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Population growth, energy use, and environmental impact: Comparing Canadian and Swedish records on CO_2 emissions

About the Brief

This research brief is based on Don Kerr, "Population growth, energy use, and environmental impact: Comparing the Canadian and Swedish records on CO_2 Emissions", Canadian Studies in Population 41, no. 1-2(2014): 120-143. For further information, contact Don Kerr, King's University College, University of Western Ontario.

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Target Audience

- Researchers
- Policy Makers
- Graduate Students

Summary

Canada and Sweden are both northern countries with predominantly export-oriented economies that have recently witnessed demographic growth and climbing affluence. However, there is a stark contrast in their respective records on greenhouse gas emissions: Sweden is often considered a world leader in emission reduction, while Canada has largely failed to meet international commitments. This study aims to understand the factors responsible for their differing records. It demonstrates that Canada's relatively rapid population growth, persistent reliance on fossil fuels, and heavy demand for energy have contributed to its increasing level of CO_2 emissions. On the other hand, Sweden has managed to move away from fossil fuel dependency and intense energy use while still driving economic activity.

Key Findings

Total CO_2 emissions produced in Canada have risen by 20% over the 1990-2009 period, while Swedish emissions have declined by 21%. To understand these differing environmental records, this study applies a modified version of the IPAT equation to both countries. The IPAT equation states that a country's environmental impact is a product of its population, its affluence (indicated here by GDP per capita), and the technology it employs to produce goods.

The study found that:

- Canada's population grew by 21.6% from 1990-2009, while Sweden's population grew by 8.8%. Relatively high population growth in Canada implies increased consumption and therefore partially explains its significant environmental impact.
- Nevertheless, both countries saw a similar increase in affluence from 1990-2009: Canada's GDP per capita increased by 27.9%, Sweden's by 31.1%.
- It therefore appears that Sweden has succeeded in "decoupling" its economic growth from environmental impact, in particular by lowering its dependency on fossil fuels and its energy intensity.
- In contrast, Canada maintains high levels of fossil fuel dependency and a high demand for energy, especially as its government has actively encouraged investment in pipelines and export of crude oil.
- Notably, however, these emission records consider only production-based emissions. The emissions created from the goods that a country imports and consumes are not taken into account. Canada exports more than Sweden, but Sweden's consumption levels are on par with Canada's. As such, Sweden's recorded emission levels may be understated.

Background

Canada and Sweden share many similarities. Both are northern countries with diverse modern economies, a high standard of living, and long democratic traditions. They are ranked 8th and 9th, respectively, on the UN's Human Development Index. Both have also witnessed substantial economic growth over recent decades. However, there is a great difference between their environmental impact records: Sweden is doing significantly better than Canada in reducing greenhouse gas emissions (Simpson *et al* 2007). On a per capita basis, Canada ranked 27th across OECD countries in 2009 in terms of a carbon footprint, while Sweden ranked 3rd, producing less than any other wealthy nation. Further, as stated above, total CO_2 emissions produced in Canada have risen by roughly 20% over the 1990-2009 period, while Swedish emissions have declined by 21%.

This study uses environmental impact equations, data from the International Energy Association on CO_2 emissions and energy use, and demographic and economic data from the UN and OECD, to investigate the factors responsible for the observed differences between Sweden and Canada. Since the bulk of greenhouse gases are CO_2 emissions resulting from energy use and burning of fossil fuels, the study focuses solely on CO_2 emissions.

Method

This investigation is based on the following IPAT equation, formulated by Ehrlich and Holdren in 1971:

Impact (I) = Population (P) x Affluence (A) x Technology (T)

This equation argues that an increase in population will lead to a proportional increase in environmental impact, if there were no change to the other components (likewise, this is also true of affluence and technology).

The Intergovernmental Panel on Climate Change (2000) has modified the IPAT identity to specifically express CO_2 emissions for a nation-state, where population size represents P, GDP/Population represents A, and CO_2 emissions/GDP[1] represents T:

CO_2 emissions = Population x (GDP/Population) x (CO_2 emissions/GDP)

Debate continues as to the relative importance of each term, but it is commonly acknowledged that each definitely belongs in the equation. Increased population and affluence both indicate heightened consumption and therefore larger ecological footprints. The technology term is more complex: technology often causes many environmental difficulties, but it also holds promise of potential solutions. The equation has therefore been modified to break the technology component down further. Hamilton and Turton's 2002 revised equation is:

CO_2 emissions = Population x (GDP/Population) x carbon intensity effect x fossil fuel dependency effect x conversion efficiency effect x energy intensity effect

- Carbon intensity effect refers to the ratio of CO_2 emissions relative to total fossil fuel combustion. This term is at its highest in societies that burn low-grade, high carbon content fossil fuels.
- Fossil fuel dependency effect indicates the proportion of total primary energy supply obtained from fossil fuels.
- Conversion efficiency effect refers to the extent to which energy resources are used to create energy in another form (for instance, coal is often used to generate electricity).
- Energy intensity effect of economic activity refers to total final energy consumption relative to GDP.

The following section looks at each of the terms in Hamilton and Turton's equation for both Canada and Sweden.

Results

Population Growth and Environmental Impact

Canada's population grew by 21.6% from 1990-2009. On the other hand, Sweden has not experienced nearly as much demographic pressure, with its population up by 8.8% over this same period. As is common for European countries, Sweden has an older age structure than Canada, and older populations tend to grow more slowly. Canada's population has also been supplemented with relatively high immigration targets.

[1] CO_2 emissions/GDP indicates the intensity of carbon use in economic activity.

If we assume no departure from observed trends in affluence or technology, we can contrast Canada's observed CO_2 emissions with what it might have hypothetically experienced if it had demographic growth comparable to Sweden's (i.e., with a population growth of 8.8%). We can also do the converse for Sweden, creating a hypothetical trend using Canada's much higher population growth. In these situations, Sweden's success in reducing emissions would have been cut in half, from a 21% reduction in 1990-2009 to an 11.6% reduction. Similarly, the estimated climb in emissions for Canada under a slower population growth scenario would be cut by more than half, from 20% to 7.8%. According to the IPAT model, then, Canada's increase in CO_2 emissions is partially the byproduct of its rapid population growth.

CO_2 Emissions and Affluence

Although Canada's population growth has outpaced Sweden's, the same does not hold for the second IPAT component, affluence. From 1990-2009, GDP per capita in Canada increased by 27.9%. In Sweden, this figure was even higher at 31.1%. One may therefore expect an increase in CO_2 emissions from both countries; however, as aforementioned, Sweden's emissions declined by 21%. It seems that Sweden has managed to "decouple" its economic prosperity from a high carbon footprint.

Using the IPAT equation, we can again examine how Canada's record on CO_2 emissions would have differed if its increase in GDP per capita had matched Sweden's, and vice versa. We see that with a 31.1% GDP per capita increase, Canadian emissions would have been up 23.4% rather than 20%. Meanwhile, if Sweden's GDP per capita increase had matched Canada's at 27.9%, its emissions would have been down 22.8% instead of 21%. It appears that the impact of demographic growth in comparing the two countries has been partially offset by differences in economic growth. To further explain the substantial differences, it is necessary to turn to the technology component of IPAT.

CO_2 Emissions and Technology

As explained above, the technology component in the IPAT equation can be delineated into four separate terms: fossil fuel dependency effect, carbon intensity effect, conversion efficiency effect, and energy intensity effect.

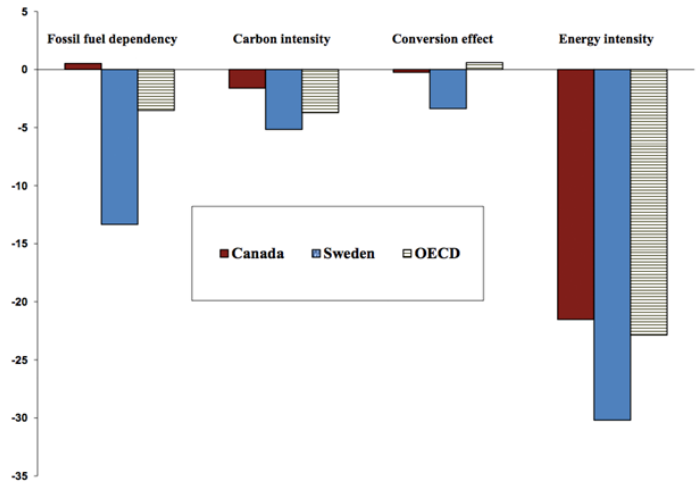


Figure 1— Percentage change in the technology components (1990-2009) for Canada, Sweden, and the OECD total

Figure 1 illustrates percentage change for the four technology components for Canada and Sweden from 1990-2009. The lower the percentage change for each component, the more environmental impact has been reduced. For instance, the graph shows that Sweden has reduced its carbon intensity effect by about 5%.

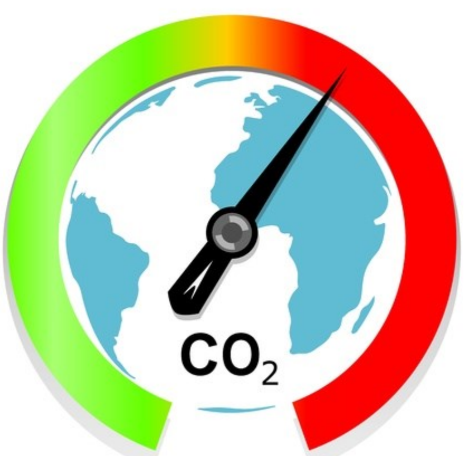
It is striking here that Sweden has managed to reduce environmental impact with all four terms. Meanwhile, Canada has lagged behind: it shows relatively negligible reduction, plus a small increase in its fossil fuel dependency. Notably, Canada also lags behind the OECD average, with the exception of its conversion effect component. Overall, the simple fact that Sweden has managed to move away from fossil fuels and intense energy use over the last two decades, whereas Canada has not, seems to play a large part in why the two countries are almost at opposite extremes in terms of per capita CO_2 emissions.

Indeed, Canada is a resource-rich country with major reserves of fossil fuels, which has arguably left it without the same sorts of incentives to reduce fossil fuel dependency. Canada has few regulatory limits on fossil fuel consumption in sectors that are the most responsible for greenhouse gas emissions, such as transportation and electricity generation. Additionally, governments and industry in Canada continue to encourage growth in the Canadian energy sector, with active promotions of pipelines and investment in crude oil.

Canada is also an energy-intense country, using more energy (per unit of GDP) than practically any other country in the OECD. This is partly because its export-oriented economy produces far more than its small population would suggest, including 10% of the world supply of aluminum and 15% of the world's wood pulp. Further, typical Canadians use much more energy than typical Swedes: they tend to drive more fuel-inefficient vehicles, live in larger homes, and require more transportation due to the country's vast landmass.

Meanwhile, Sweden is in a very different situation. Since it must import its oil and natural gas, its favorable record partially relates to the necessity for seeking out fossil fuel alternatives. Instead, it utilizes hydroelectricity and nuclear energy. Sweden is also at the forefront in terms of eco-friendly initiatives. For instance, it recently committed itself to be completely "oil-free" by the year 2020.

Notably, however, there has been little attention paid to the emissions associated with the consumption of goods and services in each country. A substantial proportion of what is consumed in Sweden is produced elsewhere; it is thus a "net importer" of CO_2 (Davis and Caldeira 2010). Canada, on the other hand, is a "net exporter", as it produces more emissions in extraction and production than it does through consumption. It has been estimated that roughly one-half of the discrepancy between these countries disappears if one shifts from production-based accounting of CO_2 emissions to a consumption-based framework.



Conclusion

Overall, the IPAT model illustrates how Canada's rising population and affluence, in combination with its lack of effort to move away from fossil fuels, has contributed to an energy intense economy with relatively high CO_2 emissions. Meanwhile, Sweden's lesser demographic pressures and the "decoupling" of its economic growth from environmental impact have resulted in a better record. However, there are certainly limits to the IPAT's production-based framework, as well as to its argument that the effects of its components are proportional. More complex models, such as those by Jorgenson (2003) or Davis and Caldeira (2010) are, respectively, good places to further examine other potential drivers of environmental impact, and the complex relationship between population and environment in the globalization context.

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