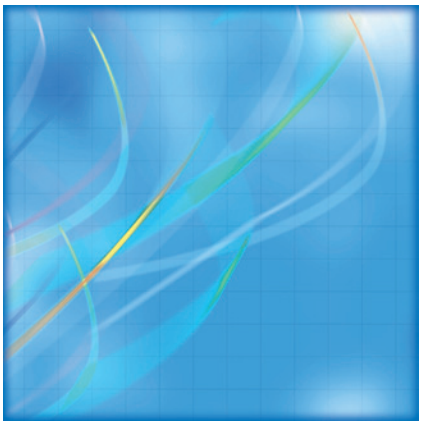
Catalogue no. 11-624-MIE — No. 001
ISSN: 1708-0169
ISBN: 0-662-34291-7

Analytical Paper

Insights on the Canadian economy

Greenhouse gas emissions in the Canadian economy, 1981-2000



by Tarek M. Harchaoui

Micro-economic Analysis Division
18th floor, R.H. Coats Building, Ottawa, K1A 0T6

Telephone: 1 800 263-1136

This paper represents the views of the author and does not necessarily reflect the opinions of Statistics Canada.

Statistics Canada Statistique Canada

Canada

Greenhouse Gas Emissions in the Canadian Economy, 1981-2000

by

Tarek M. Harchaoui

11-624-MIE No. 001

ISSN: 1708-0169
ISBN: 0-662-34291-7

Micro-Economic Analysis Division
18-F R.H. Coats Building
Ottawa, K1A 0T6
Statistics Canada

How to obtain more information :
National inquiries line: 1 800 263-1136
E-Mail inquiries: infostats@statcan.ca

Published by authority of the Minister responsible for Statistics Canada

May 2003

Aussi disponible en français

Abstract

Canada's greenhouse gas emissions have risen by 30% between 1981 and 2000. Per capita, Canada has one of the world's highest levels of greenhouse gas emissions. Canada's heavy reliance on fossil fuel for energy rather than other forms of power (such as nuclear) and the structure of its economy are two influences behind this high rate of emissions. Over this period, carbon dioxide emissions per capita reported a moderate increase primarily as a result of the increase of energy consumption per capita but improvements in eco-efficiency—defined as the growth of saleable output per unit of CO_2 emissions—slowed in the 1990s, compared to the 1980s. In the 1990s, Newfoundland and Labrador, Prince Edward Island and Quebec were the provinces that experienced the fastest improvement in eco-efficiency.

Overview

Over the past 100 years, global mean surface temperatures have increased by 0.4 to 0.8°C, and the World Meteorological Organization reports that the 10 warmest years in the past 140 have all occurred since 1983. Some of this change may be natural, but over the past 200 years human activity has altered the worlds' atmosphere; and there is increasing evidence that these atmospheric changes are having an influence on the climate through the enhanced greenhouse effect. The effects of global warming are very difficult to predict but are of global concern.

The greenhouse effect is a natural occurrence that results from a blanket of atmospheric gases that surrounds the Earth. These gases (carbon dioxide (CO_2), methane, and nitrous oxide) act to trap heat in the atmosphere and so keep the Earth's temperature at a level necessary to support life.

In recent years, there has been much debate about how this natural phenomenon has been affected by human activities that increase greenhouse gas concentrations in the atmosphere. It is difficult to provide a precise answer to this question, given the uncertainties associated with atmospheric science. Indeed, some argue that human activity has had a negligible impact. However, the majority of scientific opinion appears to support the view that human activity has created an enhanced greenhouse effect that is causing global climate change. Most notably, the Intergovernmental Panel on Climate Change expects an average global surface temperature increase of 1.4°C to 5.8°C over the period 1990 to 2100.

CO_2 emissions per capita trend

At 18.3 tonnes in 2000, Canada's CO_2 emissions per capita are amongst the highest in the world. Canada and United States rank third after Australia and Luxembourg in terms of CO_2 emissions per capita.

Canada's carbon dioxide emissions in 2000 were 564 megatonnes (Mt), up from 434 Mt in 1981, an increase of 30%. In order to compare countries of different population size, one can consider per capita emissions of CO_2 (the main greenhouse gas). About 18.3 tonnes of CO_2 were produced for every Canadian in 2000. This is lower than for the U.S. (21.1 tonnes) and Australia (27.6 tonnes), countries that exhibit many similarities to Canada in terms of the

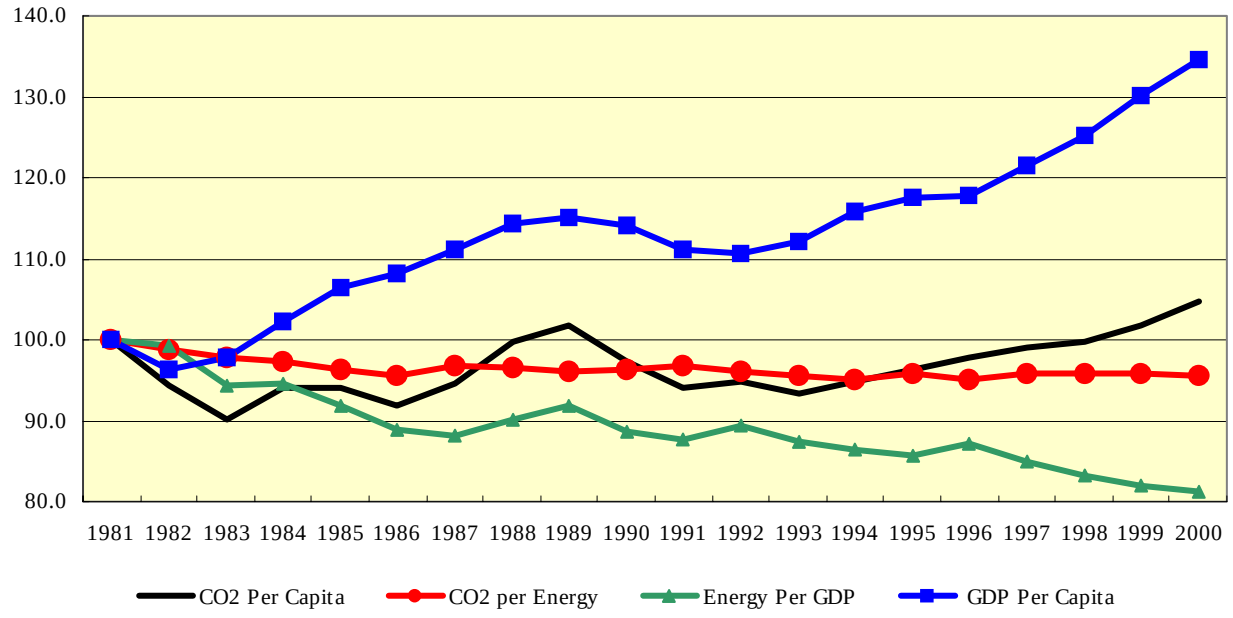
structure of the economy. Nevertheless, Canada's per capita emissions are among the highest in the world. In 2000, Canada's per capita emissions were some 30% higher than the average for countries belonging to the Organisation for Economic Co-operation and Development.

Sources of growth of CO_2 emissions per capita

Despite an increase in their standards of living during the 1981-2000 period, Canadians have been efficient in CO_2 emissions. This is the result not only of the decline in their energy use for every unit of goods and services produced but also because they have been using forms of energy that generate increasingly less emissions.

Economic growth and population increase are important factors behind the growth in emissions. Changes in per capita emissions can be decomposed into three components: emissions per unit of energy consumption, energy consumption per unit of GDP and GDP per capita, an indicator of standards of living. Had we not experienced a less carbon intensive energy consumption pattern (CO_2 per energy) and, particularly, an efficient use of energy (energy per unit of GDP), Canada's emissions per capita would track closely our standards of living (GDP per capita), which improved remarkably in the late 1990s (Figure 1).

Figure 1. Carbon dioxide emissions per capita and their sources of growth in Canada



Over the 1981-2000 period, CO_2 per capita in Canada increased at 0.25% per year. This is largely the result of the increase in our standards of living (+1.6%) offset to a large extent by the decline in the energy consumption per unit of GDP (-1.08%) and CO_2 emissions per unit of energy consumed (-0.23%). CO_2 efficiency has improved in Canada as a result not only of the decline in their energy use for every unit of goods and services produced, but also because they Canada has been using forms of energy that generate less emissions.

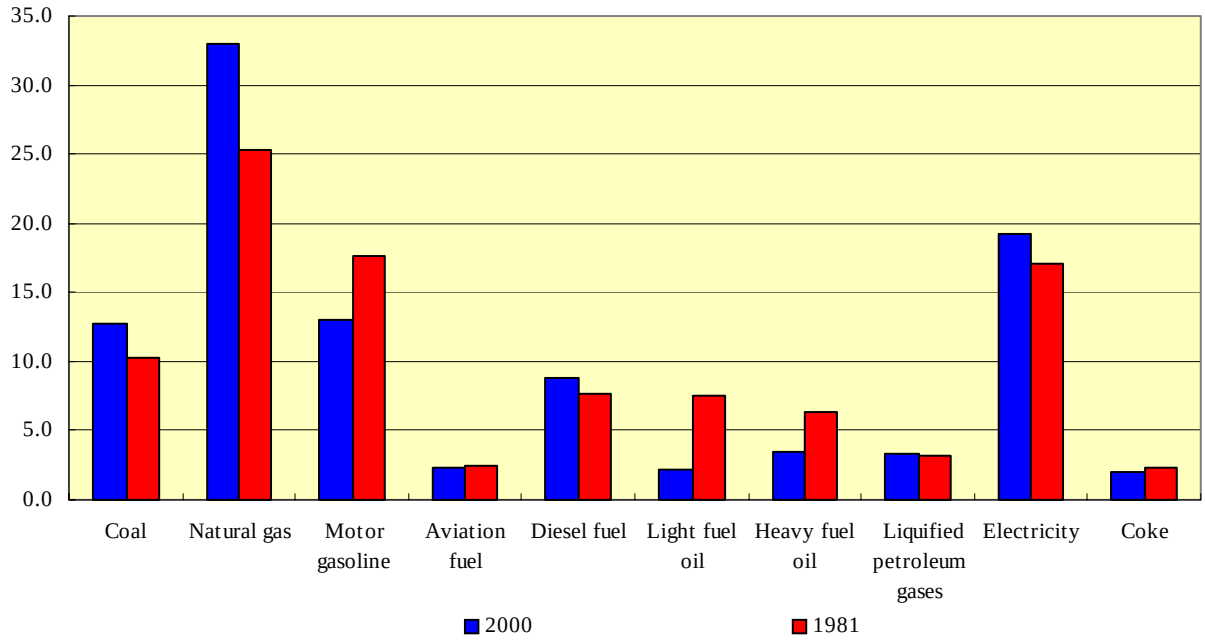
Structure of energy consumption

Oil products lost ground over the last fifteen years to the benefit of hydroelectricity and natural gas, which have a lower CO_2 emission intensity.

An important determinant of the downward trend in CO_2 emissions per unit of energy consumed is the type of fuel used. For example, electricity generated from non-fossil fuel sources, such as hydro-electric (falling water) and solar, has a very low emission intensity (emissions per unit of electricity supplied). Among fossil fuels, brown coal tends to have a higher emission intensity than black coal and natural gas.

Changes in fuel mix had a notable effect on CO_2 emissions. The decline in carbon dioxide emissions per unit of energy consumed over the last fifteen years was due, in part, to a continual shift by many sectors away from petroleum and coal products toward natural gas.

Figure 2. Energy consumption by type of fuel in the Canadian Economy (percentage)



In 1981, coal, coke and petroleum products taken together represented 59% of the total economy energy consumption; by 2000, this had fallen to 49%. In contrast, natural gas rose from 25.4% of energy consumption in 1981 to 32.3% in 2000. Since natural gas emits considerably less carbon dioxide per unit of energy than petroleum and coal products, this shift in the composition of energy use exerted a downward force on carbon dioxide emissions per unit of energy consumed (Figure 2).

Table 1. CO_2 Emissions and real GDP by major sector

	Shares of sectors in terms of CO_2 emissions (average over the 1981-2000 period)	CO_2 Emissions average annual growth rate			Real GDP average annual growth rate			Real GDP per unit of CO_2 emissions average annual growth rate		
		1981-2000	1981-1990	1990-2000	1981-2000	1981-1990	1990-2000	1981-2000	1981-1990	1990-2000
Primary resource sector	**13.3**	**1.9**	**1.8**	**1.9**	**3.0**	**3.0**	**2.9**	**1.1**	**1.2**	**0.9**
Crude petroleum and natural gas	7.0	4.0	5.5	2.7	3.1	2.4	3.2	-0.9	-3.1	0.5
Agricultural and related service	3.7	-0.2	-1.0	0.5	3.0	3.4	2.6	3.2	4.4	2.1
Mining	1.4	-0.3	-1.1	0.3	2.5	3.7	1.4	2.8	4.8	1.1
Other	1.2	0.6	-2.2	3.2	0.4	0.1	0.6	-0.2	2.3	-2.5
Manufacturing sector	**23.4**	**0.7**	**-0.2**	**1.6**	**3.0**	**2.7**	**3.4**	**2.3**	**2.9**	**1.8**
Refined petroleum and coal products	5.0	1.7	1.6	1.8	2.2	5.7	-0.9	0.5	4.1	-2.8
Primary metal	5.4	-0.1	-2.1	1.7	3.9	3.3	4.4	4.0	5.4	2.7
Chemical and chemical products	4.0	1.0	-1.1	3.0	3.2	5.1	1.6	2.2	6.2	-1.4
Non-metallic mineral products	3.0	0.9	0.9	0.9	0.9	1.2	0.6	0.0	0.2	-0.2
Paper and allied products	2.8	0.1	-0.5	0.7	3.0	1.3	4.6	2.9	1.8	3.9
Other	3.3	0.7	0.6	0.8	2.3	1.8	2.7	1.6	1.2	1.9
Other major sectors	**40.3**	**2.2**	**2.5**	**1.9**	**3.4**	**3.2**	**3.5**	**3.4**	**3.2**	**3.5**
Other utility	19.6	2.3	3.2	1.5	2.4	2.3	2.4	0.1	-0.9	0.9
Transportation	8.4	2.5	2.9	2.1	2.3	3.3	1.5	-0.1	0.4	-0.6
Pipeline transport	1.7	6.3	5.8	6.7	5.6	4.6	6.4	-0.7	-1.2	-0.3
Finance and real estate	2.2	2.4	3.7	1.2	3.4	1.9	4.8	1.0	-1.8	3.6
Wholesale trade	1.7	2.1	1.3	2.9	5.2	5.8	4.7	3.1	4.6	1.8
Other	6.7	0.6	-0.2	1.3	1.6	1.5	1.6	1.0	1.7	0.3
Government	3.3	-0.7	-0.9	-0.5	1.2	2.0	0.6	1.9	2.8	1.1
Households	19.7	0.8	-0.8	2.2	-	-	-	-	-	-
Whole economy	**100.0**	**1.4**	**0.9**	**1.8**	**2.7**	**2.7**	**2.8**	**1.3**	**1.8**	**1.0**

Note: - not available

The sectoral sources of growth of CO_2 emissions

Utilities, transportation, crude petroleum and gas industries, manufacturing and households accounted for ¾ of Canada's CO_2 emissions.

The size of the economy, its structure and the energy intensity of industries are important determinants of emissions. Over the 1981-2000 period, more than one-third of CO_2 emissions is attributable to a handful of industries: utilities (19.6%), transportation (8.4%) and crude petroleum and natural gas industries (7.0%). The other major emitter, outside the business sector, is the household sector (19.7%).

Industries that are closely related to the oil and gas sector experienced the fastest growth of CO_2 emissions over the 1981-2000 period. In contrast, the largest CO_2 emitters reported a relatively modest growth.

During the 1981-2000 period, industries reported different patterns in terms of CO_2 growth. Industries that are closely related to the oil and gas sector such as crude petroleum and oil gas, and pipeline transport showed the most rapid growth (4.0% and 6.3%, respectively). The largest emitters, utilities and transportation, displayed a relatively less rapid growth (2.5% and 2.3%, respectively), while households reported a modest growth (0.8%). Other industries such as agriculture, mining, primary metal, and government experienced a decline in the emissions growth.

During the 1990-2000 period, households have significantly increased their CO_2 emissions growth. Industries such as crude petroleum and natural gas, other utilities, transportation finance and real estate and government, have significantly reduced theirs.

During the 1990s, when the Canadian economy doubled its CO_2 emissions growth (1.8%) compared to the 1980s (0.9%), industries showed a wide diversity in the pattern of their emissions growth (see Table 1). Agriculture, mining, manufacturing and households saw a pick up in the growth of their emissions between these two periods. Industries such as crude petroleum and natural gas, other utilities, transportation, finance and real estate and government, reduced their emissions growth significantly. But there are some industries, such as pipeline transport, households and wholesale that substantially increased their emissions during the late 1990s.

Trend in eco-efficiency

Canada's eco-efficiency—output per unit of CO_2 emissions—has improved at a rate of 1.3% on average during the 1981-2000 period. But there is a substantial diversity in eco-efficiency gains across industries and time periods.

Labour, capital and energy are marketed inputs that give rise to saleable output. The production process also generates pollutants such as CO_2 emissions. To produce more goods and services, businesses may use more capital and more labour, but may produce more CO_2 emissions. Labour productivity (output per unit of labour) and capital productivity (output per unit of capital) are partial productivity indicators that measure the extent to which the production process is becoming more efficient in terms of its use of each of these marketed

inputs. Likewise, output per unit of CO_2 emissions can be taken as an eco-efficiency partial indicator. It captures the extent to which economic activity makes an efficient use of the environment as a free input.

The eco-efficiency partial indicator used in this paper is relatively easy to develop using the existing information from environmental and economic accounts. It does not require estimates of the value to society of CO_2 emissions. But single resource productivity indicators have some limitations, since what appears to be an efficient use of one resource may only be the reflection of a substitution effect that may or may not be accompanied by an efficient use of other resources.

Over the 1981-2000 period, the Canadian economy showed a 1.3% increase in eco-efficiency, though this efficiency gain is less rapid than the one reported by labour productivity (1.8%). There is, however, a significant diversity cross industries in eco-efficiency performance. Primary metal showed the most rapid increase in eco-efficiency, followed by agriculture, wholesale, crude petroleum and natural gas, and paper and allied products. In contrast, the major producers of CO_2 emissions (utilities and transportation) displayed a less rapid eco-efficiency improvement.

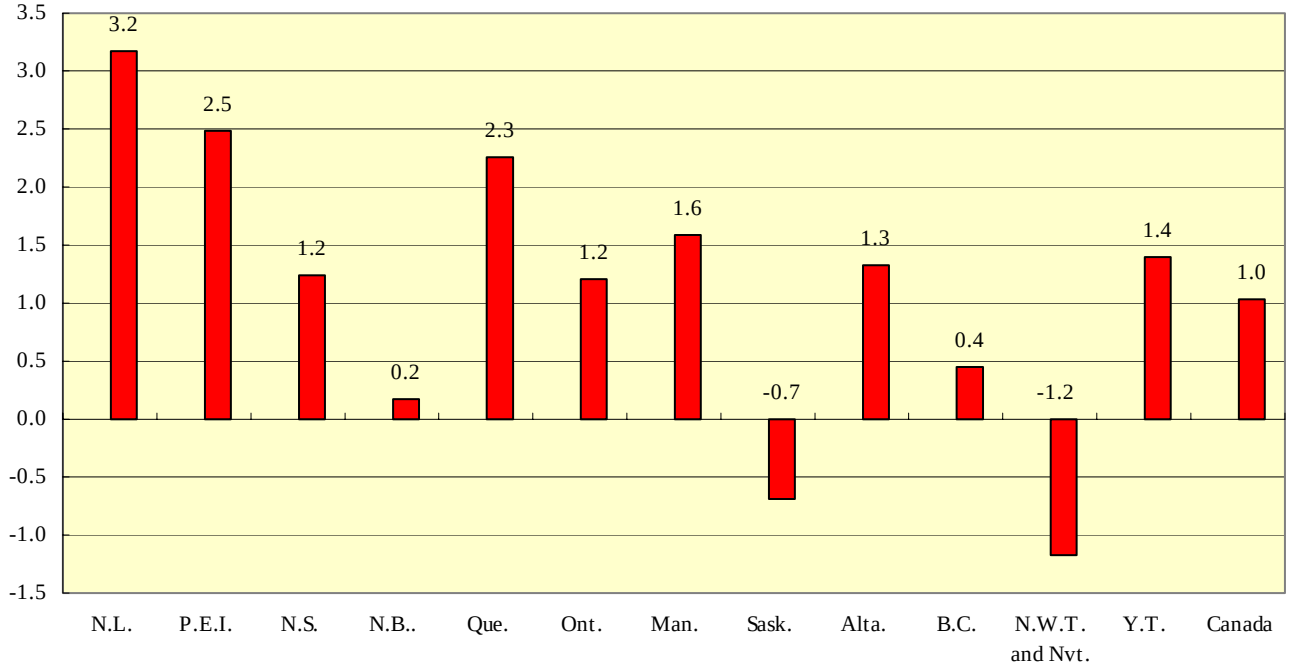
Overall, eco-efficiency grew more rapidly in the 1980s (1.8%) compared to the 1990s (1.0%). During the latter period, eco-efficiency trends varied significantly across industries: agriculture, mining, primary metals and wholesale experienced a slowdown, while refined petroleum, chemical, non-metallic mineral products and transportation reported negative growth rates. In contrast, the major CO_2 producers, such as utilities and crude petroleum and natural gas, improved their eco-efficiency performance significantly.

During the 1990s, Newfoundland, Prince Edward Island and Quebec posted eco-efficiency gains well above the 1% national average.

The overall 1.0% increase in eco-efficiency during the 1990s can be decomposed into two types of changes: those arising from the energy intensity of GDP (the ratio of energy consumption to GDP) and the substitution between various forms of energy. Based on this decomposition, the improvement in the ratio of GDP to energy explains two-thirds of the eco-efficiency improvement. In other words, the bulk of the eco-efficiency gains during the 1990s were attributable to the fact that the economy has become more efficient in the use of energy. The remainder is attributable to the substitution away from types of fuel with high carbon intensity to those with lower carbon intensity.

The 1.0% improvement in eco-efficiency reported by the Canadian economy during the 1990s (see Table 1) masks significant variations at the provincial level. Figure 3 shows that Newfoundland, Prince Edward Island and Quebec are the provinces that reported the highest eco-efficiency gains during this period (3.2%, 2.5% and 2.3%, respectively). Ontario and Alberta reported approximately the same eco-efficiency gains (1.2% and 1.3%, respectively). British Columbia and New Brunswick posted the slowest increase in eco-efficiency (0.4% and 0.2%, respectively), while Saskatchewan with –0.7% experienced an eco-efficiency decline.

Figure 3. Provincial trends of GDP per unit of CO_2 emissions, 1990-2000 (average annual growth rate in percentage)



Note: The trend for Northwestern Territories and Nunavut cover the 1981-1998 period. Data on CO_2 emissions are not available for Nunavut.