Have Most North Americans Already Met Their Kyoto Obligations? Trends in the CO2 Content of Consumption and the Role of Income Inequality

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Have most North Americans already met their Kyoto Obligations?
- Trends in the CO_2 content of Consumption and the role of Income Inequality.

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The Kyoto Protocol, which Canada signed in 1997, and ratified in 2002, committed Canadians to a collective obligation – reducing greenhouse gas (GHG) emissions to 6% below 1990 levels by 2008-2012. The US target of a 7% reduction was signed but never ratified. Total GHG emissions by both nations have in fact increased substantially. But the majority of Americans and Canadians have seen little change in the real value of their consumption, which is now significantly more energy-efficient, per dollar of spending, than it was in 1990. Many Canadians and Americans have in fact therefore already reduced their own household production of greenhouse gases by as much, or more, as the Kyoto Protocol would require. So who has been responsible for the overall increase in GHG emissions by North Americans? Who should now pay for reduced GHG concentrations?

This paper argues that the GHG emissions of each individual household (i.e. their 'carbon footprint') includes both their direct emission of CO_2 in the consumption of carbon energy in home heating, transportation, etc and their indirect responsibility for the CO_2 emitted in the production of the goods and services which they purchase. However, underlying the Kyoto Protocol is a point-of-production oriented accounting mechanism – each Annex I Party is required: "to establish and maintain a national system for the estimation of anthropogenic emissions by sources and removals by sinks of greenhouse gases[2]." Targets and credits are then counted with reference to sources or sinks of greenhouse gases within the territory of state parties.

All the same, it is ultimately consumption that causes pollution. Although emissions of CO_2 and other greenhouse gases occur in the process of production of goods and services, that production only occurs because the commodities in question are eventually purchased in order to be consumed. Viewed from this angle, it is misleading to assign to households just their direct consumption of energy, and their direct production of greenhouse gases, as they, for example, drive automobiles and heat houses[3]. Households also consume energy, and produce greenhouse gases, indirectly when they purchase commodities whose production, transportation and distribution used carbon-based energy and produced greenhouse gases.

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[1] *Comments and criticisms welcomed. Thanks to Peter Burton, Ruth Forsdyke, David Green, Stephen Hazell, Molly Hurd, John Myles, Mike McCracken and Ed Wolff for their feedback. Please check with the author for the most recent version before any citation. In this paper, greenhouse gases are measured in CO_2 equivalents, and the text refers interchangeably to GHG and CO_2 .*

[2] See *Kyoto Protocol Reference Manual on Accounting of Emissions and Assigned Amounts* – available at http://unfccc.int/files/national_reports/accounting_reporting_and_review_under_the_kyoto_protocol/application/pdf/rm_final.pdf

[3] As in *Survey of Household Energy Use* Natural Resources Canada, December 2005 – available at http://oee.nrcan.gc.ca/Publications/statistics/sheu-summary/pdf/sheu-summary.pdf

Furthermore, when the issue of concern is Global Warming and the increased atmospheric concentrations of greenhouse gases that are its cause, it does not much matter where a commodity is produced, since CO_2 diffuses rapidly into the world's atmosphere from the location of production. The 'carbon footprint' of each household's consumption of commodities is the greenhouse gases emitted directly and indirectly at each stage of their production, transportation and distribution, regardless of the country of origin of intermediate or final goods[4].

When, for example, German blast furnaces are disassembled and exported to China so that German motorists who used to speed down the autobahn in cars made with German steel can now do the same thing in cars made with Chinese steel[5] , is the global environment improved? A consumption perspective would argue that one should not count an off-shoring of greenhouse gas production as implying a reduction in Germany's contribution to GHG emissions targets. However, that is precisely what the accounting conventions underlying the Kyoto Protocol now imply[6].

If we recognize that it is consumption which ultimately drives GHG emissions, who then is really responsible for the increase in global concentrations of CO_2 and other greenhouse gases? Section 1 of this paper presents the basic case that the poor and middle class Canadians and Americans of 1990 are not the people who have been responsible for the rising consumption that drives increased global concentrations of greenhouse gases. Nevertheless, under some proposals, the costs of policies to reduce greenhouse gas concentrations will be borne disproportionately by the less well off – so Section 2 discusses the implications for income distribution of possible alternative policies to reduce GHG emissions. Section 3 considers methodological issues and Section 4 concludes.

[4] The energy used, and GHG emitted, in the production of investment goods enables capital to be later used up in production – hence is best seen as just another form of indirect, time delayed, input into consumption. In National Income accounting, the private expenditures of households are distinguished from the consumption of government services (e.g. health care, education, defence) – for the purposes of this paper, the institutional context of consumption is not particularly relevant. This paper therefore emphasizes the direct and indirect GHG content of expenditure benefiting each household income class – see Section 3.3 for further discussion.

[5] **See *German steel works finds Chinese home* BBC** Monday, 2 September, 2002, **http://news.bbc.co.uk/2/hi/asia-pacific/2231403.stm** or ***China Grabs West's Smoke-Spewing Factories*** **http://www.nytimes.com/2007/12/21/world/asia/21transfer.html**

[6] Similarly, the US ran a cumulative current account deficit of roughly $4.5 trillion over the period 1980 to 2005. US consumers got commodities, while foreigners accepted US bonds and other financial instruments in payment. The greenhouse gases emitted in the production of those imported commodities were counted, under the Kyoto conventions, as the emissions of the countries which exported them to the US, although their consumption occurred in the US. Unredeemed financial instruments have negligible GHG content – it is only when foreign holdings of US currency are spent that GHG will be released.

1. Whose GHG emissions have been increasing?

1.1. The Impact of Rising Income Inequality

An approximate estimate of how much each household contributes to total global greenhouse gas concentrations can be made using the total dollar value of each household's expenditures and the average greenhouse gas content (measured in CO_2 equivalents) of a dollar's spending. In both Canada and the US, there has been a substantial decline since 1990 in the average CO_2 content of a dollar's spending, but the bottom 80% of the income distribution have seen little increase in the real value of their incomes. Total consumption and GHG production have grown substantially, because incomes and consumption at the top end of the income distribution have grown dramatically, and because roughly 20% more people now live in Canada and the United States[7].

In the US, the Department of Energy notes that "From 2002 to 2003, the greenhouse gas intensity of the U.S. economy fell from 684 to 668 metric tons per million 2000 dollars of GDP (2.3 percent), continuing a trend of decreases in both carbon intensity and total greenhouse gas intensity." Table 1A presents their estimates of intensity trends in the US, which document a substantial downward trend in GHG emissions per dollar of US GDP[8].

Table 1A

Historical Growth Rates for U.S. Carbon Intensity

	Overall Change in Intensity (Percent)		Average Annual Change in Intensity (Percent)	
Decade	Carbon Dioxide	Total GHG	Carbon Dioxide	Total GHG
History				
1950-1960	-12.9	—	-1.4	—
1960-1970	-3.3	—	-0.3	—
1970-1980	-17.7	—	-1.9	—
1980-1990	-25.9	—	-2.7	—
1990-2000	-15.2	-17.9	-1.6	-1.9

Source: Energy Information Administration, *Annual Energy Review 2003*, DOE/EIA-0384(2003) (Washington, DC, September 2004), and estimates presented in Appendix B of this report.

GHG emissions per dollar of US spending fell by roughly 18% between 1990 and 2000, and have continued to fall since then (by roughly 2% per annum). Hence, the cumulative reduction in GHG intensity between 1990 and 2006 was approximately 30%. Total GHG emissions have, of course, continued to increase, since GDP (Gross Domestic Product) in the US has increased by substantially more than that.

[7] Between 1990 and the fourth quarter of 2007, Canada's population increased 19.47%, while US population was up by 20.71%.

[8] Further data available at http://www.eia.doe.gov/oiaf/1605/archive/gg04rpt/trends.html

Table 1B is taken from Environment Canada[9]. It shows both the 18% cumulative improvement in GHG intensity *per dollar of GDP* between 1990 and 2005 and the reason why total GHG emissions in Canada have increased by 25%. Canada's 52% increase in total real GDP has simply overwhelmed the improvement in GHG intensity per dollar of GDP.

Table 1B
Trends in Emissions and Emissions Intensities in Canada
(1990, 1995, 2000 – 2005)

	1990	1995	2000	2001	2002	2003	2004	2005
Total GHG (Mt)	**596**	**646**	**721**	**714**	**720**	**745**	**747**	**747**
Change Since 1990 (%)	*N/A*	*8.3*	*21.0*	*19.8*	*20.9*	*25.0*	*25.4*	*25.3*
Annual Change (%)	*N/A*	*2.8*	*3.7*	*-0.9*	*0.9*	*3.4*	*0.3*	*-0.1*
GDP (Billions 1997$)	**708**	**773**	**946**	**961**	**989**	**1013**	**1046**	**1079**
Change Since 1990 (%)	N/A	9.2	33.7	35.7	39.8	43.1	47.8	52.5
Annual Change (%)	N/A	2.6	5.5	1.5	3.0	2.4	3.3	3.2
GHG Intensity (Mt/$B GDP)	**0.84**	**0.84**	**0.76**	**0.74**	**0.73**	**0.74**	**0.71**	**0.69**
Change Since 1990 (%)	*N/A*	*-0.8*	*-9.5*	*-11.7*	*-13.5*	*-12.7*	*-15.1*	*-17.8*
Annual Change (%)	*N/A*	*0.2*	*-1.7*	*-2.4*	*-2.1*	*1.0*	*-2.8*	*-3.1*

GDP: Industrial Sector Real Gross Domestic Product by NAIC Code - Millions 1997 dollars - Informetrica, 2006

However, income distribution is an unequal thing. *Average* income and *average* consumption have gone up in both Canada and the US since 1990, but this is an average of those people whose incomes have gone up dramatically and those who have experienced little or no increase, or even a decline. The inequality of income and expenditure in both Canada and the US has always been substantial, and has notably increased in recent years. The inequality of growth in consumption, plus the fact that the GHG intensity of consumption has improved, means that many households have in fact already met their personal Kyoto obligations.

A key trend in recent years in both countries has been rising income inequality – gains in real annual income in both Canada and the United States have largely been confined to the top few percentiles of the income distribution[10]. Tables 2A and 2B[11] document real income trends throughout the income distribution. Because the gains from growth have gone almost entirely to the already affluent, most Canadians and American households have increased the real dollar value of their consumption fairly little, if at all.

[9] http://www.ec.gc.ca/pdb/ghg/inventory_report/2005/2005summary_e.cfm

[10] The literature on income trends is huge – a recent survey is L. Osberg (2007) *A Quarter Century of Economic Inequality in Canada 1981 – 2006*, Canadian Centre for Policy Alternatives, December 2007.

[11] Survey data drawn from population samples have the disadvantage that estimates of the top percentiles are not available - only the average income of each fifth of the income distribution is presented in, for example, CANSIM v1546479 to v1546483. Table 2B is based on income tax data, because the large sample size of such data enables much finer disagregation.

Table 2A
Real Income Trends - USA
Mean Household Income Received by Each Fifth and Top 5 Percent
All Races: 1990 to 2006

year	Lowest	second	third	fourth	top fifth	Top 5%
2006	11352	28777	48223	76329	168170	297405
1990	10716	26963	44536	67147	130309	207503
% change	5.94%	6.73%	8.28%	13.67%	29.05%	43.33%

2006 CPI-U-RS adjusted dollars
http://www.census.gov/hhes/www/income/histinc/h01ar.html

Table 2B
Real Income Trends – Canada
Taxable Income of Canadian Families

	1992	2004	% gain 1992-2004
	2004 $ ('000)		
Bottom 20%	10	10	0.00%
20%to 40%	23	25	8.70%
40% to 60%	40	43	7.50%
60% to 80%	62	70	12.90%
81st to 90th	88	101	14.77%
Top 10%	160	215	34.38%
Top 5%	206	296	43.69%
Top 1%	404	684	69.31%
Top 0.1%	1196	2493	108.44%
Top 0.01%	3490	8443	141.92%

Source: calculated from Table 4 in Brian Murphy, Paul Roberts and Michael Wolfson "High-income Canadians" *Perspectives on Labour and Income* – September 2007 Pages 5 to 17 Statistics Canada Cat No. 75-001-XIE

Table 3 just combines Tables 1B and 2B and calculates the implications, in the Canadian case. Column (a) identifies the income class – the only change from Table 2B is that the bottom 80% of Canadian taxpaying households are averaged together. Average income from Column (b) is multiplied by Environment Canada's estimate of average early 1990s GHG intensity per dollar of income (i.e. 0.84 - see Table 1B) to give Column (c): total CO_2 emissions in1992. In Column (d) the Kyoto target implied by an obligation to reduce CO_2 emissions by 6% is calculated. Column (e) reports the actual average income in 2004 of each segment of the income distribution and Column (f) computes the CO_2 emissions of households at this income, if their expenditure has the actual average GHG intensity of 2004 (i.e. 0.71 – see Table 1B). Column (g) calculates the average percentage by which each income group in Canada has met, or fallen short of, their Kyoto obligations.

Table 3
Income Changes and their implications for GHG - Canada 1992 - 2004

A	b	c	d	e	f	g
income class	1992 income average- $000	tons CO_2 1992 @ 0.84 Intensity	Kyoto Target (tons)	2004 income average - $000	tons CO_2 2004 @ 0.71 Intensity	% below/above Kyoto obligations
bottom 80%	33.75	28.35	26.65	37	26.27	-1.4%
81st - 90th percentiles	88	73.92	69.48	101	71.71	3.2%
top 10%	160	134.4	126.34	215	152.65	20.8%
top 1%	404	339.36	319.00	684	485.64	52.2%
top 0.1%	1196	1004.64	944.36	2493	1770.03	87.4%
Top 0.01%	3490	2931.6	2755.7	8443	5994.5	117.5%

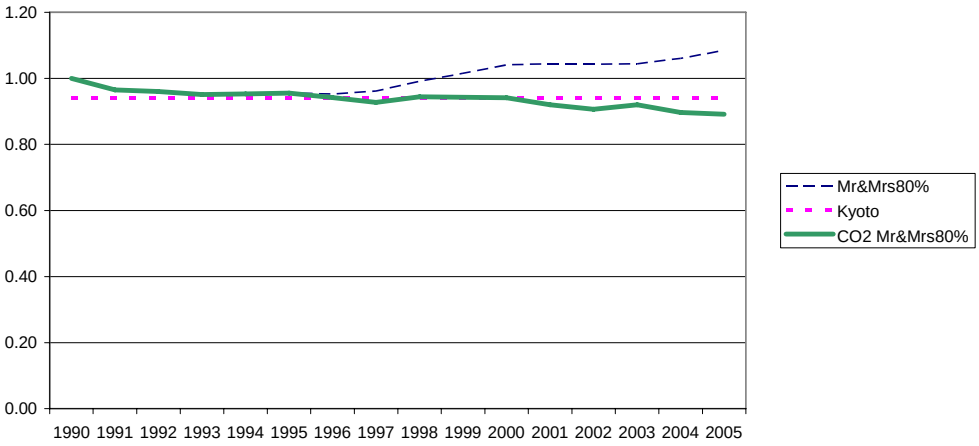
In the US case, Kyoto mandated a 7% reduction in GHG emissions. If GHG emissions per dollar of spending have decreased by 30% in the US, this implies an American household's GHG emissions would have declined by 30%, if their real expenditures (adjusting for inflation) had remained constant. Indeed, their GHG emissions would have fallen by at least 7%, thereby meeting their share of the Kyoto targets, even if their real dollar spending had increased by as much as 23%. American households whose expenditures, in real terms, have increased by more than 23% between 1990 and 2006 are the ones who have not met their Kyoto obligations – as Table 1A indicates, the bottom 80% of American families have not had this big an increase.

In Canada, if we accept the estimate of Environment Canada in Table 1B of an 18% improvement in GHG intensity per dollar of spending by 2005, a Kyoto target of 6% net reduction in GHG emissions would imply that a household whose expenditure increased by 12% or less would have met their personal Kyoto obligations – again, at least 80% of the Canadian families of 1990 had sufficiently low income growth to meet this target.

Chart 1 shows the year by year trend, for the household that is just at the 80% point in the Canadian distribution of household income – let's call them "Mr.&Mrs.80%"[12]. Statistics Canada publishes each year the 'quintile cutpoints' which divide the Canadian income distribution into fifths, and one could draw a similar chart for the 20%, 40% or 60% point. Chart 1 presents the income trend for 'Mr.&Mrs.80%' and it uses the estimates of GHG intensity per dollar of spending presented in Table 1B to calculate the CO_2 emissions that their expenditure implies. It illustrates how the recession of the early 1990s, by cutting Canadian family incomes by roughly 5% over the 1990 to 1994 period, forced families to cut back on consumption – and thereby very nearly achieve the Kyoto target of a 6% reduction, even without much change in the GHG intensity of each dollar of spending. In the latter part of the 1990s, there was a recovery in personal incomes, but the improving energy efficiency of production enabled "Mr.&Mrs.80%" to achieve more than a 6% reduction in GHG emissions, every year after 1994.

[12] Specifically, CANSIM variable v25731824 Canada; All family units; Upper income limit (Dollars); Fourth quintile

Chart 1
Income and CO2 emissions for "Mr&Mrs 80%"
Canada - 1990-2005
CANSIM v25731824



	01/01/1990	01/01/1991	01/01/1992	01/01/1993	01/01/1994	01/01/1995	01/01/1996	01/01/1997	01/01/1998	01/01/1999	01/01/2000	01/01/2001	01/01/2002	01/01/2003	01/01/2004	01/01/2005
Mr&Mrs80%	1.00	0.96	0.96	0.95	0.95	0.96	0.95	0.96	0.99	1.02	1.04	1.04	1.04	1.04	1.06	1.09
Kyoto	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
CO2 Mr&Mrs80%	1.00	0.96	0.96	0.95	0.95	0.96	0.94	0.93	0.94	0.94	0.94	0.92	0.91	0.92	0.90	0.89

Hence, there is a prima facie case that a clear majority – perhaps 80% or more – of the Canadian and American households of 1990 have already reduced their GHG emissions sufficiently to meet the Kyoto commitment that governments made on their behalf in 1990. In terms of their own personal household incomes, the majority of North Americans have, for some time, been familiar with "slow growth". Improvements in energy efficiency have enabled lower income families to reduce their carbon footprint substantially. The real dollar value of the consumption of less affluent Canadians and Americans has not increased much, if at all, but because they are driving more fuel efficient cars, insulating their homes and consuming commodities which use less carbon-based energy to produce, their personal carbon footprint has decreased. The publicity attached to the ostentatious life-style of North America's elite has undoubtedly obscured the fact that monster homes and multiple SUVs are not the daily reality of most North American households.

But for those families at the very top of the income distribution – the top 5% and top 1% – the dollar value of household expenditures has grown significantly faster than the 'per-dollar' improvement in GHG intensity of the last 16 years. This implies that total GHG emissions continue to increase in Canada and the US, partly because income and expenditure at the top end of the income distribution have been growing so very rapidly.

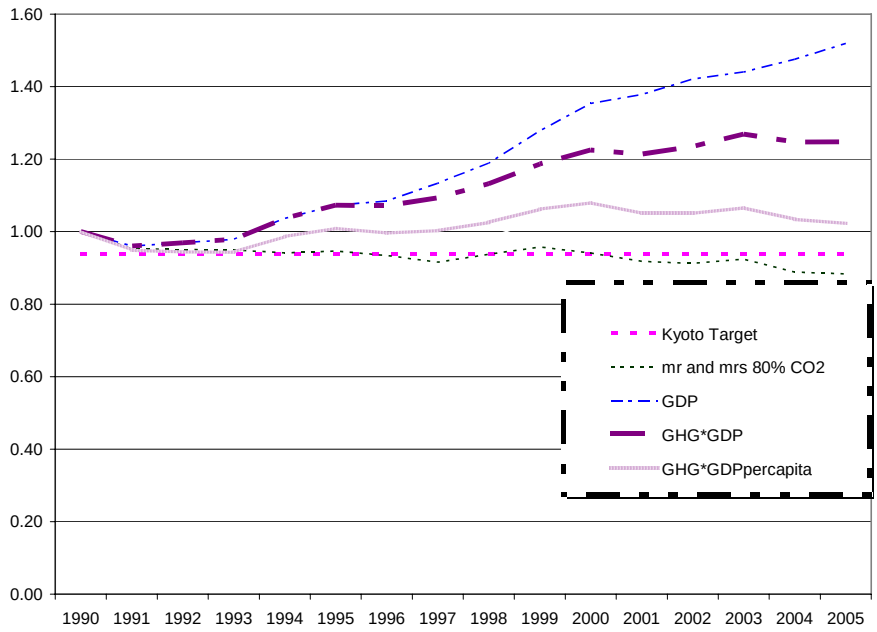
1.2 The role of population growth

In some parts of North America there was relatively little population growth between 1990 and 2008. In Canada, Quebec, Manitoba, Atlantic Canada, and Saskatchewan[13] were areas where, approximately speaking, the population of 2008 was the same people (or their descendants) as the population of 1990. In these places, Table 3 is really the end of the story, since the achievement of a collective obligation to a given total level of GHG emissions depends entirely on the relative consumption, and CO_2 emitted, of different parts of the income distribution.

However, elsewhere in Canada (in Alberta, BC and Ontario) the picture is very different – their total population has grown substantially. The increase in GHG emissions in those areas is therefore partly due to trends in the consumption of the people who were resident there in1990 and partly due to the increase in population in those provinces.

Chart 2 presents the picture for Ontario.

Chart 2
Greenhouse gases, population and inequality trends
Ontario: 1990-2005
v429911,v15855724,v25732076



The bottom two lines in Chart 2 replicate, for Ontario, the calculations of Chart 1 indicating the CO2 emissions of a household at the 80% point in the income distribution, and comparing it with the Kyoto obligation of a 6% cut from 1990 levels. In Ontario, as

[13] Provincial population estimates are available up to 2006 (CANSIM Table 051-0001). The percentage growth in total population between 1990 and 2006 was -11.8% Newfoundland, +6.1% PEI, +2.7% Nova Scotia, +1.2% New Brunswick, +9.3% Quebec, +6.5% Manitoba and -2.2% Saskatchewan. For Canada as a whole, population growth was 17.8% from 1990 to 2006,. With its much larger base, Ontario's +23.2% outweighed growth in BC (+30.1%) and Alberta (+32.5%).
With 50 states, the variance in population growth rates in the US was even larger – see State Population Estimates and Demographic Components of Population Change
http://www.census.gov/popest/estimates.php

for all Canada, Chart 2 thus indicates how the GHG emissions of "Mr.&Mrs.80%" have been below the Kyoto target, most years since 1990 – by 2005, they were 12% below their 1990 emissions level. But because the top 5% (and especially the top 1%) of the income distribution has been pulling away from the rest, the increase in top end incomes pulled GDP per capita up by 24.5% from 1990 to 2005 - well in excess of the 7.5% growth in incomes of Mr.&Mrs.80%. The solid line (labeled GHG*GDPpercapita) in Chart 2 is the 'population-constant' level of GHG emissions, which reflects the influence of this rising inequality – it increases by 2.2% over the period. The 14.2 percentage point difference between reducing GHG emissions by 12%, and increasing them by 2.2% in Ontario can be ascribed to rising inequality.

The top line in Chart 2 represents the growth in total GDP (52%) over this period – so the distance between it and the heavy dashed line indicating growth in total GHG emissions (up by 24.8% by 2005) can be read as indicative of the progress that has been made in greater energy efficiencies. Nevertheless, from the point of view of Global Warming, it is actual total emissions that matter, and the difference between actual total emissions and 'population-constant' emissions (i.e. the difference between the light solid line and the heavy dashed line in Chart 2 – amounting to 22.5 percentage points by 2005) can be ascribed to population growth (and even more in BC and Alberta, due to their more rapid rate of population growth).

The Kyoto protocol is a voluntary collective commitment of Canada to a national obligation to reduce GHG emissions. But how should one allocate a collective obligation among individuals? If the total population of 1990 were the same as the population of 2008, and if the income distribution had not become more unequal, Canada would have met its collective obligation, quite easily. The increase in global atmospheric GHG concentrations that is imperiling the environment of everybody's children and grand-children has been due, in part, to the rapid rise in income and expenditure of the already very affluent elite of North America and in part to the welcoming of immigration, which has raised the consumption of immigrants.

2. **Who should pay for reducing Green House Gases?**

In international discussions of the global warming problem, the representatives of poor nations often protest that they did not cause the rising concentration of carbon dioxide and other greenhouse gases in the world's atmosphere – so it is unfair that they should now be asked to pay, out of their lower incomes, for the solution. Within North America, the same point can be made. Rising levels of atmospheric CO_2 have come about partly as a result of the rapidly rising consumption levels of the already affluent – yet it is the relatively poor who are expected, under many policy proposals, to absorb a disproportionately large share of the costs.

Table 4A below is taken from a US Congressional Budget Office[14] calculation of the burden on poorer and richer income groups of the higher prices for energy that would be caused by a "cap-and-trade" system of marketable pollution permits. As the CBO says "Employing incentive-based policies to reduce CO_2 emissions would be much more cost-effective than using more-restrictive command-and-control approaches." They note that there are "two general forms of incentive-based policies— those that limit the overall level of emissions (so-called quantity instruments) or those that reduce emissions by

[14] Available at http://www.cbo.gov/ftpdocs/80xx/doc8027/04-25-Cap_Trade.pdf

raising their price (so-called price instruments). The simplest price-based mechanism would be a tax on emissions. Under a tax, a levy would be imposed on each ton of CO_2 emissions or on each ton of carbon that is contained in fossil fuels (and which is ultimately released in the form of CO_2). The simplest quantity-based mechanism would be a cap-and-trade program. Under such a program, policymakers would set a limit (cap) on total emissions during some period and would require regulated entities to hold rights, or allowances, to the emissions permitted under that cap."

The CBO summarizes the available evidence as indicating that: "Although both types of incentive-based approaches are significantly more efficient than command-and-control policies, studies typically find that over the next several decades, a well-designed and appropriately set tax would yield higher net benefits than a corresponding cap-and-trade approach.[15]" Nevertheless, a "cap-and-trade" system remains under active consideration – partly because "By establishing a cap-and-trade program, policymakers would create a new commodity: the right to emit CO_2. The emission allowances—each of which would represent the right to emit, say, one ton of CO_2—would have substantial value. Based on a review of the existing literature and the range of CO_2 policies now being debated, the Congressional Budget Office (CBO) estimates that the value of those allowances could total between $50 billion and $300 billion annually (in 2006 dollars) by 2020."

All 'incentive based policies' depend on using the market mechanism to provide an incentive to decrease GHG emissions, by increasing the relative cost of carbon-intensive goods and activities. In the longer term, the social payoff to using market-based systems is the multiplicity of changes in behavior – e.g. in commuting patterns, size and type of trucks and cars, industrial production processes, etc. – that price incentives motivate. But in the short term, households have an existing stock of housing, automobiles and energy needs which is hard to change quickly – so the short run income distributional implications of higher prices for CO_2 intensive goods and activities are key to the political feasibility of reform.

[15] see pages 1, 8 and 10 in *Issues in Climate Change Statement of Peter R. Orszag Director* Presentation for the CBO Director's Conference on Climate Change November 16, 2007 CONGRESSIONAL BUDGET OFFICE WASHINGTON, D.C.

Table 4A

Effects on U.S. Households of the Higher Prices Resulting from a 15 Percent Cut in CO_2 Emissions

	Average for Income Quintile				
	Lowest	Second	Middle	Fourth	Highest
Annual Cost Increase in 2006 Dollars	680	880	1,160	1,500	2,180
Annual Cost Increase as a Percentage of Income[a]	3.3	2.9	2.8	2.7	1.7

Source: Congressional Budget Office, *Who Gains and Who Pays Under Carbon-Allowance Trading? The Distributional Effects of Alternative Policy Designs* (June 2000).

Notes: These numbers do not reflect any of the benefits from reducing climate change.

The policy examined here is a cap-and-trade program designed to lower U.S. carbon dioxide (CO_2) emissions by 15 percent from 1998 levels. (CBO performed the analysis in 2000 and used 1998 emission levels so that the distributional effects could be based on actual, rather than projected, data on consumer spending and taxes.) CBO assumed that the full cost of cutting emissions would be passed along to consumers in the form of higher prices and that the price increase for a given product would be proportional to the amount of CO_2 emitted from the fossil fuels used in its production.

These numbers reflect data on each quintile's cash consumption and estimates of cash income. (A quintile contains one-fifth of U.S. households arrayed by income.) Because of data limitations, the numbers should be viewed as illustrative and broadly supportive of the conclusions in this analysis rather than as precise estimates.

a. The cost increases are equivalent to percentage declines in households' after-tax income.

A carbon tax would have the same disproportionate impact on the less affluent. Table 4B is taken from Hassett et al (2007)[16], and documents the distributional incidence, by annual income class, of a carbon tax of $15 per ton in the US when both the direct and indirect burden of the tax are added together. Various years are presented in order to document the change over time in the likely level of carbon tax costs caused by the changing structure of US production and consumption. However, Table 4B is quite consistent with Table 4A in illustrating the larger relative burden borne by the less affluent.

[16] THE INCIDENCE OF A U.S. CARBON TAX: A LIFETIME AND REGIONAL ANALYSIS Kevin A. Hassett, Aparna Mathur, Gilbert E. Metcalf Working Paper 13554 http://www.nber.org/papers/w13554 NATIONAL BUREAU OF ECONOMIC RESEARCH October 2007

TABLE 4B
Distribution of Total Burden: Percentage of Annual Income

Decile	1987	1997	2003
Bottom	3.91	4.29	3.70
Second	3.27	3.33	3.02
Third	2.64	2.91	2.33
Fourth	2.37	2.37	2.04
Fifth	1.92	1.94	1.74
Sixth	1.65	1.67	1.51
Seventh	1.52	1.53	1.30
Eighth	1.40	1.36	1.24
Ninth	1.21	1.16	1.02
Top	1.03	0.88	0.82

Source: Authors' calculations. The table reports the within decile average ratio of carbon tax burdens to income.

Poor and middle class Canadians and Americans know all too well that they have not shared much in the benefits of economic growth over the last 25 years. They face ongoing financial pressures and increasing economic insecurity. Hence, although environmentalists may say that higher heating oil and gasoline prices would be a "good thing", is it a surprise that, for most people, high energy prices are perceived as a problem?

Is it then a surprise that practical politicians avoid suggesting that energy prices should be even higher?

How then to reconcile the need for environmental action and the political pressures for inaction?

In both Canada and the US, recent years have seen a consistent rhetoric of attack on the presumed wasteful nature of "tax and spend" governments. Under the cover of repeated assertions that more taxes just encourage more government waste, many taxes have been cut – but the cynicism of the electorate has been deepened by observation that just when the pretax incomes of the very affluent have been growing strongly, 'tax reform' has particularly benefited the same upper income groups. In both Canada and the US, reforms to the tax system since 2000 have notably increased the post-tax income share of the top few percentiles of the income distribution[17].

[17] See, for example, Marc Lee (2007) *Eroding Tax Fairness: Tax Incidence in Canada, 1990 to 2005* Canadian Centre for Policy Alternatives, Toronto November 2007

How then could one convince the poorer 80% of the electorate that a carbon tax is in their interest, when (1) recent tax reforms have primarily benefited the affluent and (2) that tax is specifically designed to increase the cost of the gasoline they need to get to work and the fuel oil they need to heat their houses?

A carbon tax (e.g. at $30 per ton) could raise significant revenues. In Canada, GHG emissions in 2005 were approximately 747 Megatonnes. A carbon tax of $30 per ton applied to that level of emissions would raise a bit over $22 Billion in tax revenue[18]. How could one persuade Canadians that such a tax would not just be a massive tax grab by governments – one which encourages government waste and primarily benefits upper income groups (as tax reforms since 1995 consistently have)?

The political feasibility of a carbon tax probably depends on it being transparent in its implementation and crystal clear in its implications – that it will only penalize people with a large carbon footprint.

Transparency and efficiency imply that a carbon tax should be applied at the initial point of carbon energy production – as a direct levy (proportional to embodied carbon[19]) on firms as coal, or petroleum or natural gas is produced. Administration and compliance costs of such a tax are relatively low, given the large scale nature of most carbon energy production. As higher carbon energy costs are embodied in the prices of both intermediate and final goods, greater incentives to economize on energy usage are created throughout the economy, and are felt at all subsequent stages of production, distribution and consumption.

However, "more expensive energy" is not what voters want to hear. And if unfair income distribution is fundamental to causing increased GHG emissions, then a fair distribution of the net costs of GHG reduction has to be a central part of the solution. One way to convince Canadians that the purpose of a carbon tax is not to benefit upper income groups and not to enable governments to waste resources would be to explicitly earmark all its revenue to be paid back to individual Canadians.

In Canada, there is the added complication of the 'provincialization' of Canadian policy against Global Warming. In April 2008, the Government of Manitoba announced a commitment to meeting Kyoto targets – for the province of Manitoba. This followed earlier announcements by Quebec and British Columbia of carbon tax initiatives – likewise to implement the Kyoto protocol in their own jurisdictions. Because, as already noted, Canadian provinces differ widely in population growth rates, achieving those targets is easy for some of the smaller provinces (like Newfoundland) that have been losing population – but wasn't it the nation of Canada which assumed this obligation on behalf of all its citizens?

If the collectivity which accepted the Kyoto obligation is conceived of as "Canada", then that has to mean all the citizens of Canada – whatever their province of residence. If so, then it is the federal government that should act. Suppose that the Government of Canada were to impose a carbon tax, and also to pay each year to all Canadians – as a per capita "Carbon Tax Credit" – the total amount of the tax which is

[18] The whole point of a carbon tax is to provide an incentive to reduce GHG emissions. Because of this behavioral response, the total revenue yield of a $30 per ton carbon tax would be less, and would decline over time. This rough calculation is intended only to provide an intuition for the order of magnitude of initial revenue impacts.

[19] Embodied carbon includes both the CO_2 content of the fuel and the CO_2 released in its production – e.g. the CO_2 content of bitumen or natural gas burned to produce oil from tar sands. Note that a carbon tax paid at the point of consumption by households (as proposed in BC) could not recognize differences in embodied carbon by fuel source.

expected to be collected, based on the carbon content of energy usage in the previous year.

Since the point of a carbon tax is to motivate change in energy consumption patterns, and since it takes time for people and firms to change those patterns, it would make sense for the carbon tax to be set initially at a fairly low level, but with a clearly defined schedule of future increases. If, for example, the federal carbon tax were to start at $5 per ton, but rise each year by $5 to an initial level of $30, Canadians would have both a clear signal of greater future energy costs and time to adjust to those costs. Based on 2005 emissions levels, an initial $5 per ton tax might generate about $3.6 Billion, implying that the Carbon Tax Credit in the first year could be approximately $110 per Canadian.

In the first year, a carbon tax at $5 per ton of CO_2 would not be onerous and, except for large families, the Carbon Tax Credit would not be large enough to make much of a difference to annual incomes – in the initial year the main function of the tax is as a signal to all Canadians that future change is coming and adaptation is necessary. Clearly, those households whose carbon footprint is less than the per capita average (i.e. most Canadians) will be net beneficiaries of the Carbon Tax/Credit scheme. Those who generate more than the per capita average of GHG emissions will be net losers financially, because the increased cost of the carbon-based energy they consume is greater than the Carbon Tax Credit they receive – and they are put on notice that they will face an increasingly large net financial cost. Mailing out the cheques – together with literature on future carbon tax/credit increases, and how to avoid carbon energy usage – would be an important part of the process of reinforcing an environmental signal of the importance of conservation, accompanied by an incentive (cash) that households have good reason to pay attention to.

In most discussions of tax policy, the objective is to raise tax revenue in the most efficient way possible[20], in order to finance the necessary activities of government. For many years, the Public Finance literature has therefore emphasized strongly the idea that taxes should not distort behavior and that tax revenues should not be ear-marked. But a carbon tax is different. A carbon tax is, quite explicitly, a tax measure whose sole motivation is to *change* consumption patterns (i.e. of carbon energy). Discussion of this new tax has only arisen because of concern over Global Warming, but needed action to reduce GHG emissions is being impeded because of the perceived inequity of making those who did not cause the problem pay for its solution. Hence, in making the case for a new carbon tax, *transparency is key*[21]. The advantage of an ear-marked carbon tax/credit scheme is the clarity that only the largest contributors to GHG emissions will bear a net burden.

If all Canadians own the air we breathe and all Canadians care about the common environment that our descendants will face, then those who add greenhouse gases to our common atmosphere should compensate the owners (i.e. all Canadians) for the damage that they are causing. Allocated equally among all 33 million Canadians, a $30 per ton tax at 2005 levels of GHG production would generate about $22 Billion in carbon tax revenues, which could finance a demo-grant of approximately $680 per person annually.

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[20] In analysis of most tax issues (e.g. regarding income or sales taxes), setting the tax rate at a level such that behavioural response will shrink the tax base is seen as a bad thing – with a carbon tax, shrinking the tax base (carbon emissions) is precisely the point of the tax.

[21] The first objective of a carbon tax is the reduction in GHG it motivates – the "double dividend" is the potential for efficiency gains from using carbon tax revenues to cut other taxes that distort economic incentives. Essentially, this paper is arguing that a "single dividend" carbon tax which actually happens is preferable.

At $30 per ton, the direct carbon content of a litre of gasoline would produce an additional carbon tax of about 7 cents per litre[22]. (In addition, there would be an additional tax as the charge for embodied carbon released as the gasoline was being produced, which would vary by method of production.) Hence, a carbon tax at these levels would not be so onerous as to strangle livelihoods – but it would be a highly visible signal to economize. A guarantee that carbon tax revenues would be kept separate from other tax revenue and would be used to compensate Canadians for the average cost of the carbon tax would go a long way to ensuring that a carbon tax is not seen as just a 'tax grab' by governments, would not hurt the poor and would not just enable more 'government waste'. As such, it would be possible to increase the carbon tax over time to levels at which it started to have a real impact on carbon energy consumption behavior – without any accusation that government was grabbing resources from the citizenry.

3. Conclusion

Adopting a 'consumption-oriented' approach to environmental accounting would represent a substantial change from current practice – and would open up a whole new set of fascinating research issues. Much work remains to be done.

However, the key trends are strong ones. Greenhouse gas intensity per dollar of expenditure has improved considerably in both Canada and the USA since 1990. Since the bottom 80% of the income distribution in both countries has not seen much change in the number of real dollars they get to spend, the improvement in the CO_2 intensity of their spending means that they have substantially reduced their CO_2 emissions, and thereby met their obligations under Kyoto. It is the very rapid growth in income and consumption at the top of the income distribution, plus the growth of total population, that entirely accounts for the failure of Canada and the USA to meet their international obligations under the Kyoto protocol.

The causes of rising GHG emissions are part of the reason why it is difficult to implement a market oriented system for reducing CO_2 emissions. If it were the case that all citizens were producing more green house gases, then it would be easier to convince the same people to that everyone should pay some of the cost to solve the problem that everyone's behavior had created. But the reality is that people who have not benefited much from recent economic trends (i.e. the bottom 80%) are being asked to bear a cost to reduce GHG emissions *that come from other people* – total greenhouse gas emissions would not have increased if the incomes of the top 1% of the income distribution had not grown so quickly or if immigration had not happened. So the majority of the community is being asked to pay for reducing the increase in GHG caused by a minority. However, Kyoto was and is a collective national obligation. Hence, it is crucial to avoid the fault lines of class and nativity within nations – which makes transparency all the more important. A carbon tax that is entirely and visibly refunded as a demo-grant to all citizens is a transparent, equitable and efficient mechanism to help Canada and the US meet their Kyoto obligations.

[22] In rural areas and for low-income suburban commuters, driving is a necessity – given the urban design of North American cities. At 20,000 Kilometres per year, a 16 litre per 100 Km car or truck consumes 3200 litres annually, on which a 7 cent per litre carbon tax would impose additional gasoline cost of $224 – a cost which might well be covered by the carbon tax credit. Crucially, a fixed demo-grant would not lessen the incentive for individuals to switch to more economical vehicles.

Appendix A
Methodological Issues and More Precise Estimates

In Section 1, this article made a key assumption – that one can use the average CO_2 intensity of expenditure as currently calculated by government agencies in Canada and the US to estimate the CO_2 intensity of expenditure by income class. However, it has also noted that CO_2 emissions statistics are now calculated on a production basis and averaged over the economy as a whole. Hence, this assumption raises three possible questions:

1] could the trend in the CO_2 intensity *of household expenditure* between 1990 and 2007 have been substantially[23] different from the trend in CO_2 intensity *of production*?

2] could there have been a substantial trend in any difference in CO_2 intensity by income class? and

3] could household expenditure trends have diverged substantially from household income trends over the period 1990 to 2007?

A fourth methodological issue is whether the accounting period for analysis could make a substantial difference.

The discussion of Sections 1 and 2 provide approximations, based on aggregate figures. While recognizing that more detailed analysis would be more precise, this section will argue briefly that better measurement is not likely to upset the core conclusion – that most North American households have already met their Kyoto targets, and the net increase in GHG emissions by Canada and the US is driven by the rapidly rising expenditure of upper income groups. The basic reason is that divergences in the growth rates of the income of different income classes have been very large – which drives the core conclusion. Furthermore, because the Kyoto Protocol asks for a 6% (Canada) or 7% (US) cut from the 1990 level of GHG emission, *whatever it was in 1990*, an error of estimate of *levels* that is about the same in 1990 and in 2008 does not affect the conclusion. Only divergences in *trends* can overturn the conclusion, and these would have to be implausibly large.

A1
Could trends in the GHG intensity of *production* have differed substantially from trends in the GHG intensity of *consumption*?

Tables 1A and 1B are based on the point-of-production accounting system used under the Kyoto protocol. They imply a substantial divergence between the GHG intensity improvements recorded in Canada and the US. However, it can be argued that the Canadian and American economies are highly integrated and that a major reason for Canada's record of increased CO_2 production, using the production oriented accounting conventions of the Kyoto Protocol, is that "Petroleum Industries contributed significantly, with a total increase in GHG emissions of 56.4 percent between 1990 and 2005. Much of the increase in the Petroleum Industries sector is attributable to the rapid growth in crude oil and natural gas exports to the United States over the period.[24]"

[23] 'Substantially' is intended to mean here 'by an amount large enough to overturn the conclusions of Section 1'.

[24] Environment Canada http://www.ec.gc.ca/pdb/ghg/inventory_report/2005/2005summary_e.cfm

The Athabasca tar sands are only the most extreme example of the fact that it is costing progressively more in greenhouse gases to produce each litre of petroleum that Canada sells – both those exported for the use of US motorists and those consumed domestically. However, under the Kyoto convention of assigning CO_2 emissions to the site of initial production, only the final consumption of that gasoline is assigned to the US, while the environmental costs of its production are booked in Canada – specifically, in Alberta. Hence, because the energy costs of producing tar sands gasoline are booked against Alberta, the American record of improvement in GHG intensity is made to look relatively good. Similarly, in within-Canada comparisons of CO_2 emissions per capita, Central Canada (particularly Quebec) looks good and Alberta looks bad.

A consumption oriented perspective would revise downward somewhat the Energy Department's estimates of US improvement in GHG intensity and revise upward the Environment Canada estimates. If we think of the North American economy as a whole, an expenditure weighted average of GHG intensity improvements between 1990 and 2008 in the two countries, considered as a unit, would probably be something like 27%, implying that a household whose spending increased by less than approximately 20% would, on average, have met its Kyoto obligations – which would imply that households between the 81st and 90th percentiles of the income distribution in Canada are very likely to have met their Kyoto obligations.

Gross Domestic Product (GDP) is a measure of the total money value of expenditure on the market goods produced in a nation. It therefore includes the value of exports and excludes the value of imports. The measures of CO_2 intensity per dollar of GDP presented in Tables 1A and 1B are consistent with the production-oriented focus of GHG emissions accounting, since they calculate the ratio of the greenhouse gases produced within the US and Canada (including the CO_2 produced as a byproduct of production of export goods, which are consumed elsewhere) to the total money value (after inflation[25]) of GDP.

This paper has argued for a consumption oriented approach, and it is obvious that in a closed economy without exports or imports, no difference is possible between the GHG intensity of the goods produced or consumed. But even in an open economy, the vast majority of goods and services are both locally produced and locally absorbed[26]. Furthermore, if the trend rate of change in GHG intensity is no different in export and import goods, foreign trade will have no impact on GHG intensity trends. Hence, trends in the GHG intensity of consumption can diverge from trends in the GHG intensity of production, only to the extent that the trend rate of change in GHG intensity is different in export and import goods, weighted by the relative importance of traded goods.

A2
Could there have been a substantial trend in any difference in GHG intensity by income class?

Income classes will differ in the average CO_2 content of their spending if, for example, the affluent are more likely to take vacations, to travel on vacation and to travel

[25] Inflation indices provide a practical example of the general issue, since changes in the prices of goods produced in a nation are measured by the GDP deflator (which includes export goods but excludes imports), while inflation in the prices of goods consumed is measure by the Consumer Price Index (which includes import goods but excludes exports). Price trends in these two indices can diverge somewhat.
[26] In the US, in 2006 imports of goods and services were 16.9% of GDP and exports were 11.1% see: http://www.bea.gov/newsreleases/national/gdp/2007/pdf/gdp307f.pdf

by air to exotic destinations – while the poor stay home or drive locally. Input-Output Tables have long been used by economists to track more exactly the direct and indirect inputs of commodity production, and expenditure surveys have long tracked the average expenditure, by type of commodity, of different income classes. These are the tools used by Hassett et al (2007) to estimate the indirect burden of a carbon tax on the GHG content of household expenditure, by income class, to add to the direct impact (see Table 4B).

Whether a particular income class of household has met its Kyoto obligations or not depends on whether, between 1990 and 2008, the real income of the household income class grew by 6% (Canada) or 7% (US) more than the cumulative percentage improvement in GHG intensity per dollar of that household income class's spending. The issue is not whether the level of GHG intensity differs by income class, but how substantially the *rate of change* in GHG intensity by income class differs from the average rate of change in GHG intensity.

In the point-of-production accounting system underlying the Kyoto protocol, there is no particular point in knowing who consumes a commodity once it has been produced – income inequality is, by construction, assumed to be irrelevant to the aggregate amount of environmental degradation. Whether or not this is a reasonable presumption depends on household income elasticity of GHG intensity (direct and indirect) of the expenditure of each income class. If it is greater than one – i.e. if GHG emissions are like "luxury goods" – then, at any point in time, increasing concentration of purchasing power will tend to increase the average GHG content of expenditure. To overturn the conclusion of Section 1, the household income elasticity of GHG intensity would have to be declining over time at a rate greater than the differential in income growth rates. Given the size of that differential, this seems implausible.

A3
Could total household expenditure trends have diverged substantially from household income trends over the period 1990 to 2008?

This paper argues that one should attribute to income classes of individual households the GHG content (direct and indirect) of the commodities whose consumption they benefit from and that micro-based evidence (e.g. from Tables 2A and 2B) on household income trends are a reliable indicator of such household consumption trends.

Personal consumption spending can be directly and unambiguously attributed to individual households, but households also pay taxes and consume government services – and if income and expenditure diverge in a given year, they may accumulate or draw down assets.

Could trends in consumption delivered through the public sector been substantial enough to overturn the conclusion of Section 1?

Since the Kyoto obligation of each household is to reduce GHG production by 6% (Canada) or 7% (US) of its 1990 level, *whatever that was*, this paper is not particularly concerned with the level of inequality in receipt of public services – it is the rate of change in the degree of inequality of public services that is relevant. If the period since 1990 had seen a massive growth in pro-poor government expenditure in Canada and the US, then one might have to worry a bit about the robustness of Section 1's conclusion. However, to override the differential in growth of private incomes revealed in Tables 2A

and 2B it would have had to be a truly massive increase in pro-poor spending – and in actuality government services have contracted as a percentage of GDP[27].

If one is to attribute GHG emissions to income classes, how should one think of the deferral of consumption (i.e. savings or dis-savings), the GHG content of investment and the current and capital account of the balance of payments[28]?

In many ways, the "absorption" of resources by different incomes classes is a more accurate word to use as a guide to their carbon footprint than their "consumption". When a household saves and thereby acquires investment goods (either directly or via financial intermediaries), the manufacture of those capital goods produces CO_2. Because the household will in future years get to consume more goods, as they receive the income from their capital investments, the CO_2 content of capital goods production is rightly attributed to them. In the current year, the GHG emitted in the production of investment goods should therefore be assigned to those households who will receive the factor returns from that capital. Since post-tax income will be either saved or consumed, a household should be assigned, in any given year, the GHG emitted in the production of both the consumption goods they enjoyed and the investment goods they acquired.

A4
Could use of a 'lifetime income' perspective substantially alter the basic conclusion?

Underlying any discussion of income is a choice of the appropriate accounting period. Most analyses of both environmental and inequality issues use an annual accounting framework because actual data is commonly organized on this basis – complex (and controversial) imputations for uncertain future incomes and consumption are not necessary. Although 'lifetime' income may be a better indicator than annual income of the total well-being of individuals, estimates of 'lifetime income[29]' of the current population are highly problematic.

In the real world, individual households go somewhat up or down in the distribution of annual income as, for example, individual earnings increase with seniority or household incomes change with the arrival or departure of additional earners. A household's position in the annual income distribution in a particular year is therefore an estimate of their position in the lifetime income distribution – but there is, for any

[27] see "Income Distribution and Public Social Expenditure: Theories, Effects and Evidence" Lars Osberg, Tim Smeeding and Jon Schwabisch), Pages 823 - 862 in Social Inequality, Kathryn Neckerman (Editor) Russell Sage Foundation, New York, 2004

[28] If there were no net foreign borrowing or lending, aggregate domestic absorption of resources would have to equal aggregate domestic income – but the US has been running a substantial trade deficit for many years. When foreigners are willing to send Americans goods and services (whose production created Greenhouse gasses) and accept paper IOUs in return, total American absorption of resources exceeds total American incomes. To estimate more exactly the total worldwide CO_2 created by the consumption of each American income class, one could use household expenditure surveys and input-output tables to estimate the import intensity by country of origin of each income class and the implied GHG, given the GHG intensity of the exports of that nation. [In the Canadian case, the current account has moved strongly into surplus – implying that, in aggregate in recent years, Canadians absorb less than their incomes might indicate.]

[29] If capital markets enabled universal access to borrowing and lending at the same interest rate without transactions costs and if future incomes were predictable, then an argument can be made for using actual consumption as a proxy for lifetime income. But there are huge problems with both assumptions and with estimating actual consumption from survey data. As well, individuals typically join and depart from a number of households over their lifetime.

individual household, some error of estimate (positive or negative). The question for present purposes is whether the trend in annual income inequality noted in Tables 2A and 2B is substantially the same as the (unobserved) trend in lifetime income inequality. The only way in which this could not be true would be if there had been a very large increase in income mobility – a proposition for which there is no support in available empirical work.