countries from 1970 to 2014. They applied a two-level random intercept model and controlled for labor conditions. Their results suggest a negative association between the percentage of labor force that is unionized and per capita CO_2 emissions. The authors argued that "…efforts for workers'

Table 1 Variables used in the study

Variable	Definition	Source
COPC	Per capita CO_2 emissions in metric tons	World Bank (2021)
CB	Percentage of employees with the right to bargain	OECD (2021)
EN	Per capita energy use measured in the kg of oil equivalent	World Bank (2021)
U	Rate of unemployment	World Bank (2021)
YPC	Per capita GDP measured in constant US$	World Bank (2021)

rights may help efforts to reduce CO_2 emissions and to mitigate climate changes" (Alvarez et al. 2019, pp. 34). One of the important suggestions made by Alvarez et al. (2019) is that future research should study unions' impact on the environment using country-specific research. This study responds to their call: it examines how unionization is associated with environmental outcomes in Canada. Given unions' recognition of collective agreements as an important tool to tackle climate change, having a stable union density as compared to other developed countries makes Canada an intriguing case to study the union-climate nexus. Nonetheless, the link between unionization and climate change in Canada is conspicuously absent. The aim of this study is to fill the gap in the existing literature. This is the first study that uses time series analysis to explore how unionization potentially impacts CO_2 emissions in Canada.

Data and methods

Data

To examine the relationship between unionization and environmental outcomes, I use Canadian time series data from 1969 to 2016. The time period of the analysis is constrained by the availability of data. The variables used in the analysis are collective bargaining coverage rate (CB) to represent unionization and CO_2 emissions (COPC) to represent climate change. To accommodate the impacts of macroeconomic factors on CO_2 emissions, I include energy consumption (EN), unemployment rate (U), and GDP (YPC) in the dataset. CB is defined as the percentage of employees with the right to bargain. It is important to note that, unlike many other countries, the collective bargaining coverage in Canada is a fairly good representation of unionization. For example, in France, the rate of collective bargaining coverage in the last two decades was approximately 98%. During the same period, the ratio of union members to all employees was only 11% (OECD 2021). This is due to the fact that in France, collective agreements are negotiated at the industry level and then implemented for the whole industry. Thus, even non-union members are mostly covered by collective agreements. In the case of Canada, collective bargaining only takes place between unions and employers, and non-unionized industries are typically not covered by any collective agreement. Therefore, data on collective bargaining coverage and trade union density exhibit a close relationship in Canada. According to the OECD (2021), on average, Canadian collective bargaining coverage rate was 31% over the 2000 to 2020 period. During the same time, over 27% of all employees were union members.

Among other variables, COPC is the per capita CO_2 emissions in metric tons. EN is the per capita energy use measured in the kg of oil equivalent, U is the rate of unemployment, and YPC is the per capita GDP measured in constant US$. Data on CB are obtained from OECD (2021). Data on all other variables are collected from the World Development Indicators published by the World Bank (2021). While U starts in 1969, COPC is only available until 2016. Therefore, I was unable to include more recent information on emissions. I transform the variables, CB, COPC, EN, U, and YPC by taking their natural logarithms. The transformed variables are denoted as LNCB, LNCOPC, LNEN, LNU, and LNYPC, respectively. Table 1 summarizes the variables used in the study. The general form of the estimated equation is given below:

$$LNCOPC = F(LNCB, LNEN, LNU, LNYPC) \tag{1}$$

Methods

Time series variables can often be attributed as non-stationary (Nelson and Plosser 1982). To examine the order of integration of the variables, I conduct two tests: the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. For both tests, the null hypothesis is that the series contains a unit root. If the series are integrated of order one, then the standard least square techniques will be inappropriate and will produce inconsistent estimates. In such a situation, the ideal approach is to proceed with cointegration techniques. I first call for the Johansen cointegration method. However, before proceeding with the Johansen technique, it is important to identify the appropriate lag length. I use several lag length criteria including Akaike information criterion (AIC), Schwarz Bayesian criterion (SC), and Hannan-Quinn criterion (HQ) to select the appropriate lag length to estimate the cointegration model.

Further, to tease out the long-run and short-run coefficient values, I implement an ARDL model. The specific ARDL model for Eq. (1) can be written as:

$$\begin{aligned}\Delta LNCOPC_t = \alpha_0 &+ \sum_1^m \alpha_{1i}\Delta LNCOPC_{t-a} \\ &+ \sum_0^n \alpha_{2i}\Delta LNCB_{t-b} + \sum_0^o \alpha_{3i}\Delta LNEN_{t-c} + \sum_0^p \alpha_{4i}\Delta LNU_{t-d} \\ &+ \sum_0^q \alpha_{4i}\Delta LNYPC_{t-e} + \beta_1 LNCOPC_{t-1} + \beta_2 LNCB_{t-1} \\ &+ \beta_3 LNEN_{t-1} + \beta_4 LNU_{t-1} + \beta_5 LNYPC_{t-1} + \varepsilon_t\end{aligned} \tag{2}$$

where lag lengths, a, b, c, d, and e, are selected based on the AIC and the error term ε_t is serially independent. Within the ARDL framework, I use the bounds testing using both the F-test and t-test (Pesaran et al. 2001; Banerjee et al. 1998). The F-test is based on the joint significance of the restriction in the null hypothesis of $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5$. This is done at a given level of statistical significance that there exists a long-run relationship. The estimated test statistic is compared with upper bound (I(1)) and lower bound (I(0)) critical values. If the F-test statistic is greater than the upper bound critical value, then the null hypothesis of no long-run level of relationship is rejected. Contrarily, if the F-test statistic is smaller than the upper bound critical values, then the null hypothesis is no long-run relationship is rejected. However, if the F-test statistic is between the upper and lower bound critical values, the decision on the existence of a long-run relationship is inconclusive.

The F-test is a necessary condition, and the t-test is a sufficient condition. The null hypothesis of the t-test is that $\beta_1 = 0$, and the alternative hypothesis is that $\beta_1 < 0$. Similar to the F-test, if the absolute value of the t-test statistic is greater than the upper bound value, then we reject the null hypothesis of no long-run relationship. The decision is inconclusive if the absolute value of the test statistic lies between the upper and lower bound critical values. Finally, we fail to reject the null hypothesis of no long-run relationship when the test statistic is smaller than the upper bound critical values. If the null hypothesis of no cointegration is rejected by both F-test and t-test, I will then proceed to estimate the long-run and short-run coefficients of the independent variables. The short-run equation will also estimate the error correction term which must be negative and statistically significant to have a stable cointegrating relationship. Further, I will conduct a battery of diagnostic tests to examine overall model adequacy. First, I will conduct the Jarque-Berra, the Breusch-Godfrey Lagrange Multiplier (LM), and the Breusch-Pagan-Godfrey tests to examine normality, serial correlation and heteroskedasticity, respectively. Second, to test for structural stability of the model, I will conduct the Ramsey regression equation specification error test (RESET). The cumulative sum of the recursive residuals (CUSUM) and the cumulative sum of the recursive residuals squares (CUSUM of squares) will be presented to provide further evidence of the stability of the estimated model.

Table 2 Unit root tests

Variable	ADF	PP
LNCOPC	− 0.273	0.082
ΔLNCOPC	− 4.784***	− 6.439***
LNCB	− 0.500	− 0.429
ΔLNCB	− 6.026***	− 6.058***
LNEN	0.552	1.261
ΔLNEN	− 3.462***	− 5.524***
LNU	0.163	0.330
ΔLNU	− 5.274***	− 5.163***
LNYPC	3.550	6.660
ΔLNYPC	− 3.914***	− 3.900***

(1) The null hypothesis of both ADF and PP tests is that the series contains a unit root. (2) *** represents statistical significance at the 1% level

Table 3 VAR lag order selection criteria

Lag	AIC	SC	HQ
0	− 12.482	− 12.278	− 12.407
1	− 22.485*	− 21.256*	− 22.032*
2	− 22.305	− 20.052	− 21.474
3	− 22.012	− 18.735	− 20.804
4	− 21.943	− 17.642	− 20.357

(1) * represents selected lag. (2) AIC is Akaike information criterion, SC is Schwarz Bayesian criterion, and HQ is Hannan-Quinn criterion

Finally, I estimate the long-run model (i.e., Eq. 1) using the fully modified ordinary least squares (FMOLS) method. As a robustness check, this is done to compare the results from the ARDL model with that of the FMOLS model.

Results

Table 2 presents the results from both the ADF and PP tests. For the variables in levels, the null hypothesis that the series contains a unit root is not rejected even at the 10% level of statistical significance. However, the null hypothesis is rejected at the 1% level of statistical significance for all variables at their first differences. Thus, the variables are non-stationary at levels but stationary at first differences. In other words, all the series in the dataset are integrated of at most order one. These results allow me to proceed with the estimation of the Johansen cointegration model.

In Table 3, I present the results from selecting the optimal lag length for the Johansen tests. All three lag length criteria, i.e., AIC, SC, and HQ, suggest that the optimal lag length is 1, which is used to estimate the Johansen model. I report the test results in Table 4. For the trace test, it is evident that the

Table 4 Johansen cointegration

Number of cointegrating vectors	Eigenvalue	Trace statistic	5% critical value	Max-Eigen statistic	5% critical value
None*	0.607	87.580	60.061	42.022	30.440
At most 1*	0.438	45.558	40.175	25.935	24.159
At most 2	0.240	19.622	24.276	12.362	17.797
At most 3	0.148	7.260	12.321	7.227	11.225
At most 4	0.001	0.033	4.130	0.033	4.130

* represents statistical significance at least at the 5% level

Table 5 ARDL bounds tests

Equation	F-statistic		t-statistic	
LNCOPC = F(LNCB, LNEN, LNU, LNYPC)	13.365***		− 6.591***	
Significance level	Lower bound	Upper bound	Lower bound	Upper bound
10%	1.90	3.01	− 1.62	− 3.26
5%	2.26	3.48	− 1.95	− 3.60
1%	3.07	4.44	− 2.58	− 4.23

(1) The null hypothesis of both tests is that there is no level relationship. (2) *** represents statistical significance at the 1% level

trace statistics are greater than their 5% critical values for up to two cointegrating vectors. Therefore, the null hypothesis of two cointegrating vectors cannot be rejected by the trace tests. Similarly, for the maximum eigenvalue test, we cannot reject the null hypothesis of two cointegrating vectors since the first two maximum eigenvalue statistics are greater than their 5% critical values. Therefore, in summary, both tests suggest that there are long-run level relationships among the variables in the dataset.

Next, I report the results from the *F*-test and *t*-test in Table 5. The value of *F*-test statistic is 13.37, which is greater than the upper bound value of 4.44 at the 1% level of statistical significance. Similarly, the absolute value of *t*-statistic (6.59) is greater than the upper bound value (4.23) at the 1% level of statistical significance. Thus, the hypothesis of a long-run level relationship is satisfied by both *F*-test and *t*-test.

The next stage of the analysis involves in estimating the short-run and long-run forms of the ARDL model. The upper portion of Table 6 reports the long-run coefficients, and the lower portion presents the short-run cointegrating form. Starting with the short-run equation, the error correction term is negative and statistically significant at the 1% level. The absolute magnitude of the coefficient is 0.51, suggesting that over 50% of any deviation from the long-run equation is corrected within the first year. Among other variables in the short run, the second lag of the first difference of LNCOPC is statistically significant at the 5% level. The main focus of this study, however, is on the long-run equation. Not surprisingly, an increase in energy consumption increases CO_2 emissions, and an increase in the unemployment rate (i.e., a fall in the employment rate) is negatively associated with CO_2 emissions. Per capita GDP is however negatively related with CO_2 emissions, which is in line with the previous finding of Das (2018) for Canada.

Table 6 ARDL long-run equation

Variable	Coefficient	Standard error
	Long-run equation	
LNCB	− 0.254**	0.119
LNEN	1.377***	0.196
LNU	− 0.097**	0.043
LNYPC	− 0.305***	0.051
	Short-run equation	
ΔLNCOPC (first lag)	− 0.123	0.097
ΔLNCOPC (second lag)	− 0.194**	0.084
ΔLNYPC	0.099	0.078
Error correction term	− 0.511***	0.059
R-squared	0.687	
ARDL model	(3, 0, 0, 0, 1)	
Number of observations	44	
Time period	1969-2016	

*** and ** represent statistical significance at the 1% and 5% level, respectively

The goal of this study is to understand the association between LNCB and LNCOPC. The coefficient of LNCB is negative and statistically significant at the 5% level. This means that collective bargaining coverage is negatively associated with CO_2 emissions. The size of the coefficient is negative 0.25. Thus, a 1% increase in unionization, represented by

Table 7 Diagnostic tests

Test	Test statistic	Probability
Breusch-Godfrey serial correlation Lagrange multiplier*	0.838	0.441
Harvey heteroskedasticity**	0.371	0.929
Jarque-Bera normality***	1.146	0.564
Ramsey regression equation specification error****	2.364	0.133

*H_0 no serial correlation; **H_0 Homoskedastic; ***H_0 normally distributed; ****H_0 the model does not suffer from misspecification

collective bargaining coverage, on average, reduces per capita CO_2 emissions by a quarter percent in the long run after controlling for per capita GDP and energy consumption and unemployment rate. This result echoes the previous findings for the OECD countries (Alvarez et al. 2019).

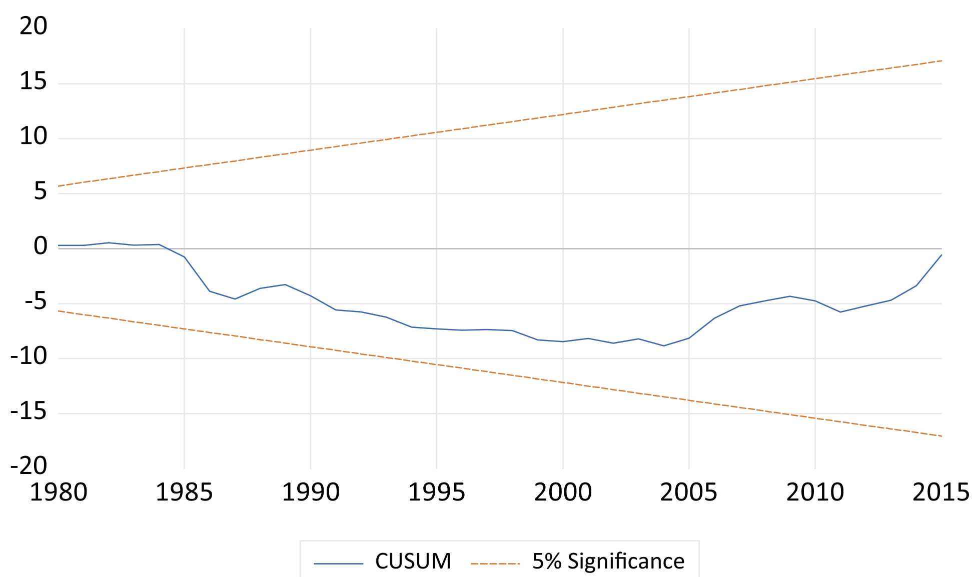
Next, I carry out a set of diagnostic tests including the Jarque-Berra, the Breusch-Godfrey LM, and the Breusch-Pagan-Godfrey tests. I present the results in Table 7. The estimated test statistics for all three tests are not statistically significant at the conventional levels. Therefore, the null hypothesis of no serial correlation, homoskedasticity, and normal distribution is not rejected, respectively. Further, Ramsey RESET test statistic, also presented in Table 7, is not statistically significant. The null hypothesis of the test that the functional form is correct is not rejected. Therefore, the parameters of the model are stable. Finally, I present the CUSUM and CUSUM of squares in Figures 2 and 3. If the CUSUM falls outside the 5% significance confidence bands, then the parameters in the long-run relationship are unstable. On a similar note, if the CUSUM of squares deviates from the 5% significance bands, then the parameters and variance are unstable. Both figures suggest that the parameters and variance are stable. Therefore, the model is internally valid and stable for statistical estimations.

As an additional robustness test, I compare the results from the baseline ARDL model with that of a FMOLS model. I present the findings in Table 8 in Appendix A. The coefficient of LNCB is still negative and statistically significant at the conventional level. Among other variables, LNEN is positive, and both LNU and LNYPC are negative. All three variables are statistically significant. Further, the null hypothesis of normal distribution is not rejected. Therefore, the results from FMOLS are in line with earlier findings from ARDL.

Discussion, future research, and concluding remarks

The societal impacts of unions are indisputable. Scholars have long suggested that unionization reduces inequality and increases social protections. However, in the empirical existing literature, it is not clear what roles unions play in addressing climate change. In Canada, some unions advocated for protecting jobs over reducing emissions, while others realized mutual benefits of both welcoming climate-related regulations and job protections. Within the Canadian context, no study has empirically examined the role of unionization in climate change. This study contributes to the literature by bridging the gap in the literature. After controlling for macroeconomic factors including energy consumption, unemployment rates, and per capita GDP, I examine how unionization, measured by the rate of collective agreement coverage, impacts CO_2 emissions over the 1969–2016 period. I apply the Johansen cointegration and ARDL techniques. Results suggest that unionization is negatively associated with CO_2

Fig. 2 Stability test: cumulative sum (CUSUM)



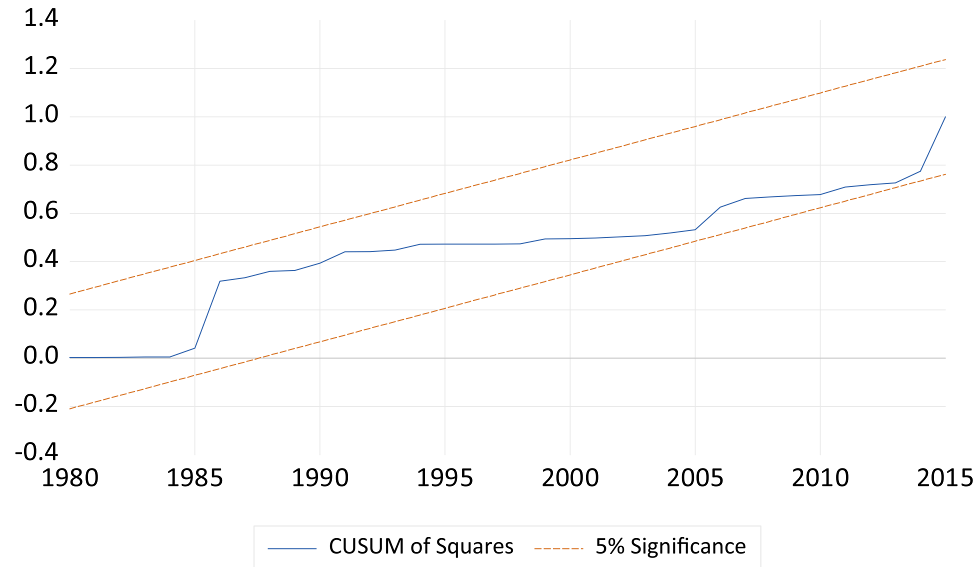


Fig. 3 Stability test: cumulative sum (CUSUM) of squares

emissions in Canada. Specifically, on average, a 1% increase in unionization tends to reduce emissions by a quarter of a percent in the long run. The empirical finding of this study echoes the previous results of Alvarez et al. (2019). Following Obach (2002, 2004) and Galgóczi (2020), I argue that perhaps there is no conflict between unions and environmentalists in Canada. Instead, unions complement environmentalists and promote policies to address climate change. Explaining the causal links between unionization and environment using the econometric results is beyond the scope of this study. However, the mechanism of this relationship warrants a discussion. First, following the *bargaining hypothesis*, I argue that unions and employers address climate change by successfully negotiating green clauses at the bargaining table. This is evident from the survey of over 100 collective agreements (as discussed in "Unions and the green movement" section) which include *green* clauses. Thus, collective agreements played an important role in unions' contributions to CO_2 emissions. The second argument uses the *advocacy hypothesis.* Perhaps unions also pushed for climate actions outside bargaining. We have seen evidence where union members are involved in taking actions to address climate issues at the policy level. Therefore, I argue that an effort by Canadian unions through collective bargaining and advocacy may have been instrumental in adapting green policies and, thereby, tackling environmental degradation.

The econometric model estimated in this study is statistically adequate and stable. However, future studies should investigate several key issues. First, it will be interesting to conduct a panel study of Canadian provinces and territories to verify the findings of the current study. Second, to have a better understanding of the process of how unions impact climate change, a survey study on unions and a qualitative study of evaluating union policies and respective collective agreements will be of some importance. This will further help us unpack the differences in unions' response to climate change due to heterogeneity among unions in Canada. Third, future studies should further explore if the union-climate nexus varies across provinces. Finally, similar time series studies can be conducted for other OECD countries to examine if there is any discernible impact of unionization on climate CO_2 emissions. However, as mentioned in an earlier section, unlike Canada, the trade union density may be significantly different from the rate of collective agreement coverage in other countries. Thus, academics should keep that in mind while conducting the statistical analysis in future studies.

From a policy perspective, it is important to note that the primary finding of this study is that unionization is negatively associated with CO_2 emissions (i.e., unionization has a positive impact on CO_2 reduction). Both employers and unions from every spectrum of society should develop their own policies to address climate issues. Eventually, both parties should negotiate climate-related measures. Further, governments at the federal, provincial, and local levels should consider providing incentives to the industries that successfully include climate clauses in their collective agreements. At the federal level, these incentives should be funded through the Government of Canada's Net Zero Accelerator initiative,[4] which currently provides up to $8 billion to support companies that actively participate in achieving net zero emissions. Similar programs should be undertaken by other levels of government. The specifics outlined as policies are directly applicable to the Canadian context. However, other nations can apply similar policies

[4] More on this initiative can be found here: https://www.ic.gc.ca/eic/site/125.nsf/eng/00039.html

based on their own unique administrative structures. These are long-term policies and will require a joint effort from both employers and the unions to structurally transform the workplace. Nonetheless, given the current climate crisis, there is no better time than now to introduce a set of holistic policies to ensure a sustainable future.

Appendix A

Table 8 FMOLS estimation

Variable	Coefficient	Standard error
LNCB	− 0.180*	0.097
LNEN	1.153***	0.136
LNU	− 0.063*	0.033
LNYPC	− 0.244***	0.035
R^2	0.742	
Jarque-Bera normality	2.155 (*p*-value: 0.341)	
Number of observations	46	
Adjusted Time period	1970–2015	

(1) *** and * represent statistical significance at the 1% and 10% level, respectively. (2) The null hypothesis of the Jarque-Bera test: H_0: normally distributed

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Author contribution Dr. Anupam Das formulated the research questions, developed the literature review, collected data, developed methodology, conducted statistical analysis, and wrote the full paper.

Availability of data and materials All data and relevant materials are available upon requests.

Declarations

Ethical approval Not applicable

Research involving human participants and/or animals This research does not involve human participants and/or animals.

Consent to participants Not applicable

Consent to publish Not applicable

Conflict of interest The author declares no competing interests.

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