2023 SSC Case Studies in Data Analysis Poster Competition

Case Study	Understanding How Canada's Economy Might be Impacted by Climate Change
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Project Title	Using Time Series Analysis Models to Explore the Present and Potential Impacts of Climate Change on Canada's Economy

1 Introduction

There have been considerable efforts to understand the ramifications of climate change, especially in economic and financial markets [1, 2, 3]. Consequently, national [4] and international [5] reports have documented concerning trends and predictions in factors such as greenhouse gas emissions and average temperature. This has brought climate change analysis to the forefront of research in numerous sectors, resulting in many frameworks being developed to understand, model, and forecast these trends and ascribe response measures to mitigate and adapt to their implications. To explore the impacts of climate change in the Canadian economy, this project will use time series models to perform inference on climate change parameters and understand their underlying trends.

2 Objective

An extensive literature review was undertaken to help identify which topics could be reasonably addressed using the provided data. One avenue of interest is to determine the regions that are experiencing the fastest changing climate. This goal was interpreted as a descriptive statistic comparison with climate anomaly trends subset by geographic region and analysis performed on the magnitude of the rate of change of these variables. The second objective of this project is to assess which economic industries have already experienced observable impacts from changing climate. This goal was understood as a statistical inference exercise on the parameters of multivariate models with climate change variables as the exogenous features.

3 Methods

Exploratory data analysis identified potential cases of prevented residual disclosure in reported industry productivity, and revealed quality deficiencies in the weather measurements due to missing and inconsistent values. The provided data was therefore augmented with carbon dioxide concentrations and readings from more stations to improve data quality [6]. Climate anomalies were used in place of the absolute weather measurements to reduce variance in recorded values and improve predictions across large distances [7]. The baseline climate normal period was selected as 1971-2000. To construct a balanced climate panel data set, spatial interpolation using inverse distance weighting (IDW) was performed over the geographic multi-polygons of each census sub-division.

For the first objective, the trend components of seasonal trend decompositions of each climate anomaly per province were visually compared by their correlation magnitudes and variances. To investigate the second objective, several modelling paradigms were reviewed, including the Dynamic Integrated Climate-Economy (DICE) model [8] and related Integrated Assessment Models [9]. Simpler generalized linear regression models and scenario-based methods have also been used in relevant works [10], and deep learning implementations of Recurrent Neural Networks and Long-Short Term Memory [11] were also investigated. In the end, a multivariate fixed-effects model using entity-demeaned OLS regression was computed independently for each industry per province, where the response variable was the proportion of total productivity that an industry comprised and the explanatory variables were the associated normalized climate anomalies in that region.

4 Results

Analysis of the climate anomaly trends revealed that minimum, maximum, and mean temperature anomalies follow similar upwards patterns and exhibit increasing variances from East to West. Conversely, total precipitation anomalies display decreasing trends in Atlantic Canada but gradually increase to become slightly positive on the West Coast. The volatility also smoothens out further inland.

Parameter inference on the coefficients of the regression models factors in the previously discussed observed climate anomaly trends. It shows that industries impacted by climate anomalies varied between regions but were similar within them. The *construction* industry in Ontario was negatively impacted by climate anomalies, as was the *financial sector* on both coasts. These can potentially be attributed to physical risk, which manifests itself in stranded financial assets, larger insurance claims, and worse housing conditions. The impacts on the *natural resource* industries were mixed. In Alberta, these anomalies increased the productivity proportion of the natural resource industry, potentially due to a related increase in growing degree days. Conversely, in Atlantic Canada, these anomalies had a negative impact on natural resource productivity proportion, reflecting negative repercussions on the climate-vulnerable fishery and aquaculture industry. Increasing temperature anomalies benefited New Brunswick's *wholesale and retail trade* industries, as well as Ontario's and Nova Scotia's *manufacturing* industries. Surprisingly, *health care and social assistance* demonstrated a mixed response to the climate anomalies requiring further analysis.

5 Conclusions

In this project, we investigated various strategies in time series analysis to better understand the present and potential impacts of climate change on Canada's economy. We found that the West Coast and Atlantic Canada experienced the greatest volatility and trends in average temperature and total precipitation anomalies, while the Prairies and Central Canada were more resilient to them. Construction, natural resources, wholesale and retail trade, manufacturing, health care and social assistance, and the financial sector experience noticeable but distinct impacts explained by climate anomalies. There is still room for improvement in this analysis, and extensions of this project could investigate methods that incorporate economic shocks, spatio-temporal correlation [12], and account for related complex interacting covariates in their predictions [13, 14].

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