CANADA'S **ECOFISCAL** COMMISSION
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Revenue Recycling:

Six Position Papers on the Options for Recycling Carbon Pricing Revenue

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Introduction

Provinces are increasingly moving forward with carbon pricing to reduce their greenhouse gas emissions in a cost-effective way. Yet a price on carbon is only half of the policy story. Pricing carbon also generates revenue for governments, so governments need to decide how best to "recycle" this revenue back to the economy.

A new report from the Ecofiscal Commission explores the options for provinces in recycling revenue from carbon pricing policies. The report is called *Choose Wisely* for a reason: the trade-offs between options are complex. No single option outperforms the others on all dimensions.

In short, there are many opportunities for revenue recycling. But there are also lots of trade-offs. Some approaches to revenue recycling are better for economic efficiency. Others can drive more emissions reductions, above and beyond those from the carbon price itself. Some approaches address concerns around the fairness of carbon pricing, while others address concerns around the competitiveness of emissions-intensive and trade-exposed industries. And still other approaches might make carbon pricing more politically practical. To complicate the choice even further, differences between provinces mean that the right mix of revenue recycling in one province will not necessarily work best for another.

To help inform our analysis, but also to frame these trade-offs, we commissioned six position papers from smart policy thinkers across the country; these papers are presented here. Each makes the case for a different approach to revenue recycling. They are entirely the work of their authors. While the Ecofiscal Commission provided comments and suggestions on early drafts, the analysis and positions presented are exclusively those of the authors.

The six papers are as follows:

- **Lars Osberg** makes the case for a "Carbon Fee and Dividend" approach in which revenue is returned to citizens as lump-sum cheques. He suggests this approach is fair, but can also build a constituency for carbon pricing, allowing for more ambitious policy.
- **Ken McKenzie** makes the case for using revenue to reduce existing tax rates. In particular, he highlights reductions in corporate and personal income taxes as the best way to minimize the costs of carbon pricing policy.
- **P.J. Partington and Vicky Sharpe** argue that revenue should be invested in the development of low-carbon technologies in order to complement the carbon price by driving more emissions reductions at lower costs.
- **Marc Lee** argues that carbon revenue should be invested in public infrastructure. He suggests that these investments could lead to long-term improvements in productivity, but also to additional emissions reductions if infrastructure projects are chosen wisely.

- **Jean-François Wen** suggests that provincial governments should pay down their public debt, thus giving future generations fiscal flexibility, but also reducing the economic costs associated with public debt.
- **Mark Purdon, David Houle, and Blake Shaffer** explore the case for providing transitional support to industries to address competitiveness concerns. They show that *forgoing* revenue by providing emitters with free permits can reduce the extent to which economic activity and emissions relocate to jurisdictions with weaker climate policy.

As a collection, the papers highlight the strengths of different approaches to revenue recycling. They also illustrate the range of perspectives on this issue: smart policy analysts can—and do—disagree as to how carbon revenue should be used. By presenting a diversity of views, we hope to help provincial governments think through and determine their own policy priorities. Considering the full range of these perspectives in designing revenue-recycling approaches can help them to choose wisely.

1. We All Own the Air: Why a Carbon Fee and Dividend Makes Sense for Canada

Lars Osberg, Economics Department, Dalhousie University

ABSTRACT

This paper argues that the opponents of carbon pricing have successfully framed it as a "tax grab by government," while its advocates have neglected the very real financial pressures facing middle-class Canadians. The Carbon Fee and Dividend (CFD) proposal, therefore, is that a fee be charged per tonne of CO_2 equivalent emissions for all greenhouse gas (GHG) emissions and that all fee revenue be refunded as an equal cash dividend to all citizens. It is a "fee" rather than a "tax" because the underlying idea is compensation for a property right. Unlike taxation, whose purpose is to transfer resources to the control of government, the moral rationale is that collectively, we all own the air, so those who use and degrade the air (i.e., GHG emitters) should compensate the owners (i.e., all citizens) for the damage caused. By reframing carbon price revenue as deserved compensation for degradation of the property of citizens, a CFD fundamentally shifts the frame of debate. Like other property income, carbon dividend income would be taxable for income-tax purposes—hence, the net after-tax benefits of a CFD would be greatest for low- and middle-income households (the majority of the population), and revenue would be available for other environmental investments. With a broad constituency of support, the CFD could thus increase over time, instead of "stalling out" at a level essentially irrelevant to climate change.

INTRODUCTION

In Canada, the urgency of reducing greenhouse gas (GHG) emissions and slowing down climate change is widely recognized (Angus Reid Institute, 2014).[1] Economists have been saying for many years that the most efficient way to do this is to make polluters pay for the "negative externalities" they are imposing on others. In the environmental, policy analysis and business communities, many agree that "putting a price on carbon" would be an efficient and effective method.

There is a consensus that although the carbon price might start small to minimize adjustment costs, it should increase over time until it fully reflects the social cost of carbon, taking into account all the costs of global climate change. However, despite all this agreement, there is little carbon pricing in Canada. Starting from the understanding that carbon pricing would help reduce GHG emissions and slow down

[1] When asked in September 2014 how much of a threat climate change poses for the planet, three-quarters of Canadians (75%) said the threat is either very serious or serious (38% and 37%, respectively). Nearly two-thirds (62%) agreed that "Global warming is a fact and is mostly caused by emissions from vehicles and industrial facilities." See: http://angusreid.org/majority-of-canadians-call-for-more-robust-efforts-to-curb-climate-change-2/.

climate change, this paper therefore asks: Why is carbon pricing now seen as "good policy but bad politics" in Canada? How can carbon pricing be designed so that it can become "good politics"—and thus actually happen?

An unfortunate reality in Canada in 2016 is that the opponents of carbon pricing—most importantly, the federal government from 2006 to 2015—have inaccurately framed it as a "job-killing tax," whose implementation will "hurt the economy." This framing feeds on the insecurities and financial anxieties of lower- and middle-income households in Canada, which have seen little change in real incomes in recent years. Soft labour markets and weakened employment insurance coverage have heightened economic insecurity, and many Canadians feel pressured financially.

Promises that a carbon price, which visibly adds to the day-to-day cost of living, will be somehow offset by invisible benefits sometime far in the future require a lot of trust to be believed. However, the advocates of carbon pricing have not been sensitive to the immediate economic stresses facing the less affluent and have not effectively addressed their suspicion that carbon pricing is just another tax grab by government that will make ordinary Canadians worse off.

Mistrust of big government, resentments of taxation, and fears that carbon pricing will be a job-killing attack on hard-working Canadian families are narratives that were assiduously encouraged for the last nine years by the former Harper government. Hence, carbon pricing has become framed as implying costs and risks (potentially large), and as having only uncertain and distant benefits. As a result, no major political party in Canada outside British Columbia now dares to openly advocate a carbon tax or admit that pricing carbon through an equivalent cap-and-trade system will have equivalent impacts on the living costs of individual households.

How can good policy turn into good politics in Canada? This paper argues that a "Carbon Fee and Dividend" (CFD) approach offers a way to reframe the debate on carbon pricing. Section 1 begins by presenting the proposal, summarizing recent polling evidence on carbon pricing and suggesting how the CFD might enable a reframing of the debate. Section 2 then asks what kind of evidence matters in the public debate on carbon pricing and compares the CFD with alternative carbon pricing proposals. Section 3 addresses complications and administrative issues, and Section 4 is a conclusion.

1. THE CARBON FEE AND DIVIDEND PROPOSAL AND ITS CURRENT CONTEXT

The Carbon Fee and Dividend (CFD) proposal is that a fee or carbon price be charged per tonne of CO_2 equivalent emissions for all GHG emissions and that all fee revenue would be refunded as an equal cash dividend to all citizens (Osberg, 2008).[2]

[2] Osberg (2008) was an early advocate. The proposal has been adopted by the Citizens' Climate Lobby in the U.S. (see http://citizensclimatelobby.org/carbon-fee-and-dividend/) and Canada (see http://www.citizensclimatelobby.ca/content/about-citizens-climate-lobby-canada). For draft U.S. legislation, see http://dv7gcmvxe5e8l.cloudfront.net/wp-content/uploads/2014/04/Carbon-Fee-and-Dividend-April-2014.pdf.

It is framed as a "fee" rather than as a "tax" because the underlying idea is enforcing compensation for a property right[3]—it is not taxation, whose purpose is to transfer resources to the control of government. The moral rationale is that collectively, we all own the air, so those who use and degrade the air (i.e., GHG emitters) should compensate those who own it (i.e., citizens) for the damage they are causing. By reframing carbon fee revenue as deserved compensation for degradation of the property of citizens, a CFD fundamentally shifts the focus of debate.[4] It therefore has a crucial advantage over other carbon pricing proposals, and may catch the imaginations of enough voters to become good politics, as well as good policy.

What is the current political standing of carbon pricing proposals? An April 2015 Angus Reid poll (Angus Reid Institute, 2015)[5] indicates soft majority support for some form of carbon pricing in Canada; as Table 1 indicates, three-quarters of respondents were in favour of a cap-and-trade system and a majority (57%) supported a carbon tax. However, support for carbon pricing has to be seen as relatively soft. Another question in the same survey found that less than half (47%) of respondents believed that cap-and-trade would be effective in reducing GHG emissions.[6] Table 1 also shows that most of those who support either form of carbon pricing do so only "moderately."

Table 1: Canadian Attitudes: Angus Reid Poll, April 2015

	Carbon Tax	Cap-and-Trade
Strongly Support	24%	33%
Moderately Support	33%	42%
Moderately Oppose	18%	12%
Strongly Oppose	25%	13%

Do you support or oppose Canada as a whole adopting a carbon tax?
Do you support or oppose Canada as a whole joining or forming a cap-and-trade system?

Source: Angus Reid Poll, http://angusreid.org/wp-content/uploads/2015/04/Cap-and-Trade1.pdf.

However, the framing of carbon pricing proposals can be crucial to public support, as a December 2014 poll (Anderson & Coletto, 2014) of 1,438 Canadians by Abacus Data illustrates. Any carbon tax has the property that tax payments will be lower for low emitters and higher for high emitters. Like a glass of water that can equally accurately be described as half full or half empty, a carbon tax can equally well be described in terms of its lower relative impact on low emitters or its higher relative impact on high emitters. As Table 2 illustrates, in December 2014, 78% of Canadian respondents were in favour of lower taxes on activities and products that produce lower emissions. Logically speaking, that is the same as

[3] Phrased in this way, it has attracted the support of political conservatives such as Shultz and Becker (2013). An alternative term is "citizenship right," which is more popular on the left. Importantly, a CFD is not easily labelled on a standard "left–right" political continuum, which increases the probability that it can gain support across the spectrum.
[4] As an equal owner of a share of the common asset, each citizen therefore has an equal claim on fee revenue.
[5] Online survey conducted April 15, 2015. Sample size was 1,536.
[6] Only 12% said "very effective," while 35% said "quite effective." Although cap-and-trade systems are notoriously complex, the question asked offered no explanation of the concept, so it is not clear what respondents thought they were supporting.

saying that activities and products that produce higher emissions will pay higher taxes, but only 59% were willing to say explicitly that they supported this. And when a carbon tax (which would do exactly the same thing as both the other options named) is mentioned, support drops still further, to 44%.

An optimistic interpretation of Table 2 is that despite years of attacks on "job-killing carbon taxes," slightly less than half the Canadian population are still willing to declare themselves in favour of that option. Moreover, Table 2 also implies that about a third of Canadians (34%) may switch their support, depending on how a tax initiative is labelled. Specifically, a third of the population shifted to being in favour of carbon taxes when "good news" (i.e., benefits to the relatively advantaged low emitters) was the focus. However, the general importance of framing also illustrates how vulnerable carbon pricing initiatives are to the "bad news" framing that Canada's current federal government has promoted—that is, carbon prices are job-killing taxes.

Table 2: Framing the Question

Percentage of Canadians who favour/oppose:	Favour	Oppose
Lower taxes on activities and products that produce lower emissions	78%	12%
Increase taxes on activities and products that produce higher emissions	59%	28%
Introduce a carbon tax that would be phased in over time	44%	38%

Source: Abacus Data, http://abacusdata.ca/wp-content/uploads/2015/01/CarbonRelease_Dec2014.pdf.

Central to the CFD proposal is the "good news" of a dividend that returns all the fee revenue to all citizens. How much do public attitudes shift when the possibility of refunding the revenue from a cap-and-trade system or carbon tax is mentioned? As Table 3 shows, American pollsters have asked that very question.[7]

[7] Regarding the cap-and-trade system, Q38A asked: "There's a proposed system called 'cap and trade.' The government would give permits to companies limiting the amount of greenhouse gases they can put out. Companies that do not use all their permits could sell them to other companies. Companies that need more permits can buy them, or these companies can pay money to reduce the amount of greenhouse gases that other people or organizations put out. Economists say that this system is likely to cause companies to figure out the cheapest way to reduce greenhouse gas emissions. Would you favour or oppose this cap and trade system?" Q38B added: "The money the government makes from selling the permits would be returned to all Americans equally by reducing the amount of income taxes they pay." Regarding the carbon tax, Q92 asked: "Do you think the federal government should or should not require companies to pay a tax to the government for every ton of greenhouse gases the companies put out?" Q92B added: "All this tax money would be given to all Americans equally by reducing the amount of income taxes they pay."

Table 3: U.S. Attitudes to Carbon Pricing and Carbon Dividends

	Dec-13	Jan-15		Dec-13	Jan-15
Cap-and-Trade			Cap-and-Trade With Dividend		
Favour	48	52	Favour	65	62
Oppose	49	42	Oppose	33	34
DK/Refused	4	6	DK/Refused	2	4
%	100	100	%	100	100
N	271	497	N	258	
Carbon Tax			Carbon Tax With Dividend		
Favour		61	Favour		67
Oppose		35	Oppose		31
DK/Refused		3	DK/Refused		2
%		100	%		100
N		497	N		509

Source: Global Warming National Poll, Resources for the Future, *New York Times*, Stanford University. Interview dates: January 7-22, 2015, http://www.rff.org/Documents/RFF-NYTimes-Stanford-global-warming-poll-Jan-2015-topline-part-3.pdf.

Table 3 indicates that there is a significant increase in the percentage favouring either a carbon tax or a cap-and-trade system when a carbon pricing proposal is paired with mention of an equal refund of all revenues to all citizens. However, because these questionnaire wordings retain the terminology of "carbon tax" and "cap-and-trade," they do not probe the impacts on public opinion of reframing carbon pricing as fair compensation for the use of the common property of all citizens.

In order to stick with commonly used terms, this paper refers throughout to a Carbon Fee and Dividend approach, but it would be more accurate to call it a "Carbon Price and Dividend" (CPD) approach, since it is, in principle, compatible with either cap-and-trade permits or carbon fees. In general, compensation for the use of property can be done in a variety of ways. For example, to get compensation when other people use privately owned land, a landowner can charge a fee for entry onto the property or auction off a limited number of entry permits. Either mechanism will reduce the number of visitors who use the land and provide compensation for the wear and tear that they cause. Enforcing a common property right in the atmosphere is similarly compatible with either a carbon fee or a cap-and-trade system for raising the revenues that can compensate all citizens for GHG emissions.

An important political advantage of a carbon tax or carbon fee is clarity and simplicity. However, in theory, in a world of perfectly informed policymakers, cap-and-trade and carbon taxes/fees are equivalent.[8] A price could be put on carbon by either specifying the quantity of carbon to be emitted and

[8] Some advocates of carbon pricing may believe that the complexity of cap-and-trade systems will shield such proposals from political attacks, but the Harper government was quite clear in asserting (correctly) that the two mechanisms are theoretically equivalent.

letting prices adjust (cap-and-trade) or setting the price of carbon emissions and letting quantity adjust (carbon tax/fee). There is an ongoing debate as to which mechanism is more effective in limiting GHG emissions at least cost, given real-world information imperfections and administrative constraints. Since the distinguishing feature of the CFD approach is the carbon dividend, the focus of this paper is how to use the revenue raised by carbon pricing, not the specific mechanism chosen for carbon pricing.

However, two issues in the “carbon tax versus cap-and-trade” debate remain highly relevant.[9] First, because cap-and-trade schemes are vulnerable to special interest lobbying that undermines their impact on emissions by grandfathering the pollution of large emitters through the issuance to them of free quota, cap-and-trade systems also reduce the revenue initially available for a carbon dividend, thereby also reducing the constituency of support for further increases in the price of carbon. Second, because cap-and-trade implies fluctuating carbon prices that are difficult to integrate with the tariff surtaxes and rebates for GHG emissions required to maintain a level playing field for trade between jurisdictions with and without carbon pricing, carbon price revenue from cap-and-trade will be less likely to increase over time.[10]

Whether it is a carbon fee or quota auctions under cap-and-trade that raise revenue, when a carbon price is thought of as compensation for the use of a common property right, the owners (i.e., citizens) have the right to 100% of the revenue raised. But carbon dividend income would be before-tax income.[11] For the same reason that the rental income of apartment owners is considered taxable income for income-tax purposes, the carbon dividend income of all citizens would be income they receive in right of their ownership of property (specifically, their share of the income from ownership of the common property resource, the atmosphere). As such, their carbon dividend income should be added to all their other property and labour income from all other sources and taxed accordingly—which means in practice that the carbon dividend would be taxed at the marginal income-tax rate of all citizens. Hence, the CFD approach does not mean forgoing all the possible benefits of reduced taxation or alternative investments in environmental improvement that other carbon pricing proposals promise.[12]

The increase in income-tax revenue resulting from taxable carbon dividends could be used in many possible ways. When British Columbia implemented a carbon tax, tax credits were used to mollify the complaints of northern and remote constituencies who felt particularly aggrieved by increased energy costs. Alternatively, business groups have argued that income and corporate tax cuts could be paid for by

[9] As well, in this author’s view, a carbon tax or carbon fee also has important technical advantages. An announced carbon tax schedule provides a stable, known price signal to guide investment decisions, while cap-and-trade implies uncertain carbon costs, due to fluctuating permit prices. Because recessions depress the demand for, and price of, GHG permits, the price signal, which is supposed to guide long-term transition to a low-carbon economy, is vulnerable to the transitory noise of business cycle fluctuations. Additionally, compliance with carbon quota allocations, within specific time periods, requires expensive and uncertain monitoring, which is only feasible for large emitters. In contrast, a carbon fee or carbon tax can be applied upstream, at the point of initial production or importation of carbon fuels, enabling relatively simple administration and compliance, and wide diffusion in downstream impact.

[10] See Section 3 below.

[11] Section 3 below considers retained earnings from the collection of a carbon price—namely, carbon dividends that amount to less than 100% of revenue from carbon pricing.

[12] At current Canadian emissions levels (20.1 tonnes of CO_2e per person in 2012) and a population of roughly 35 million, a carbon fee or tax of $10 per tonne would initially produce total carbon dividend income of about $7 billion. An average marginal tax rate of 35% would imply additional federal and provincial income-tax revenue of about $2.45 billion, which would increase over time as the carbon price increased.

carbon price revenues. Social assistance increases, or public transit investments or other environmental spending might also be deemed to be the priority. Governments of different persuasions would presumably choose differently from this menu, but they could all choose how to spend the additional revenue, while still balancing the public budget.

The CFD approach is therefore very much a “good news” agenda. It recognizes a property right of all citizens and provides compensation for its use—with visible financial benefits to all citizens, which would be a net positive for most households. It enables government to provide additional services and/or lower taxes, while maintaining budget balance. And it creates incentives, increasing over time, to shift away from GHG emissions, thereby helping to improve the environment and reduce global warming. Politically, it reframes the debate on carbon pricing as an assertion of the property rights of all citizens, which could be a populist platform for either the left or the right.

A key feature of all carbon pricing proposals is phasing-in: beginning at a relatively low level with a schedule for regular increases until emissions goals are achieved. Since individuals and firms need time to make investments in new technologies and to replace existing capital assets (e.g., automobiles) with more efficient alternatives, phasing-in minimizes transitional costs. A common starting point for discussion is a carbon price in the region of $5 or $10 per tonne; at current Canadian emissions levels (20.1 tonnes of CO_2e per person in 2012) (Environment Canada, 2014), that would imply revenue of approximately $100 to $200 per person per year. Even if paid out entirely as an annual dividend, this is initially too small to have much impact on family well-being.

Starting small is undoubtedly necessary for initial acceptance and has been a key characteristic of carbon pricing initiatives, such as that of British Columbia. However, small prices have small impacts. When the momentum for further increases in the price of carbon stalls, as it has in B.C., the carbon price stays small and so does its impact on GHG emissions. Fundamentally, a carbon pricing policy that only ever implies a small carbon price and a marginal impact on GHG emissions and climate change is a failure. The impact of carbon pricing on GHG emissions and climate change depends on how much the carbon price increases each year, to what ultimate level. The ultimate level of the carbon price also determines how much carbon dividend income a CFD generates for citizens. The Citizens’ Climate Lobby (CCL) in the U.S., for example, advocates a CFD[13] in which, starting in 2016 at $10 per tonne, the carbon fee increases for 20 years by $10 per year, implying a 2035 carbon price of $200 per tonne.[14] In the CCL’s modelling of impacts, GHG emissions are reduced substantially (52%) by 2035, but the annual dividend still increases to $1,152 per capita (Nystrom & Lucknow, 2014),[15] which would be a significant amount for low-income families.

[13] For some unexplained reason, the U.S. proposal (see http://citizensclimatelobby.org/carbon-fee-and-dividend/) gives children only a half dividend and limits each household to receiving a maximum of two child dividends, thereby considerably increasing administrative costs, since place of residence must be established for all children. It is also unclear why children, and especially children in larger families, should be discriminated against. Hence, the CFD proposal in this paper is for an equal dividend for all citizens.

[14] Moore and Diaz (2015) argue that if global warming adversely affects capital formation and productivity growth (particularly in poor countries), the social cost of carbon increases substantially—perhaps to $220 per tonne. Lee (2013) advocates a $200 per tonne carbon tax by 2020.

[15] Notably, the labour intensity of increased consumer spending means total employment increases by 2.1 million (i.e., about 1%).

2. THE CARBON FEE AND DIVIDEND COMPARED WITH ALTERNATIVES

Carbon pricing promises the benefit of reducing GHG emissions, at the cost of reallocating resources to less carbon-intensive uses.[16] Assessment of the total costs of carbon pricing, and the distribution of costs and benefits within the population, has thus become central to the debate. What is the evidence and, more importantly, what is the evidence that is likely to influence the public debate?

Policy analysts who rely on objective data may argue that if GHG emissions per capita in Canada in 2012 were 20.1 tonnes of CO_2e per person, then a carbon price of $10 per tonne has an initial average impact of roughly $200 per person per year, which is quite a small fraction (0.36%) of Canada's current GDP per capita.[17] Although this proportion will increase over time, if the carbon price increases, most current proposals for carbon pricing do not add up to an objectively big fraction of average income. Even though British Columbia's carbon tax was $30 per tonne in 2012, which added about seven cents (Rivers & Schaufele, 2012)[18] to the cost of each litre of gasoline, this would only have added about $144 to annual car costs for somebody driving 20,000 kilometres per year. This was less than a fifth of 1% (0.195%) of median census family income in B.C. in 2011 (Rivers, 2012)[19] and about one-seventh of the decline in Vancouver gasoline prices in 2014/15.[20] Although the impact of a carbon tax will certainly be unequally distributed, the differences in dollar impacts will usually be some fraction of the average impact and thus also a relatively small percentage of average incomes. And since the ups and downs of world energy markets have produced gasoline prices that in Canada have fluctuated over a range that is almost nine times larger than the maximum size of the B.C. carbon tax,[21] market prices have remained the overwhelmingly dominant influence on the consumption of carbon energy.

So, why is there all this fuss about instituting a carbon tax or cap-and-trade?

In a very real sense, the objective impacts of carbon pricing are not all that important for the politics of carbon pricing adoption. It is the subjective expectations—what people *think* happens because of carbon pricing—that will determine their political attitudes, which in turn will determine whether or not carbon pricing is going to be adopted. To some extent, subjective personal expectations differ from average

[16] Since reallocating resources means there will be fewer jobs in some sectors (e.g., oil sands development) and more jobs in others (e.g., wind farm construction and maintenance), it is true, but incomplete, to say that carbon pricing kills jobs—indeed, shifting jobs out of carbon-intensive sectors is entirely the intended effect.

[17] In Q1 2015, GDP per capita at market prices was $55,378, so $200 would be about a third of 1% (0.36%); CANSIM Table 380-0063. Differences in impacts will typically be some fraction of that.

[18] Rivers and Schaufele (2012) report the cost as $0.0667.

[19] Based on 10 litres per 100 kilometres. In 2008, the average annual distance travelled by light vehicles in Canada was 15,153 kilometres. Office of Energy Efficiency *2008 Canadian Vehicle Survey Update Report*; Median BC census family income in 2012 was $71,660 (see CANSIM, Table 111-0009).

[20] Pump prices for gasoline in Vancouver averaged $1.523 per litre in June 2014 and fell to $1.029 in January 2015 (see CANSIM Table 326-0009).

[21] Pump prices for gasoline in Toronto averaged $0.78 per litre in January 2005 and hit $1.367 in July 2014, for a range of $0.587. CANSIM Table 326-0009.

objective outcomes, because individuals' personal circumstances differ objectively from the norm: another $150 on the annual gas bill looks very different when family income is $130,000 compared with when it is $30,000. But differences in personal circumstances can explain only part of the political reaction to carbon pricing.

Gasoline is a standardized commodity whose price is very visibly advertised and which consumers have to buy repeatedly, so changes in the cost of gasoline are highly salient to consumers. This produces systematic subjective overestimation of the impacts of gasoline pricing on household well-being. In 2011, for example, when the price of gasoline in the U.S. had risen between January and May by nearly $1 a gallon (roughly 25 cents per litre), Gallup (2011) found that 67% of Americans reported that this had caused them financial hardship (21% reported "severe hardship"[22]). In recent years, gasoline expenditures in the U.S. have accounted for about 5% of household expenditures, and the increase between 2010 and 2012 in average annual household spending on gasoline was only about $500 (Doggett & Tarver, 2014). In 2011, median household income in the U.S. was $50,054. Although it may be thought implausible that two-thirds of Americans are objectively so close to the economic margin that they would experience financial hardship from a shock of approximately 1% of median annual income, the key political fact is that two-thirds of Americans *thought* they were experiencing hardship because of higher gasoline prices.

Moreover, Rivers and Schaufele (2012) argue that the econometric evidence on gasoline sales in British Columbia demonstrates that "The carbon tax … is more salient than equivalent changes in price. A five-cent increase in the carbon tax, all else constant, causes gasoline demand to decline by 10.6% whereas an identical five-cent increase in the market price of gasoline leads to a 2.2% reduction in litres consumed." The good-news part of the excess salience of carbon taxes is that visible modes of carbon pricing (like an explicit carbon tax) will have, if enacted, an impact on energy conservation and GHG emissions that is disproportionately large. The bad news is that individuals overestimate the importance of gasoline prices for their financial well-being and treat increases in gas taxes as more salient than equivalent increases in the market price of gasoline[23]; hence, their subjective expectation of carbon tax costs is way out of proportion to actual impacts, which makes a carbon tax less likely to be enacted.[24] Furthermore, in this situation, economic studies of the objective financial impact of carbon pricing are likely to provide only limited guidance on subjective expectations and political impacts.

An example of the limited impact of data on carbon pricing debates comes from British Columbia. Peet and Harrison (2012) note that opposition to the B.C. carbon tax was most vocal in the north of the province, based on northerners' beliefs that their colder winters, longer distances and the necessity of driving larger vehicles made the imposition of the tax regionally unfair. In the B.C. debate, advocates of the carbon tax cited Statistics Canada data to argue that commuters in the Lower Mainland in fact had

[22] Gallup has asked this question since 2000, with peaks of reported financial hardship from recent gas price increases in 2005 (72%) and 2008 (71%). In 2011, a majority reported that they had made "major changes to deal with rising gas prices" (53% overall, 44% among those with incomes greater than $75,000). To put a 25 cents per litre price movement in context, the Toronto price of gasoline was $1.405 per litre in June 2014 before falling to $0.91 in January 2015 and rebounding to $1.126 in May 2015; see CANSIM Table 326-0009.

[23] Hastings and Schapiro (2013) find households consistently treat "gas money" differently from other income.

[24] Carbon taxes and cap-and-trade systems are unlikely to be equivalent carbon pricing mechanisms in this respect. Since cap-and-trade impacts on gasoline prices are variable and hard to measure, they lack both the good news of greater consumer sensitivity to taxes and the bad news of greater taxpayer resistance to implementation.

longer trips to work than did northern residents. As Peet and Harrison (2012) also note, "The publication of these findings had no apparent effect".

Moreover, comparisons of average commuting distances between economic regions—even if such comparisons make, in the end, little headway in affecting public beliefs—are relatively straightforward. In communication with the public at large, it is much more of a challenge to defend the fairness of carbon pricing using computable general equilibrium (CGE) models (Araar et al., 2011; Beck et al., 2015; Fullerton et al.,2011; Rausch et al., 2011) of the distributional implications of alternative carbon pricing systems. Rausch et al. (2011) argue, for example, that carbon pricing has a similar proportionate effect on upper- and lower-income groups. Their CGE model simulations of income distributional impacts in the U.S. indicate that the impacts of carbon pricing on income sources and expenditure uses offset each other.[25] Lower-income groups use a higher fraction of their income to buy carbon-intensive goods, and therefore face a greater increase in their cost of living when carbon pricing is implemented. In their CGE model, because capital income is a more important income source for the affluent, and because the rate of return on capital falls in general equilibrium when demand shifts away from the capital-intensive energy sector, a carbon price is progressive in its impact on incomes, which offsets its regressive impact on expenditures. As a consequence, they argue that the income distributional impact of carbon pricing depends primarily on how the revenue is spent. Beck et al. (2015) go even further, arguing that even without revenue recycling, a carbon tax is progressive in its impact.

Rausch et al. (2011) argue that there is a trade-off between equity and efficiency in the spending of carbon fee revenues since they find that spending carbon price revenues on equal per capita rebates has more pro-poor distributional outcomes than reducing income taxes, but also implies a larger increase in average costs. However, the numbers involved are all very small; they calculate the average costs associated with a $20 per tonne carbon price plus income-tax reduction policy as 0.18% of household income[26] compared with 0.46% for the carbon price plus per capita payment option. Given the introduction of carbon pricing, the different revenue-recycling options thus produce a difference (0.28%) in income levels that is significantly less than measurement error in annual GDP estimates and far smaller than GDP growth, even over a year or two—and is also much less than the uncertainty surrounding current projections of future income levels.

As well, almost all voters will check the predictions of CGE models against personal life experience. The impact of carbon pricing on the uses of income (i.e., via cost of living increases) is an immediate reality that is easily understandable. The eventual general equilibrium impacts on factor prices predicted by CGE models are more inherently hypothetical: relatively few people will take on faith the projections of

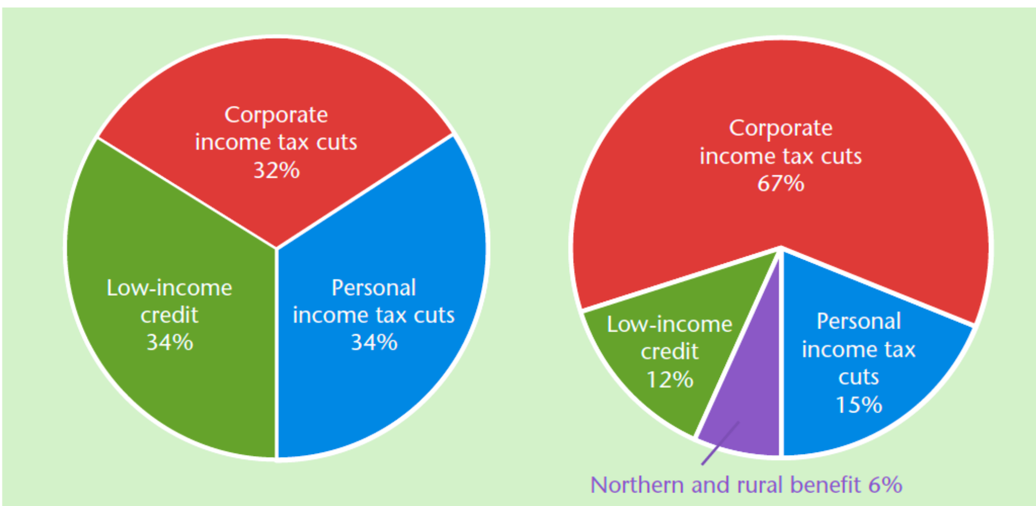
[25] Beck et al. (2015) use Canadian data but group households into 10 deciles, which are then treated as a representative household for each decile. They therefore cannot detect the intra-decile heterogeneity in impacts that Rausch et al. (2011) find swamps inter-decile differences in impacts. Their conclusion on the progressivity of income sources impacts is even stronger than of Rausch et al. (2011).

[26] Araar et al. (2011) do not include per capita rebates as a case for examination of income distributional impacts. Rivers (2012) argues that annual expenditures may be a guide to lifetime income and that organizing the data by deciles of expenditure, rather than income, reduces the perceived regressivity of the expenditure impacts of carbon pricing. However, using annual expenditure as a proxy for lifetime income depends on the belief that people know their lifetime income with certainty and can borrow and lend on perfect capital markets—which only a subset of economists thinks is plausible.

CGE simulations.[27] The cost of living impacts of carbon pricing are therefore crucial to the political attitudes that will determine whether it actually happens.

Although the recycling of the B.C. carbon tax included a Low Income Climate Action Tax Credit, it was initially small ($100 per adult, $30 for children) and has risen less rapidly than the tax itself. Lee (2013) therefore argues that by 2012, reductions in personal income tax and corporate tax made up increasingly more of the revenue recycling involved (see Figure 1). Figure 2 is also taken from Lee (2013) and portrays the average percentage cost of living impact of the B.C. carbon tax by income decile. The increasing size of carbon tax impacts on expenditures, in combination with the presumption of increasingly regressive distribution of recycled revenues, produces a regressive net impact, particularly at the very top, where the dividend and capital gain income deriving from corporate tax cuts is concentrated.

Figure 1: Share of Carbon Tax Expenditures

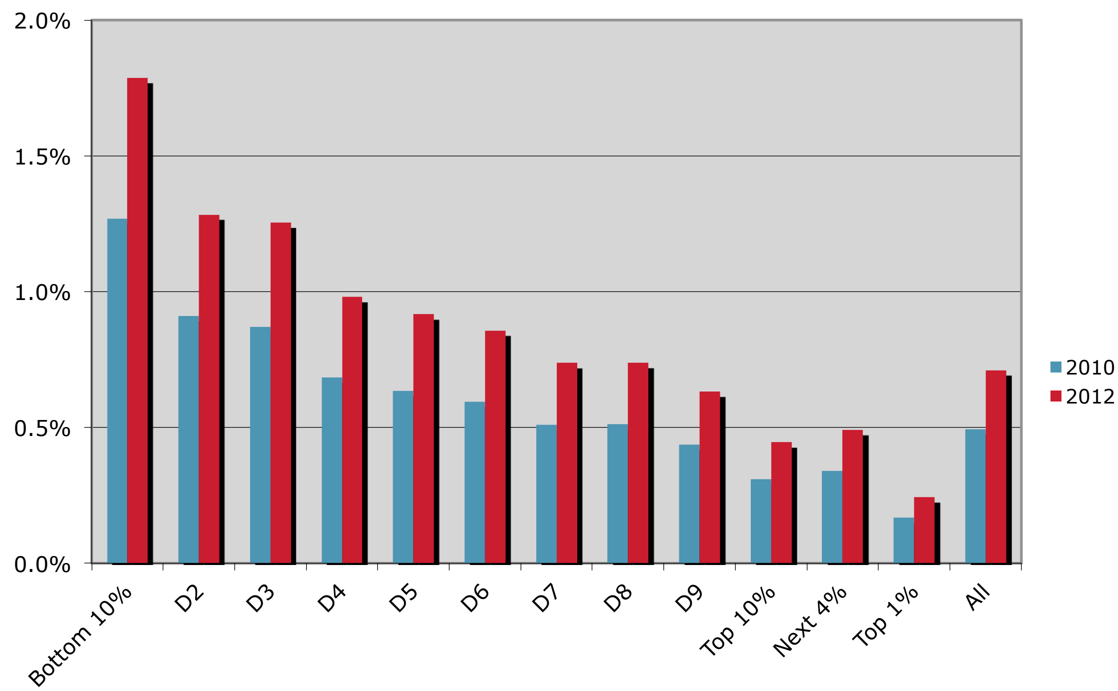


Note: Figures show shares of total carbon tax expenditures, not carbon tax revenues, which are lower and would mean the shares would not add up to 100%.

Source: Author's Calculations based on B.C. Budget 2011.

[27] Many economists question whether real-world market forces operate with the perfection necessary for carbon pricing to eventually produce lower rates of return to capital in general equilibrium factor markets. CGE models also depend critically on the market-clearing assumption, and a crucial assumption of Rausch et al. (2011) is the full indexing of transfer payments, which many find dubious. As well, the specific results of any given CGE model depend on the assumed functional forms and the parameter values chosen for crucial elasticities calibrated into the model, so any specific run of a CGE model can only show what *could* happen (i.e., conditional on the assumptions made). Without demonstrated robustness of results to alternative a priori assumptions, there is no way of knowing how sensitive results are, but none of the CGE models discussed above presents such evidence.

Figure 2: Carbon Tax as Share of Total Income



However, how do we know which part of the income tax and corporate tax schedule in British Columbia had lower rates in 2012 because of the carbon tax? Although the B.C. government says that the provincial carbon tax is revenue neutral,[28] how can one know this is true? What is the counter-factual? If a carbon tax had not been introduced, how do we know for sure that personal income tax and corporate income tax rates in B.C. would not have been cut anyway? Would there have been equal percentage point changes in these different tax bases or equal percentage changes in tax rates or different rates of change in different tax bases? In Figure 1 above, Lee uses the assumptions in the 2011 B.C. budget to allocate the revenue from the provincial carbon tax to notional changes in tax sources, but any number of other possible changes in sales tax or personal income tax or corporate income tax rates in B.C. could have been added up to the same total revenue impact.

Politically, revenues from carbon pricing may be able to claim credit for income or corporate tax reductions that are announced at the same time that carbon pricing is implemented. However, the longer carbon pricing is in place, the more difficult it becomes to argue convincingly that carbon pricing revenue is replacing any specific amount of this or that particular other tax. Past cuts to tax rates on different tax bases simply define the status quo from which current and future tax policy changes start. Governments can, and do, amend tax legislation every year. Over time, the exact reasons why a particular rate of tax for a particular tax base was once adopted are often forgotten (and ancient reasons are not particularly relevant to current impacts). When carbon pricing revenue forms part of general government revenue, it is therefore impossible to determine exactly which specific other taxes it is replacing, and therefore impossible to determine exactly whether it is in fact revenue neutral and which income groups benefit.

[28] More exactly, "revenue negative," since taxes foregone are said to exceed carbon tax revenue.

Eventually, when the revenues from carbon pricing have become embedded in the general government revenue stream, abolition of carbon pricing would mean that other taxes might have to be raised. Inertia, habituation, and the imperatives of budget balancing may then protect carbon pricing from being abolished. But because the daily costs to consumers of a carbon tax or cap-and-trade quotas are highly visible, and more salient than market-based variations in carbon energy prices, and because people overestimate the importance of energy prices to their financial well-being, carbon pricing is a politically expensive way of raising government revenue. The costs of carbon pricing are visible daily, while the benefits from carbon pricing revenues are invisible parts of general revenue. Hence, carbon pricing has a limited constituency of political support, which has two crucial long-run implications:

1. The prospects for further increases in the carbon price are dim, despite emerging evidence that the social cost of carbon may be considerably higher than the $40 to $50 per tonne assumption guiding current Canadian carbon price proposals (Moore & Diaz, 2015).
2. Carbon pricing is always vulnerable to populist appeals that lower energy prices can make life more affordable for ordinary middle-class families.[29]

There are many claimants for the potential revenue from carbon quota auctions or carbon taxes. Business groups always lobby for cuts to corporate taxation and top personal income-tax rates, and in this case the claim is that allocating carbon pricing revenue toward such tax cuts will yield a “double dividend” of efficiency and thereby increase incomes.[30] Some conservative economists may agree—but there is deep scepticism in the wider public. And even if it were true that income and corporate tax cuts were efficiency improving, the change in level of GDP associated with the size of tax changes that could be financed from carbon pricing revenues is so small as to be undetectable, relative to business cycle fluctuations and current general uncertainty about economic forecasting.[31]

Revenue recycling through income-tax cuts also faces the objection that it is fundamentally unfair. If carbon pricing revenue is recycled through income-tax cuts, the revenue benefits from the tax are concentrated among the relatively affluent, because they now pay more income tax. In public debates over income-tax recycling of carbon pricing, vivid examples of inequity can have disproportionate impacts. Reporters will, for example, be able to quote the prediction of Rausch et al. (2011) that in the U.S., when carbon pricing revenue is rebated to households via income-tax reductions, the mean welfare loss for blacks is about twice as large as that for whites.[32]

[29] The leadership of Nova Scotia’s NDP government of 2009 to 2013 believed strongly that the NDP election promise to eliminate provincial value-added tax on home-heating oil and electricity (much of which is coal-fired) was crucial to their electoral success in 2009. This tax giveaway arguably amounted to a *subsidy* to carbon consumption, but the new provincial Liberal government has not rescinded that tax exemption (which will cost the province $128 million in 2015/16) or introduced a carbon tax, despite commissioning a report that urged both (see Broten, 2014).

[30] Such changes in tax rates can only promise a level change in GDP; for example, as more labour is supplied in response to cut in income-tax rates causing an increase in the after-tax wage. Living standards in the longer term are dominated by GDP growth rates.

[31] As already noted above, Rausch et al. (2011) find a difference of 0.28% in income levels from the efficiency benefits of cutting income taxes compared with spending carbon taxes on per capita rebates.

[32] The mean welfare change is very small for both groups (-0.17% for whites and -0.32% for blacks), which implies that the difference is also very small. Rausch et al. (2011) find that, in general, impact differences within racial or income decile groups are much larger than between group differences in average impacts. But these nuances will likely be relegated to footnotes, if they are reported at all, and many people do not read footnotes.

Environmental groups have argued that carbon pricing revenues should be spent on environmental issues, particularly on reducing GHG emissions. However, since the atmospheric concentration of CO_2 depends on global emissions, added to the global stock of atmospheric CO_2 inherited from the past, global climate change is inherently a long-term issue. There is thus no promise from environmental groups that in the short run, one will be able to observe any discernible temperature difference that could be directly ascribed to carbon pricing.[33] And when carbon pricing revenue is part of general tax revenue, there is no real reason to say which particular tax is paying for which particular program—including environmental programs—so any observed environmental improvements could equally well be ascribed to the financing of environmental programs from income-tax revenues.

Spending the revenues from carbon pricing on environmental programs and making carbon pricing revenue neutral by cutting income or corporate tax rates are therefore similar policies in one important respect: in both cases, the good-news benefits of the revenue from carbon pricing will very quickly be invisible to most of the electorate. Also in both cases, the counter-factual for the revenue—what would have happened if carbon pricing had not been introduced—is not at all clear, either politically or analytically. In the years after the initial introductory announcement for carbon pricing, there may be lower income-tax rates or greater environmental spending, but in public perception, this will be just the taken-for-granted status quo that could have been funded from any other tax source (or added to the deficit).

Canadians have, for some years now, been encouraged to believe that there is no link between taxes and government services. Specifically, Canadians have been told repeatedly by their governments that tax cuts have no costs in foregone government services—that tax cuts are "all gain and no pain." The Harper government, for example, repeatedly promised, and delivered, tax cuts without saying what the corresponding cut in public services would be. It has been a recurring theme in Canadian political rhetoric that there is so much fat in waste and mismanagement in government that taxes can be cut, again and again, without any real impact on the quality of life of families. Since this discourse implies that any tax increase will be all pain and no gain, carbon pricing is collateral damage in a broader narrative. So when Canadian political culture produces no challenges to the general proposition that taxes almost always can and should be cut, why should Canadians now believe that a new tax on carbon energy is necessary?

By contrast, the CFD proposal establishes a clear link between a carbon price and observable short-run benefits to ordinary families, because it resets the carbon dividend each year as equal to (Total Carbon Price Revenue)/(Population). It therefore has a clear counter-factual: no carbon pricing revenue, no dividend payments. Because the CFD proposes a 100% return of carbon pricing revenue, via equal dividends to all citizens, there is an immediate and highly visible financial benefit, to everybody, of carbon pricing, in addition to the long-run benefit of moving to a less carbon-intensive world. This creates a widely based constituency of support—which is crucial both for future increases in the carbon price and to undercut future populist appeals to make life affordable for middle-class families by cutting the cost of energy.

[33] Increased carbon energy prices will, one hopes, have the observable short-run implication that, for example, more people buy less-powerful, smaller cars. Committed environmentalists will (correctly) see this as an instrumental benefit of carbon pricing, but many others will see it as a cost.

Fundamentally, the environmental benefits of carbon pricing depend on how many mega-tonnes of CO_2e GHG are *not* emitted into the atmosphere over the next several decades, which depends on how much and for how long the price of carbon increases. Given the scale of global climate change impacts, it is not nearly good enough to institute a small carbon price, which then stays small, and therefore always has a small impact on GHG emissions and climate change. It is therefore crucial that enough voters derive immediate and tangible benefits from carbon pricing and that there is a broad constituency of support for continued increases in the price of carbon over time.

3. COMPLICATIONS AND ADMINISTRATIVE ISSUES

Delivery

In the first year, the amount of the dividend could be calculated based on forecast revenues. In each subsequent year, the annual dividend per person could be calculated either as (1) equal to the total carbon pricing revenue collected in the previous year, divided by the total population[34] or (2) equal to forecast revenue for the current year, plus or minus any forecast error for the previous year, divided by the total population. The CFD payable to children could be paid to their parent or guardian on their behalf.

The most visible form of payment would be as a quarterly cheque; if the carbon price is initially low, a monthly cheque would initially imply quite small payments. A possible alternative delivery mechanism would be to integrate the CFD as a refundable tax credit within the income-tax system.[35] The advantage would be lower administrative and mailing costs, but the disadvantage is less political visibility.

Federal and Provincial Roles

If the CFD proposal is implemented at the provincial level, the carbon dividend would be taxable income, which would be subject to both federal and provincial income tax. However, it would be unfair for the federal government to free-ride on provincial initiatives in carbon pricing. A provincial government that paid all the political costs of implementing carbon pricing would have a reasonable claim to receive all the tax revenue from such initiatives—namely, all the carbon tax revenue or auction value of carbon permits plus all the federal and provincial income tax collected on carbon dividends paid to that province's residents.

Border Taxation Issues

In the U.S. debate on carbon pricing, there is considerable concern about potential trade implications. If the carbon tax or carbon quota costs embodied in goods and services produced for export are not rebated to exporting firms, those firms will have higher costs and be at a competitive disadvantage in global export markets. Similarly, if no carbon tariff is applied to imports, and if the carbon energy embodied in imports escapes carbon pricing at equivalent levels in the origin country, imported goods will be cheaper, implying that those imported goods and services will have a competitive advantage in

[34] It would be reasonable to define the recipient population as Canadian citizens residing in Canada.
[35] If a carbon dividend were delivered through the income-tax system as a refundable tax credit, making it inversely proportional to income level would increase net benefits to lower-income groups—but at the expense of undermining the common ownership rationale that distinguishes a carbon fee from a carbon tax. See discussion of partial dividends below.

U.S. markets. In both instances, American jobs are put at risk. The CFD proposals for the U.S. therefore include detailed provision for remitting carbon price costs on exports and collecting carbon fees on goods imported from countries that do not price carbon (Citizens' Climate Lobby, 2015).

If carbon pricing always remains a cosmetic policy that promises environmental benefits while delivering a carbon price that remains at nuisance levels (i.e., small enough to be ignored in plant location decisions), then border issues will not matter. However, every Canadian province that initiates significantly large carbon pricing will have similar grounds for concern about trade implications, with the added complications that (1) an individual province has to worry about both interprovincial and international competition, and (2) unlike the federal government, provinces do not have the policy levers of border control and tariff policy. If carbon pricing is left to the provinces, the inability of provinces to protect themselves against trade implications (both internationally and interprovincially) will therefore bias policy choices toward a "lowest common denominator" model of low carbon pricing, which will imply a low carbon dividend.

Partial Dividends

Even if all citizens have equal ownership of the air, and have an equal right to be paid for the use of that air, citizens might rationally decide to save some of their income from carbon pricing as "retained earnings"—in other words, only pay out part of the current year's carbon pricing revenue as a current-year carbon dividend. Retaining part of the carbon dividend could be justified in part by the argument that future generations, as yet unborn, will also own the air and deserve some payment for the depleted quality (due to rising GHG concentrations) of the asset that they will inherit.

The retained earnings from carbon pricing could be loaned to government and, in principle, could be used for any public purpose; but to be consistent with the idea that earnings are retained to benefit future generations, investment in public infrastructure or environmental improvement, or reduction of the public debt might be thought most appropriate. However, whatever the uses to which retained earnings from carbon pricing are put, the moral rationale of a carbon price as deserved payment for use of the property of all citizens would require that all retained earnings be accounted for, and accumulate with interest as a defined fund. If the carbon price increases over time, the fund could grow to significant size, which could open up a plausible new option for counter-cyclical fiscal policy, since it would make macroeconomic sense to vary accretions to retained earnings cyclically by declaring larger carbon dividends during recessions and smaller carbon dividends during booms.

However, whatever the technical economic advantages of a partial dividend, the political question is the important one. Does a straightforward 100% carbon dividend rule have a transparency that makes carbon pricing more likely to be adopted and to increase over time? Would blurring the connection between the carbon price and the carbon dividend undermine the political constituency for carbon pricing? There is no point at all to a plan for carbon pricing that never happens, and there is little point to a small carbon price that always stays small—so the political implications of a partial dividend approach are crucial.

CONCLUSION

Carbon pricing would be good policy, but how can it become both good policy and good politics in Canada? This essay has argued that politics depends on perceptions, and that opponents of carbon pricing have been successful in focusing the debate about cap-and-trade or carbon taxes on the potential costs of such policies.

When framed as a "job-killing tax" that will decrease the income and increase the cost of living of middle-class Canadian families, carbon pricing is clearly "bad politics." Since the advocates of carbon pricing cannot agree on what to do with the revenue, but their current proposals (cuts to corporate and personal income-tax rates, increased spending on environmental protection, and GHG emissions reduction) share the characteristic that immediate benefits to the middle class will be invisible, carbon pricing is now a proposal with little "good news" to offer.

This essay has argued that the debate on carbon pricing could be reframed as being about deserved compensation and the rights of all citizens. If we all own the air, charging a fee for GHG emissions is compensation for environmental damage done. When all revenue raised is paid out as an equal dividend to all citizens, the revenue from carbon pricing then becomes an immediate, visible, and deserved benefit of carbon pricing, which creates the broad constituency of support necessary to maintain and enhance that policy. The long-run benefit of putting a price on carbon is to speed the transition to a low-carbon society, reduce GHG emissions, and slow global warming—but none of that will happen unless carbon pricing is actually implemented and the carbon price increases over time. The Carbon Fee and Dividend proposal thus offers a way to reframe the debate on carbon pricing and a good-news agenda that may enable carbon pricing to become both good policy and good politics.

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2. Environmental Tax Shift: Arguments for Using Revenue From a Carbon Tax to Reduce Existing Taxes

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ABSTRACT

This paper summarizes the arguments in favour of an environmental tax shift in Canada: using the revenue from the imposition of a carbon tax to reduce existing taxes in a revenue-neutral fashion. The arguments are twofold. First, existing taxes impose efficiency costs on the economy by reducing the gains from trade and distorting economic behaviour. The introduction of a carbon tax exacerbates these distortions, and the best way to mitigate the resulting increase in efficiency costs is to lower existing tax rates. Second, there is no economic rationale for expanding the size of government in conjunction with the introduction of a carbon tax. Increases in spending, environmentally related or not, need to be justified on the merits, independently of the imposition of a carbon tax. Moreover, a "political coalition" between those in favour of either big or small government who are concerned about the environment is more likely if the two issues are delinked. Efficiency considerations suggest that tax reductions should focus on the corporate tax, as it is the tax associated with the highest efficiency costs. Reductions in personal income taxes are also recommended, for efficiency, distributional, and political reasons. There is no compelling argument in favour of using the revenue to reduce general sales taxes. Finally, it is argued that those who argue for alternative uses of the revenue, such as "needed" public investments, must demonstrate that the social returns are greater than those associated with reducing highly distortionary taxes, which are substantial.

INTRODUCTION

The purpose of this paper is to consider options for the use of revenue raised from imposing a carbon tax in a Canadian context. The focus will be on a so-called environmental tax shift, which involves returning, or recycling, the revenue back to taxpayers by way of reductions in existing taxes, so as to make the imposition of the carbon tax revenue neutral.

The case for recycling all, or substantially all, of the revenue raised from a carbon tax is based on two broad arguments. First, there is no compelling reason why the size of the government sector should expand in conjunction with the introduction of a carbon tax. Not only is there no economic reason why the size of government should be directly related to the use of a carbon tax, but the political conditions required to establish a coalition of interests in support of introducing a carbon tax would appear to be more easily met if the two issues are delinked—those concerned about the environment can support a revenue-neutral carbon tax regardless of their stance on big versus small government. A discussion of how big the government sector can, and in my view should, take place independently of the merits of a carbon tax.

The second reason for recycling the revenue back to consumers/taxpayers, and the emphasis of most of this paper, concerns the economic costs of a carbon tax. Though there is some disagreement about the magnitude, most research indicates that the introduction of a carbon tax will impose costs on the economy. One way to alleviate these costs is to recycle the revenue in a revenue-neutral manner. A simple option in this regard would involve recycling the revenue to taxpayers by way of lump-sum (non-distortionary) distributions or transfers.[1] However, most economists argue that a better approach would be to use the revenue from a carbon tax to reduce existing distortionary taxes, which impose efficiency costs on the economy.

Which taxes should be reduced? It is argued that a balanced approach is desirable, as dictated by efficiency, distributional, and political considerations. There should be an emphasis on reducing taxes that currently impose high efficiency costs on the economy. First in line in this regard is the corporate income tax, which is almost universally thought to be one of the most distortive and inefficient taxes in a government's tax arsenal. However, personal income taxes should also be reduced, to address both efficiency costs in labour markets and potential distributional considerations. Carbon tax revenue should not be used to lower general sales-tax rates.

Before presenting more detailed arguments in support of this position, it is important to emphasize what this paper will not do. First, no original modelling or quantitative analysis is undertaken. Rather, this is a "thought piece" that draws on existing work and insights from the environmental economics and public finance literature to form conclusions regarding what I think the best approach to revenue recycling is. Second, although the discussion is framed in terms of revenue raised from a carbon tax, alternative approaches to carbon pricing, such as auctioning permits in a cap-and-trade system, can also generate government revenue. For the most part, the same considerations are relevant regardless of the precise form that carbon pricing takes, as long as it generates revenue for the government. Third, except where relevant to the recycling discussion, the specific design features of the carbon pricing scheme will not be discussed. In this regard, it is assumed that the underlying scheme is relatively broad based (pricing all, or most, emissions), without extensive or excessive exemptions or grandfathering (e.g., allocating free permits under cap-and-trade).

Finally, while I think that there are compelling arguments for using the revenue raised from a carbon tax to lower existing taxes, I cannot state unequivocally that this is the *very best* use of the revenue, or that all of the revenue should be used in this way. Other uses of the revenue might include investing in public infrastructure, increasing social transfers, health care and other program spending, subsidizing green technologies, financing research into green technology, and reducing the deficit. However, the "cost–benefit bar" suggested by the benefits of using the revenue to lower existing taxes is high, and it remains to be demonstrated that the social benefits of using the revenue in other ways exceed the substantial benefits associated with lowering existing taxes.

[1] The most straightforward lump-sum distribution would be an equal per capita transfer. More generally, any distribution that could not be affected by behavioural choices on the part of consumers/taxpayers would be lump sum.

1. HOW MUCH REVENUE ARE WE TALKING ABOUT?

The amount of revenue generated by the imposition of a carbon tax obviously depends upon several factors, most particularly the precise design of the tax in terms of both its coverage and rate, the extent of exemptions (or grandfathering, in the case of permits), and the level of government imposing the tax (federal or provincial). With regard to the base, or coverage, of a carbon tax, most economists are of the view that a very broad tax with few, if any, exemptions would be the most desirable.

What about the carbon tax rate? This is more difficult. Here it is useful to begin by briefly stating the perhaps obvious case for imposing a carbon pricing scheme. Carbon emissions generate externalities, the most obvious being climate change, that are not appropriately reflected in the price of carbon-based fuels. By "not appropriately reflected" I mean that the market price of carbon-based energy does not reflect the *social costs* associated with the resulting externality. In the case of climate change, these costs include things such as decreasing agricultural output, harm to human health, lower productivity, and costs associated with increased storm activity. Market-determined carbon-based energy prices are therefore too low, and emissions are too high, because they do not reflect these social costs. Taxing carbon emissions to reflect the social costs is intended to curb the overuse of carbon-based energy and reduce emissions accordingly. In principle, the so-called *efficient carbon tax rate* should be set equal to the marginal social cost of the associated emissions (Bovenberg & Goulder, 1996; Bovenberg, 1999). This will, in theory, reduce emissions to the socially efficient level. A problem arises, however, in determining precisely what the social cost of carbon is, and therefore in determining the socially efficient carbon tax rate.

Estimates of the efficient carbon tax rate vary widely, and it is not my intention to undertake a comprehensive survey of the research here. To get an idea of the range, consider that the official estimate from the Office of Management and Budget Office in the U.S. for the social cost of CO_2 from climate change in 2015 is $37 per tonne (Shelanski, 2013), while a recent Stanford University study pegged the cost at more than six times higher, at $220 per tonne (Moore & Diaz, 2015).

Moreover, climate change is not the only externality associated with the use of fossil fuels. Other externalities include local smog and pollution associated with the use of coal, natural gas, and petroleum products. There are also other externalities associated with motor vehicle use that may not be fully internalized by existing systems: congestion, traffic accidents, and so on. The IMF, for example, estimates that the nationally efficient carbon price, *leaving aside the costs associated with climate change*, averages about US$57.50 per tonne of CO_2 internationally; for Canada, its estimate is just under $30 per tonne (Parry et al., 2014).[2]

There is clearly some controversy regarding the appropriate social cost of carbon upon which to base a carbon tax. There is no attempt to resolve that controversy here. Rather, to get a feel for the revenue potential of a carbon tax in Canada, I instead use the B.C. carbon tax as a model and consider the broader application of a similar tax in the rest of the country.

[2] These costs are net of any existing taxes/subsidies on energy. Prices are expressed in U.S. dollars.

The B.C. carbon tax is levied at a rate of $30 per tonne and has relatively broad coverage, imposed on approximately 70% to 75% of carbon emissions in B.C.[3] In 2013-14, the tax generated $1.212 billion in revenue. The B.C. carbon tax was designed to be revenue neutral, with all of the tax revenue recycled back to taxpayers by way of reductions in existing taxes. Of the $1.212 billion raised, $522 million was used to reduce personal income taxes, primarily through a reduction in tax rates in the first two income brackets and by way of the Low Income Climate Action Tax Credit, while $710 million was used to reduce corporate income taxes, primarily through a one percentage point reduction in the provincial corporate income-tax rate for both large and small businesses.[4]

Using emissions data for 2013/14 from Environment Canada, Table 1 presents rough estimates of the amount of revenues in each of the provinces, and Canada as a whole, that could be generated from a B.C.-type carbon tax of $30 per tonne of CO_2. It should be emphasized that the carbon tax estimates in Table 1 are based on a straightforward, and simplistic, extrapolation from the B.C. experience, based on emissions data. A more detailed calculation would no doubt generate different estimates. However, the figures in the table are of the correct order of magnitude, and are roughly consistent with previous estimates. Also presented is data on total tax revenue, along with revenue from the major tax categories of Personal Income Tax (PIT), the Corporate Income Tax (CIT), and Sales Taxes (retail sales taxes, HST, GST).

[3] The major exemptions are for fuel purchased for agricultural use, jet fuel for international air service, fuel for interjurisdictional rail service, and reserve fuel purchases by status Indians.
[4] The PIT and CIT reductions credited to the carbon tax revenue actually slightly exceeded the revenue from the carbon tax, by about $20 million.

Table 1: Estimated Carbon Tax Revenue

	2013 Greenhouse Gas Emissions (megatonnes of $C0_2e$)	Estimated 2013/14 Revenue From B.C.-style carbon tax of $30 per tonne ($millions)	2013/14 Total Revenue ($millions)	2013/14 PIT ($millions)	2013/14 CIT ($millions)	2013/14 Retail Sales Tax, HST, GST ($millions)
Newfoundland and Labrador	8.6	166	7,109	1,222	358	907
Prince Edward Island	1.8	35	1,541	318	47	244
Nova Scotia	18.3	353	9,143	2,193	426	1,660
New Brunswick	15.7	303	7,764	1,370	223	1,062
Quebec	82.6	1,594	69,771	19,639	9,793	15,148
Ontario	170.8	3,296	115,911	26,929	11,423	20,481
Manitoba	21.4	413	14,214	2,978	468	2,028
Saskatchewan	74.8	1,444	11,442	2,470	1,017	1,326
Alberta	267.2	5,157	45,293	10,537	5,488	0
British Columbia (Actuals)	62.8	1,212	34,631	6,862	2,427	5,298
Canada	724	13,973	271,677	130,811	36,587	30,998

Source: Author's calculations. Emissions data from Environment Canada (2016). Government revenue data from Kneebone and Wilkins (2016), and Department of Finance Canada (2014).

It is evident that a B.C.-style carbon tax has the potential to generate significant revenue for the other provinces or the federal government. A national carbon tax of $30 per tonne would generate almost $14 billion in revenue, which is 5.1% of total federal government revenue in 2013/14. If applied at the provincial level, the revenue generated would vary significantly across provinces. A $30 carbon tax would generate in excess of $5.1 billion in revenue in Alberta, which is about 11% of its 2013/14 revenues; about $3.3 billion in Ontario, 2.8% of its revenue; and about $1.4 billion in Saskatchewan, 12.6% of its 2013/14 total revenue. In relation to the major tax categories, a carbon tax would generate revenue between 8% and 12% of existing PIT revenue in most provinces, to as high as 48% and 58% in Saskatchewan and Alberta respectively. Thus, if Saskatchewan and Alberta introduced a $30 per tonne carbon tax along the lines of B.C., and used all of the revenue to reduce provincial personal income taxes, personal taxes could decline by about 50%. The revenue from a federal carbon tax along these lines could be used to lower federal personal income taxes by 10%. Potential carbon tax revenue as a percentage of existing CIT revenue ranges from 16% in Quebec to 142% in Saskatchewan. Saskatchewan and New Brunswick could eliminate provincial CIT altogether, and still have revenue left over; Alberta could virtually eliminate its provincial CIT. At the federal level, corporate income taxes could be reduced by almost 40% if all of the carbon tax revenues were recycled through a federal corporate tax reduction.

Note that I am not arguing that the revenue from a carbon tax should be used to reduce or eliminate one tax only; indeed, below I will argue to the contrary. The point is to convey an idea of the size of the potential revenue and some possible constraints on the extent to which certain taxes might be reduced.

A couple of other caveats are in order that suggest that the figures shown in Table 1 should be considered quite rough. The most important is that the figures presume no behavioural adjustments on the part of firms and consumers to the carbon tax. But the whole point of the tax is to affect behaviour, in particular, a reduction in the use of carbon-based fuels. These behavioural reactions will reduce emissions and therefore lower the amount of revenue collected by a carbon tax. A complete accounting of these behavioural reactions would require general equilibrium modelling, which is well beyond the scope of this paper. Some models suggest that a carbon tax in the range of $30 per tonne would reduce emissions by from 10% to 20%, with carbon tax revenues reduced accordingly (Clapp et al., 2009). Also, the calculations in Table 1 do not incorporate various interactions between a carbon tax and the rest of the fiscal system. For example, carbon taxes are deductible against corporate income taxes, so corporate income taxes would automatically be reduced. The same is true for provincial royalties and mining taxes. And this is not to mention the host of general equilibrium effects that would be set in motion in response to a carbon tax and the associated revenue recycling. Also, the introduction of a carbon tax may be expected to lead to an increase in consumer prices, particularly for carbon-intensive goods (more on this below). This will lead to an increase in the consumer price index. To the extent that the tax and expenditure system is indexed for inflation, and there is indeed limited indexing in both the tax and transfer system in Canada, this will increase government expenditures and lower taxes. Last, and probably not least, if levied at the provincial level, carbon taxes may interact with the equalization system. None of these effects have been accounted for in Table 1.

While accounting for these reactions and interactions will change the precise estimates of the revenues collected from a carbon tax, the figures in Table 1 are of the right order of magnitude, and the fact remains that the revenue, and the potential to reduce existing taxes through recycling, is significant.

Since the writing of the original draft of this paper, Alberta announced the introduction of its own carbon tax. It will be imposed at $20 per tonne beginning in 2017, increasing to $30 in 2018. The precise details of the tax are sketchy at this point, and indeed the underlying legislation has yet to be developed, but it is clear that, in contrast to British Columbia, it will not be revenue neutral. As indicated above, a B.C.-style carbon tax in Alberta would be expected to generate revenue in the neighbourhood of $5 billion. Details are sparse, but it would appear that a substantial amount of the proceeds from the tax will be returned to large emitters in trade-exposed sectors by way of a “product-based emission performance standard,” which is basically an output subsidy. Precise figures are not provided, but it would appear that the output subsidy will account for between $2.5 billion and $3 billion of the revenue from the carbon tax; plans for the remaining $2 billion to $2.5 billion are unclear.[1] In her speech announcing the carbon tax, Premier Notley indicated that the “revenue will be reinvested directly into measures to reduce pollution—including clean research and technology; green infrastructure like public transit—to help finance the transition to renewable energy; and efficiency programs to help people reduce their energy use.” Despite Premier Notley's claim that “the Alberta carbon price will therefore be revenue neutral, fully recycled back into the Alberta economy,” the Alberta approach is clearly not revenue neutral in the sense of being offset by reductions in other taxes, which is the precise, and standard, meaning of the phrase.

The calculations in Table 1 raise several other issues. One is, at what level of government should a carbon tax be imposed, and therefore revenue recycling take place? As indicated above, British Columbia and now Alberta have chosen to “go it alone” and impose their own carbon tax. A tax imposed at the federal level, with the revenue used to reduce federal taxes, would have very different efficiency and distributional effects than an equivalent tax levied at the provincial level, with each province recycling the tax revenue to reduce its own provincial taxes. For example, it is clear from Table 1 that by far the greatest carbon tax revenues would be generated from Alberta. Of course, this goes hand in hand with the fact that it is the highest-emitting province and would also be the most negatively affected by a carbon tax. Collecting carbon taxes largely from the high-emitting provinces and redistributing the revenue throughout the rest of the country by way of federal tax reductions would be challenging, to say the least. One approach might be to impose a tax at the national level, and then redistribute the proceeds back to the provinces by way of transfers, but on what basis? If the funds were transferred on the basis of provincial population, the implications would be very different from if they were transferred on the basis of emissions (Böhringer et al., 2015). Moreover, there would be no guarantee that the provinces would in turn reduce their provincial taxes accordingly.

This might suggest that provincial-level carbon taxes and revenue recycling may be more appropriate. But this creates other problems. For example, one issue that may make individual provinces hesitant to impose a carbon tax is concerns about competitiveness, both internationally and interprovincially. While various “border adjustment” schemes that involve removing carbon taxes from exports and imposing them on imports have been discussed, they are inevitably complex and may well be unworkable at an international, much less interprovincial, level. This suggests that individual provinces might be reluctant to impose carbon taxes on their own in the absence of a coordinated effort. However, it should be noted that if carbon taxes make a province less competitive on one dimension, reductions in other taxes can make it more competitive on other dimensions. And indeed, British Columbia’s tax involves no border adjustments, nor does the tax announced in Alberta, nor the cap-and-trade scheme in Quebec, soon to be adopted by Ontario. However, B.C., Ontario, and Quebec have a very different industrial makeup from Alberta and Saskatchewan, where concerns about the impact of a carbon tax on competitiveness would be much higher. And indeed, the use

[1] These figures are based on “back of the envelope” calculations by Trevor Tombe, as reported in Tombe (2015).

of some of the proceeds from the carbon tax in Alberta to provide an offsetting output subsidy to large emitters is specifically motivated by these concerns.

Another potential problem is the creation of other fiscal imbalances in the federation. For example, as discussed above, Saskatchewan and Alberta could completely eliminate their corporate income taxes with carbon tax revenue, which has obvious implications for other provinces. While these issues are by no means trivial, and indeed have the potential to forestall progress altogether, a detailed discussion of them is beyond the scope of this paper (Böhringer et al., 2015). However, it will be argued below that there may be other reasons to prefer the imposition of carbon taxes at the provincial level, ideally with some coordination across provinces.

2. WHICH TAXES SHOULD BE REDUCED?

As indicated in the Introduction, there are two broad arguments in support of recycling the revenue generated by a carbon tax by way of a reduction in existing taxes. The first has to do with the mitigation of the efficiency costs associated with the introduction of the tax, and the second with the merits (or lack thereof) of linking the introduction of a carbon tax to the overall size of the government. This section focuses primarily on the first argument, though it will conclude with some thoughts on the second.

To begin, it is important to understand more precisely what is meant by the efficiency cost of a tax. The key point to understand is that a tax will typically impose a cost on the economy over and above the revenue it raises. These additional costs are referred to as the efficiency costs of the tax.[2] The reason for this is that taxes distort market prices, causing consumers and producers to alter their behaviour. In the case of an excise tax imposed on a good or service, for example, the imposition of a tax raises the price paid by buyers and lowers the price received by sellers, causing buyers and sellers to consume and produce less than they otherwise would. This reduction in the size of the market due to the tax reflects a reduction in the gains from trade.

Economists bandy about the term “efficiency costs” under the presumption that everyone understands the concept perfectly. However, it is evident in many public discussions that this is not the case. Given its importance to the discussion, it is important to have a good grasp of the concept. As such, it is useful to take a brief detour into an introductory “textbook primer” in public finance to make sure that the concept of efficiency costs is well understood.[3]

Consider the following simple vignette. Joe cleans Jane’s house each week for $100. Joe could earn $80 elsewhere by not cleaning Jane’s house, so the opportunity cost of Joe’s time to clean Jane’s house is $80; this is the amount of income he could earn elsewhere if he did not clean Jane’s house, and is therefore the minimum amount he would accept to clean the house. The value that Jane places on a clean house, which is the maximum amount she would be willing to pay to have the house cleaned, is $120. It is clear that both Jane and Joe are better off by engaging in a transaction whereby Joe cleans Jane’s house for $100—there

[2] Efficiency costs are also referred to as the “deadweight loss” or “excess burden” of the tax.
[3] This following is adapted in part from Mankiw, Kneebone and McKenzie (2013).

are gains from trade. The net benefit to Joe of cleaning Jane's house is $20 (the $100 he earns less his opportunity cost of $80). The net benefit to Jane is also $20 (the $120 value of a clean house to her less the $100 she has to pay Joe). Thus the aggregate gains from trade for Joe and Jane to engage in this transaction is $40.

Next, say the government decides to impose a tax of $50 on cleaning services. There is now no price that Jane can pay Joe that will leave them both better off after paying the tax. The most Jane would be willing to pay is $120, but then Joe would be left with only $70 after paying the tax, which is less than his $80 opportunity cost. Conversely, for Joe to receive his opportunity cost of $80, Jane would need to pay $130, which is above the $120 value she places on a clean house. As a result, Jane and Joe cancel their arrangement. Joe goes without the income, Jane lives in a dirtier house, and the government collects no tax revenue.

The tax made Joe and Jane worse off by a total of $40; these are the forgone gains from trade owing to the imposition of a tax. Moreover, the government collected no revenue from Joe and Jane because they decided to cancel their arrangement altogether. This $40—the forgone benefits to Jane and Joe in excess of the tax revenue raised (which is zero in this case)—is the efficiency cost of the tax: *it is the loss to buyers and sellers in a market that is not offset by an increase in government revenue*.

This example is obviously extremely simple and contrived, yet it contains a profound insight: taxes result in costs *over and above* the tax revenue raised because they distort economic behaviour and prevent buyers and sellers from realizing some of the gains from trade. These additional costs are the efficiency costs of taxes.

In the example, the tax caused Joe and Jane to cancel their arrangement altogether, resulting in no tax revenue for the government. Most taxes don't eliminate trade in goods or services altogether, but rather cause buyers and sellers to reduce the amount of trade that they engage in. But the story remains the same: by providing a disincentive to engage in various activities, taxes result in forgone gains from trade over and above the tax revenue raised. Thus, for example, personal income taxes levied on labour income provide a disincentive to work—the buyers (employers) and sellers (employees) of labour buy and sell less of it. Similarly, corporate income taxes levied on the returns to investment provide a disincentive for businesses to invest, and sales and excise taxes impinge on the incentive on consumers to purchase goods and services. In each case, the taxes result in losses in the gains from trade in excess of the tax revenue raised.

Despite their efficiency costs, it is clear that we need taxes to generate the revenue that governments need to do the things they do. However, the presence of efficiency costs does suggest that *one of* the criteria for evaluating which taxes to use to raise the revenue required by the government is the efficiency costs associated with various taxes. One way to do this is to determine the *marginal cost of public funds* (MCF) associated with various taxes. The MCF of a tax measures the total cost to the economy of raising one more dollar in revenue from that tax. The MCF consists of the $1 in revenue raised plus the efficiency costs associated with raising that $1. The presence of efficiency costs, resulting from forgone gains from trade, means that the MCF of most taxes is greater than $1.

To understand the MCF, note that another way of thinking about the efficiency costs of taxes is that when a tax increases, it shrinks the size of the tax base that the tax is applied to because of the associated disincentives associated with the decrease in the gains from trade. In the extreme case of Joe and Jane, the tax base shrinks to zero, as they cease their activity altogether in response to the tax. More generally, the sensitivity of the tax base to changes in the tax rate will be less than this, but it will shrink nonetheless. Moreover, the sensitivity of the tax base to the tax rate will differ across different types of taxes. All else being equal, the more sensitive a tax base is to an increase in the tax rate—the more the tax base shrinks as the tax rate increases—the higher will be the efficiency cost of the tax and the higher the MCF.

Dahlby and Ferede have calculated the MCF associated with different types of taxes in Canada, and offer the following illustration of the idea (Dahlby & Ferede, 2011; Dahlby & Ferede, 2015). Say the government increases the size of a tax by 10% and the private sector responds by reducing the amount of the taxed activity by 2%; the tax base shrinks by 2%. In this case, government tax revenue will increase by 8% owing to the behavioural response of taxpayers, which is less than the 10% increase in the tax rate. Because the 10% increase in the tax results in only an 8% increase in tax revenue, the cost of raising the last, or marginal, dollar of tax revenue is approximately 10/8, or $1.25; the MCF in this case is 1.25 (Dahlby & Ferede, 2011).[4] The additional 25 cents, over and above the $1 in incremental tax revenue raised, is the efficiency costs associated with raising that additional dollar of tax revenue.

A key consideration in assessing the efficiency costs associated with a particular tax is therefore the sensitivity of the tax base—the amount the base shrinks—to changes in the tax rate. Dahlby and Ferede have estimated the sensitivity of the three major tax categories in Canada—the corporate income tax (CIT), the personal income tax (PIT), and general sales taxes (GST), the last consisting of provincial sales taxes, the federal Goods and Services Tax, and provincial Harmonized Sales Taxes—to changes in the tax rates at both the federal and provincial level. Consistent with other studies, they find that the CIT tax base is very sensitive to changes in the corporate tax rate, followed by the PIT and then GST. They also find that all of these tax bases are more sensitive to a change in provincial tax rates than federal tax rates. This is due to the mobility of tax bases across provinces.

Dahlby and Ferede use their estimates of tax-base sensitivity to calculate the MCF associated with each type of tax, again at the federal and provincial levels. Their most recent calculations are reproduced in Table 2.[5] As one would expect, given their estimates of tax-base sensitivity, the MCF associated with the CIT tends to be higher than the PIT and GST. Indeed, for five of the provinces, a *decrease* in the provincial CIT rate actually leads to an *increase* in revenue, which renders the MCF undefined.[6] This was the case in our simple house-cleaning vignette: a $50 tax generates no tax revenue, while a reduction in the tax to, say, $20 would be low enough for Joe and Jane to reestablish their arrangement, allowing them to enjoy some (albeit reduced) gains from trade while the government collects some revenue.

[4] As pointed out by Dahlby and Ferede (2011), this is an approximation, because the 10% increase in the tax is not literally a marginal increase, as it will generate more than $1. Technically, an infinitesimal increase in the tax is required. See Dahlby (2008) for a more rigorous treatment.
[5] The MCF for each province is from Dahlby and Ferede (2015), while the MCF for the federal government is from Dahlby and Ferede (2011).
[6] This means that the CIT rate for these provinces is on the "wrong side" of the Laffer curve.

Table 2: The Marginal Cost of Public Funds for the Provincial and Federal Governments, 2013

	Marginal Cost of Public Funds		
	(1)	(2)	(3)
	Corporate Income Tax	Personal Income Tax	General Sales Tax
British Columbia	3.19	2.86	---
Alberta	2.91	1.41	1.00
Saskatchewan	***	2.38	1.31
Manitoba	3.07	2.42	1.36
Ontario	5.21	6.76	---
Quebec	3.62	3.05	1.69
New Brunswick	***	1.91	1.42
Nova Scotia	***	---	1.90
Prince Edward Island	***	2.80	2.21
Newfoundland & Labrador	***	2.16	1.50
Federal (2006)	**1.71**	**1.17**	**1.11**

Note:
*** indicates that a tax rate increase would reduce the long-run total tax revenues.
--- indicates that the MCF could not be computed because the own semi-elasticity could not be estimated.

Sources: Provincial MCF: Dahlby & Ferede (2015). Federal MCF: Dahlby & Ferede (2011).

For the provinces for which the MCF for the CIT is defined, it ranges from a low of 2.91 in Alberta to a high of 5.21 in Ontario. For the federal government, the MCF for the CIT is 1.71. This means that if Ontario, for example, increased its statutory CIT rate to raise an incremental dollar in revenue, and the tax rates in the other provinces remained the same, this would impose an additional, and somewhat astonishing, $4.21 in costs on the economy over and above the incremental $1 raised owing to the efficiency costs arising from the shrinkage in the corporate tax base.[1] At the federal level, a marginal increase in the CIT rate imposes incremental efficiency costs of $0.71. These very high MCF calculations for the CIT are consistent with other studies (Baylor & Beauséjour, 2004).

The MCF calculations for the PIT are typically smaller, but still significant, ranging from 1.41 in Alberta to 6.76 in Ontario. Notably, the MCF for the PIT in Ontario is higher than for the CIT. The MCF for general sales taxes is the lowest, indicating that it is the least inefficient of the three tax categories.

[1] It is important to note that the calculations assume no changes in tax rates in other provinces or at the federal level. If all the provinces raised the CIT in a coordinated manner, the MCF at the provincial level would be similar to the federal MCF.

An important point to note about the MCF is that it is symmetric to tax increases and decreases: while an incremental increase in a tax imposes additional efficiency costs on the economy, costing the economy more than the incremental dollar in tax revenue raised, a decrease in a tax benefits the economy by more than the one dollar in tax revenue forgone. Moreover, and importantly, differences in the MCF associated with different taxes gives rise to the possibility of efficiency-enhancing revenue-neutral tax swaps, reducing taxes with a high MCF and replacing the revenue by increasing taxes with a low MCF.

While most taxes give rise to efficiency costs for the reasons discussed above, as discussed above, taxes imposed on externalities, such as carbon taxes, are typically viewed as enhancing efficiency by aligning the private costs faced by individuals and firms using fossil fuels with the social costs, so that the gains from trade properly reflect both the private and social costs. That is, carbon taxes generate efficiency benefits rather than efficiency costs.

Herein lies the argument for using the proceeds from a carbon tax to lower existing taxes. In its strongest form, the argument is often framed in terms of the "double dividend" hypothesis. The double dividend hypothesis postulates that imposing a carbon tax and recycling the revenue in a revenue-neutral manner by lowering existing distortionary taxes generates two benefits, or "dividends": the first dividend is the benefit associated with the reduction in the costs imposed on society from the overuse of carbon-based fuels; the second dividend is the decline in the efficiency costs associated with a reduction in the use of existing distortionary taxes. Thus, it would appear, imposing a carbon tax and recycling the revenue by lowering existing taxes results in a win-win scenario—we improve both the environment and the efficiency of the tax system.

To make the idea more concrete, consider, for example, the introduction of a very small carbon tax that generates an incremental $1 in revenue for the government. As indicated above, the tax will lead to (in this case, very small) behavioural changes on the part of consumers and producers as they use less fossil fuel, and society will benefit from a reduction in the associated externalities. This is the first dividend. If the $1 in tax revenue is then simply returned to consumers/taxpayers in a lump-sum manner, that would be the end of it. While society benefits from the reduction in the externalities caused by carbon usage—generating the first dividend—because the government takes $1 away with one hand and gives it back with the other by way of a non-distortionary lump-sum transfer, there is no second dividend.

However, because most taxes give rise to costs over and above the tax revenue raised, an alternative approach would be to return the incremental $1 in revenue from the carbon tax to taxpayers by way of a reduction in an existing distortionary tax—for example, the federal CIT. In other words, undertake a revenue-neutral tax swap, replacing $1 in tax revenue from the CIT with $1 in tax revenue from the carbon tax. Using Dahlby and Ferede's MCF calculations, reducing federal CIT revenues by $1 will generate an additional benefit of $0.71 in reduced efficiency costs over and above the $1 in tax revenue given up; this $0.71 is the second dividend. This reasoning would seem to suggest that carbon taxes give rise to the fabled "free lunch"—we can have our cake (a better environment) and eat it too (a less distortionary, more efficient tax system).

This view, however, is somewhat oversimplified, and most analytical and numerical studies of the issue conclude that a double dividend is unlikely to be realized in practice.[2] While the first dividend—benefits of mitigating climate change—is not in dispute, the second dividend—an improvement in the overall efficiency of the tax system—is questionable. In the above example, it was assumed that the MCF associated with raising $1 with a carbon tax was simply $1; in other words, there was no incremental efficiency cost associated with the carbon tax. It turns out that this is not the case. The reason for this is that carbon taxes can exacerbate the efficiency costs associated with existing distortionary taxes, potentially (and indeed likely) rendering the second dividend negative, and increasing the efficiency costs of the tax system, even if the revenue is fully recycled in a revenue-neutral manner. This is often referred to as the *tax interaction effect*.

The intuition behind the tax interaction effect is as follows. Carbon taxes cause the costs and prices of products that use energy to rise. This results in effects that are similar to an increase in existing taxes on labour and capital that discourages labour supply and investment, thereby exacerbating the efficiency costs associated with the existing tax distortions in labour and capital markets. For example, consider the labour market. The rise in the prices of goods and services due to the carbon tax results in a reduction of *real wages*, as the amount of goods and services that a consumer can purchase declines as a result of higher prices. This reduction in the real wages has a similar impact as an increase in the tax on labour income, which lowers after-tax wages directly, and therefore increases the efficiency costs associated with existing taxes on labour income. Thus, the carbon tax acts, in effect, like an increase in the tax rate on labour income with the associated rise in efficiency costs.

Aside from certain special cases, which are unlikely to occur in practice, most studies find that the efficiency costs associated with the tax interaction effect dominate the efficiency benefits from reducing existing taxes by recycling the environmental tax revenues in a revenue-neutral manner.[3] Thus, an environmental tax swap typically increases rather than decreases the efficiency costs of pre-existing tax distortions, and the second dividend in the double dividend hypothesis is in fact negative (Bovenberg & Goulder, 1998).[4] Alas, it seems that there is no such thing as a free lunch after all.

However, while a double dividend may be unlikely to exist in practice, this does not mean that revenue recycling by way of reducing existing tax rates should not be pursued. Indeed, and importantly, it strengthens the argument in favour of this approach. Given that a carbon tax will exacerbate the efficiency costs associated with existing distortionary taxes, the best way to mitigate these costs is to lower existing tax rates. Indeed, study after study shows that recycling the revenue in this manner dominates returning the revenue in virtually any other manner, and most certainly by way of lump-sum distributions or transfers.

[2] I do not go into the details of individual studies here, as they have been discussed at length in other places. For surveys of the literature and more in-depth analysis, see Goulder (1995), Parry (1995), Bovenberg and Goulder (1998), Bovenberg (1999).
[3] In principle, if the existing tax system is not optimized in the sense of equating the MCF associated with all revenue sources, a positive second dividend might be realized. However, most simulation studies suggest that this is not likely in practice, even if the existing tax system is quite inefficient. See, for example, Bovenberg and Goulder (1998). However, some studies do find a positive second dividend in the presence of highly distortive taxes. For example, Carbone et al. (2013) find a double dividend in the U.S. may arise in the case of a tax swap with taxes on capital.
[4] This same reasoning—that the introduction of environmental taxes can increase rather than decrease the inefficiency of the tax system—means that the efficient carbon tax rate is somewhat lower than the standard Pigouvian tax.

The MCF calculations by Dahlby and Ferede presented above suggest that the greatest efficiency gains in the tax system would be realized by first allocating revenue from the carbon tax to the highly distortive CIT. It should be stressed, however, that the fact that the MCF associated with the CIT is higher than other taxes does not mean that all of the carbon tax revenue should be devoted to CIT reductions. The MCF calculations are made at the margin: they are the total cost savings associated with lowering a tax by $1. Reducing corporate taxes by millions, and potentially billions, of dollars is not marginal. As the CIT rate declines, so too will the MCF associated with further reductions. And indeed, as the CIT declines, eventually the MCF associated with another incremental reduction in the CIT rate may fall below other taxes.

While it is well beyond the scope of this paper to attempt to ascertain any sort of "optimal" allocation of the revenue from a carbon tax, the MCF calculations suggest that devoting a significant proportion of the revenue to reductions in the CIT is reasonable from an efficiency perspective. And indeed, the B.C. government devotes over half (58% in 2013/14) the revenue from its carbon tax to CIT reductions. It is noteworthy, however, that the MCF associated with the PIT is also quite high, particularly in some provinces. This suggests the desirability of lowering personal taxes as well. It is clear from the MCF calculations that last in line for reductions should be sales taxes. Indeed, there appears to be little rationale on efficiency grounds for devoting any of the revenues from a carbon tax to a reduction in provincial or federal sales taxes, as they are the least distortive, and most efficient, of the major tax categories.

One issue that has not been discussed to this point concerns the distributional effects of carbon taxes. While efficiency costs are important, they are not the only criterion upon which to evaluate the social costs of taxes. The equity, or distributional, characteristics of different taxes are important as well. Several studies conclude that carbon taxes are regressive, suggesting that revenue recycling should be done in a progressive manner, with tax reductions targeted at lower income groups.

In a Canadian context, Lee and Sanger (2008) have studied the distributional effects of the B.C. carbon tax. They conclude that the B.C. carbon tax is regressive and that revenue recycling should be used to mediate this. In the case of B.C., the reduction in PIT was implemented by reducing the two lowest tax bracket rates, and by implementing the Low Income Climate Action Tax Credit. Lee and Sanger argue that this does not go far enough to address the negative distributional aspects of the carbon tax.

Others have questioned this result. For example, Beck et al. (2015) argue that the Lee and Sanger analysis is based on a static partial equilibrium model, and therefore misses important general equilibrium effects. They argue that when these effects are taken into account in a computable general equilibrium model, the B.C. carbon tax is in fact quite progressive, falling more heavily on higher-income households, even in the absence of revenue recycling.

Rivers (2012) has also considered the distributional implications of a B.C.-type carbon tax. He finds that while the tax appears to be somewhat regressive when households are sorted by annual income, it is progressive when households are sorted by annual expenditure. Many economists argue that the latter is more reflective on "lifetime income," which is a better way to assess the distributional implications of taxes. Rivers also shows that the increase in transfers to low-income households associated with the indexing of transfer payments to the consumer price index, which would be expected to rise in response to the price increases associated with a carbon tax, helps alleviate any concerns over the regressivity of the carbon tax. He argues that any remaining distributional concerns can be addressed by targeting some of the revenue from the carbon tax to lower-income households. Importantly, in this regard, he shows that the revenue from a carbon tax far exceeds the funds needed to address distributional concerns. This is consistent with research by the Brookings Institute in the U.S., which concludes that only about 11% of the revenue from a national carbon tax would need to be directed to lower-income households to render them no worse off under the carbon tax, which means that the bulk of the revenue may be used to lower existing distortionary taxes to address efficiency considerations (Mathur & Morris, 2012).

Further, it was argued above that efficiency considerations suggest an initial emphasis on reducing corporate income taxes. This too has distributional implications. Many argue that the CIT is a progressive tax, as it amounts to a tax on the return to capital that is borne for the most part by high-income earners. This suggests that reductions in the CIT would disproportionally benefit high-income earners, and a revenue-neutral tax swap between a carbon tax and the CIT would increase the regressivity of the tax system. While the issue of who bears the incidence of the CIT is controversial, there is substantial support for the position that the long-run burden of the CIT falls to a large extent on labour.[5] This means that the CIT may be less progressive than is popularly perceived, and that any reduction in the CIT may therefore be less regressive.

Despite some uncertainty regarding the distributional impact of a carbon tax, it seems that both efficiency and distributional considerations suggest the need for a balanced approach, with reductions in both corporate and personal income taxes. Moreover, only a small amount of the revenue generated by a carbon tax is needed to address distributional concerns; the bulk of the revenue can be used to reduce the increased efficiency costs associated with introducing the carbon tax in the presence of pre-existing tax distortions.

As discussed in the previous section on the revenue generated by a carbon tax, the question of which level of government should impose the tax, and therefore whether the resulting revenue is recycled at the provincial or federal level, raises some challenging issues. Significant differences in the amount of emissions and the nature of the economies across the provinces may suggest that provincial-level carbon taxes, and revenue recycling, is appropriate. Further, from Table 2 it is evident that the efficiency costs of different types of taxes vary substantially across the provinces. This suggests that the efficiency costs associated with a carbon tax may be best mitigated if the tax were imposed at the provincial level, with the associated revenue used to reduce provincial taxes guided by the MCF and the associated efficiency-equity trade-offs on a province-specific basis.

Aside from the efficiency arguments for recycling carbon tax revenue in a revenue-neutral manner, as indicated in the Introduction, a political argument can also be made for delinking the imposition of a carbon tax from the issue of the size of government. There is certainly no compelling economic argument for increasing the overall size of government in conjunction with the introduction of a carbon tax, as any economic connection between the two issues is of second-order importance at best. It also seems that a political coalition of the fiscal right and left in support of a carbon tax is more likely if the two issues are

[5] Auerbach (2007) provides a useful overview of the literature. For recent empirical studies on the incidence of the CIT, see Arulampalam et al. (2012), Felix (2007), Hassett and Mathur (2006), Desai et al. (2007). See Gravelle and Hungerford (2008) for a critique of these studies.

not connected. Not everyone shares this view. Lee (2012), for example, argues that "People will be more willing to pay the tax if it funds needed public investments." Perhaps, however, this begs the question of how agreement is reached regarding what public investments are "needed." It seems clear that if public investments are in fact needed, that is a discussion that should take place independently of the merits of a carbon tax.

In this connection, and finally, while the arguments in favour of a revenue-neutral environmental tax shift are compelling, there are of course other uses to which the funds could be devoted. And indeed, it is possible in principle that some public investments will generate higher returns to society than decreasing existing distortionary taxes. However, two points need to be emphasized in this regard. The first is that, as discussed above, it is important to keep in mind that a carbon tax will exacerbate existing tax distortions, effectively increasing the MCF associated with existing taxes even further. Devoting the revenue to a reduction in pre-existing distortionary taxes is required to mitigate (if not offset) this increase in the inefficiency of the tax system relative to the status quo.

The second point is that any public investment financed by the carbon tax revenue needs to pass the cost–benefit threshold suggested by the MCF calculations. For example, again using the MCF for the federal CIT, any public expenditure financed at the margin with an incremental $1 in carbon tax revenue needs to generate *at least* $1.71 in social benefits to render it a better use of the funds than the CIT reduction. Indeed, as discussed above, because the introduction of a carbon tax actually increases the efficiency costs of existing taxes, an incremental investment would need to generate a social return even greater than this. If this is not the case, from an efficiency perspective, the money would be better allocated to a reduction in the CIT rate. It is incumbent upon proponents of using carbon tax revenue for these purposes to provide a justification along these lines. In this vein, Carbone et al. (2013) use a dynamic general equilibrium model to analyze using the revenue from a carbon tax in the U.S. to address the federal deficit. They argue that the benefits in this regard may exceed those of a revenue-neutral tax swap. However, reducing the deficit may be thought of as reducing taxes in the future. And in the steady state when the deficit is eliminated, their analysis suggests that an environmental tax swap focusing on CIT reductions dominates. I am not aware of similar studies done in a Canadian context along these lines.

CONCLUSION

This paper summarizes the arguments in favour of a revenue-neutral environmental tax shift in Canada—using the revenue from the imposition of a carbon tax to reduce existing distortionary taxes in a revenue-neutral fashion.

The arguments are twofold. First, existing taxes impose efficiency costs on the economy by reducing the gains from trade and distorting economic behaviour. The introduction of a carbon tax exacerbates these distortions, and the best way to mitigate the resulting increase in efficiency costs is to lower existing tax rates. Second, there is no economic rationale for increasing the size of government in conjunction with the introduction of a carbon tax. An economic argument in favour of increasing the size of government should therefore be made independently of the introduction of a carbon tax. Moreover, it is argued that a "political coalition" between those in favour of either big or small government who are concerned about the environment is more likely if the two issues are delinked.

Calculations of the marginal cost of public funds (MCF) argue that tax reductions should focus on the corporate tax, as it is the tax associated with the highest efficiency costs. However, it is argued that efficiency, distributional, and political considerations suggest a balanced approach, with accompanying reductions in personal income taxes. There is no compelling argument in favour of using the revenue to reduce general sales taxes.

Differences in the MCF associated with various taxes across the provinces argue in favour of provincial carbon taxes, with revenue-neutral recycling taking place at the provincial level.

Finally, it is argued that alternative uses of the revenue, such as "needed" public investments, must generate social returns that are greater than those associated with reducing highly distortionary taxes, which are substantial. It is incumbent upon proponents of using carbon tax revenue for these purposes to provide a justification along these lines.

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3. Using Carbon Pricing Revenues to Accelerate the Transition to a Low-Carbon Economy

P.J. Partington and **Vicky Sharpe**

ABSTRACT

There is a compelling case to use a significant portion of carbon pricing revenues to support investments in low-carbon technologies and companies to accelerate innovation. The International Energy Agency warns that low-carbon investment is underfunded by a factor of three and must be addressed if we are to achieve climate change targets. Investment in this area will help diversify the economy and move Canada up the value chain, thereby reducing our dependency on volatile commodity markets and partially countering reduced investment returns and risks from stranded assets. Greater innovation would empower Canada to take a share in the global, multi-trillion dollar low-carbon technology and services market, boosting exports for a country whose GDP is export dependent.

A UNEP-commissioned analysis of 100-plus studies find that stimulus spending on clean energy creates an average of three to four times as many jobs per dollar as an equivalent amount of spending on tax cuts and significantly more than investments in general infrastructure. Evidence presented shows integrating the environment and the economy is both a prerequisite and achievable.

Combining supply-push policy and demand-pull carbon pricing, with support for the broader "innovation ecosystem" (research, development, demonstration, deployment), will deliver the greatest benefit at the least cost. Policies should include increasingly stringent regulation, and mechanisms to address market failures in investment and adoption while recognizing jurisdictional differences. Critical design elements include clear goal setting, accountability, governance, broad performance criteria, and flexibility to learn and change. Examples of viable systems are given.

Of all options for using carbon revenues, investing in low-carbon innovation offers the strongest link to the ultimate goal of a rapid transition to a low-carbon economy. The outcomes from such investments enable individuals and businesses to act, which in turn increases market and societal support for decarbonization.

INTRODUCTION

Carbon pricing is an important driver for innovation and emissions reduction, yet the price signal alone is unlikely to deliver the scale of transformation required to limit the risks of climate change.

If provinces move forward with more (or more aggressive) carbon pricing systems, they must face important decisions about the use of revenues. This paper will argue that there is a compelling case for using a significant portion of these revenues to support investments in low-carbon technologies to help deliver a greener, more competitive Canada.

After outlining the case for investment, we will explore how governments currently invest carbon revenues and the options for use of these revenues across the innovation system. In the final section, we consider how governments can approach these decisions to maximize returns from investments they have made on behalf of society.

1. THE CASE FOR PUBLIC INVESTMENT IN LOW-CARBON TECHNOLOGY

Meeting the challenge of climate change will require a fundamental transformation of our energy system, cutting across sectors and time frames (Intergovernmental Panel on Climate Change, 2014).

In Canada, this transformation will likely be driven by significant electrification, radical gains in energy and process efficiency, and widespread deployment of renewable energy and other low-carbon technologies—including some that are not yet fully commercialized, such as carbon capture and storage (CCS), advanced biofuels, and energy storage (Bataille et al., 2014). Specific pathways will vary by province owing to differing starting points, economies, energy endowments, and power systems. The common theme is that realizing decarbonization goals, especially at least cost, will require significant and sustained efforts at innovation and technology deployment.

While many important mature technologies are ready to be deployed on a wider scale now, continued innovation across all stages of technological development is essential to meeting these aggressive long-term goals (International Energy Agency [IEA], 2015a). The IEA warns that low-carbon technology is currently underfunded by a factor of at least three, and must be scaled up significantly and swiftly (IEA, 2015a). Filling this gap is an ideal use of carbon pricing revenues.

Government investments in low-carbon technology[1] can generate several categories of benefits. In this section, we will explore four of these, which each provide a rationale for supporting low-carbon technology: accelerating low-carbon innovation; delivering near- and long-term emissions reductions; economic benefits; and mitigating the impacts of rising or volatile energy costs. These categories overlap significantly in many instances, and smart policy management takes account of the potential co-benefits. As we explore in Section 3, different jurisdictions can and should weight these motivations differently when deciding how to craft an approach to low-carbon investment that best suits their needs.

The bottom line is that low-carbon investments deliver stronger results when combined with recycling of revenue from carbon pricing—and vice versa. Integrating supply-push technology policy and demand-pull carbon pricing—along with support for the broader innovation ecosystem—will deliver the greatest benefits at the least cost.

[1] We define this support broadly, to include research, development, and demonstration, as well as deployment (RDD&D).

Accelerating low-carbon innovation

Low-carbon innovation in energy systems, industrial processes, and other technologies is an essential element of decarbonization. Innovation can expand the scope of solutions available and increase their affordability and efficiency, reducing the costs of tackling climate change. This is especially critical in the longer term, when delivering deep reductions at a reasonable cost will rely significantly on technologies that are not yet commercialized. The IEA, for example, estimates that 40% of the cumulative reductions required beyond its "bridge scenario" of medium-term actions will come from the deployment of these emerging technologies—namely CCS, alternative-fuel vehicles, and technologies enabling the integration of high levels of variable renewables (IEA, 2015b).[2] The Organisation for Economic Co-operation and Development (OECD) includes investment in low-carbon innovation as one of three "core" climate policies, along with carbon pricing and complementary regulation (OECD, 2015).

A major barrier to low-carbon innovation is the fact pollution externalities are not priced, sending the wrong message to the marketplace. If these costs that carbon pollution imposes on society are unpriced (or underpriced), then a core benefit of low-carbon innovation—reducing these pollution costs—will be undervalued and the innovation will be underprovided.

Correcting this market failure is the central rationale of carbon pricing. Introducing a credible carbon price should induce firms to invest more in low-carbon innovation and emissions reductions (Canada's Ecofiscal Commission, 2015). However, there are several reasons why innovation will *still be underprovided by the market* even with a carbon pricing system in place (Fischer & Newell, 2008), justifying the targeted investment of carbon pricing revenues to support low-carbon innovation. This is because political constraints are likely to place the initial carbon price far below the level of the climate change externality (and these tentative first steps are likely to be accompanied by considerable policy uncertainty in the near term) (Jenkins, 2014; Fischer, 2008), and because of additional market failures common to all types of innovation that leave it persistently undersupplied.

Carbon pricing is typically introduced at low rates that do not fully reflect the societal damages associated with climate change. And even at these low levels, these policies can be subject to significant political uncertainty. Under these conditions, firms are unlikely to invest adequately in low-carbon innovation, especially with a longer-term payoff, since the future value of these innovations is uncertain. Investing carbon pricing revenues in support of low-carbon technology can help bridge this gap and ensure an adequate incentive exists today to reward low-carbon innovation that will be essential for sustained and affordable action on climate change in the future.

The first of the broader market failures limiting innovation is what is often referred to as the "knowledge externality." The public-good nature of new knowledge means firms cannot prevent others from benefiting from their investments in research and development (R&D). Owing to these positive spillovers, where other firms and consumers benefit, the innovator takes only a portion of the total value of their investments in knowledge creation and, as a consequence, tends to invest less in R&D than would be ideal from a societal perspective (Jaffe, et al., 2005).

The second set of broader market failures that lead to general underinvestment in innovation are what can be called "adoption externalities." The benefits of an innovation grow as adoption increases

[2] Note: Additional reductions refer to the gap between the World Energy Outlook's 450 and Bridge scenarios.

(Jaffe et al., 2005). This comes from learning-by-doing on the part of producers (improving quality and reducing costs with experience) and learning-by-using on the part of consumers, who devise new and unforeseen applications for the innovation. Adding to this are the reduced incompatibility issues that generally result from increases in scale (often referred to as "network externalities"). Each of these effects amplifies the benefits of the innovation, but many of these additional benefits are spillovers from the innovator's perspective. The firms investing in the original knowledge creation and those adopting the innovation can capture only a portion of the total value, and thus (under)invest accordingly.

These barriers are amplified by impacts of the 2008 economic crisis that has seen financial institutions shed their riskier technology asset classes and many venture capital firms either move out of clean-energy technologies entirely or shift their investments downstream to later-stage opportunities (Woynillowicz et al., 2013). This leaves the Canadian capital markets focused on technology, and particularly those focused on clean-energy technology, poorly positioned to build early-stage companies or to propel expansion of later-stage companies.

Thus, even with a carbon pricing system in place, there still will be gaps between the level of innovation the market provides and the level that would most benefit society when accounting for the costs of climate change, as well as knowledge and adoption spillovers. Separate policy tools are needed to address the climate and innovation externalities. Modelling suggests that these tools work best together; combining a carbon price with targeted support for RDD&D is expected to reduce emissions at a much lower cost than through a price alone (Fischer, 2008; Fischer & Newell, 2008; Acemoglu, et al., 2012), and the pricing system can be an important source of revenue for these investments (Martin & Kemper, 2012). Directing a portion of carbon revenues toward closing the low-carbon innovation gap can increase the economic efficiency of a jurisdiction's broader climate and technology policy by correcting these market failures (Beck & Wigle, 2014).

Investing carbon pricing revenues in targeted support for RDD&D can also help address Canada's "productivity gap." The Canadian economy's well-documented challenges with slow productivity growth have been attributed to poor performance on innovation, and especially on business *demand* for innovation (Council of Canadian Academies, 2013). A carbon price signal helps grow this demand, but targeted investments in demonstration and deployment can amplify the signal further by facilitating early adoption of innovative technologies and processes.

Efforts on the supply side of innovation are important as well. The landmark Jenkins panel recommends rebalancing Canada's R&D support toward more direct programs to support R&D (Independent Panel on Federal Support to Research and Development, 2011). This is a natural fit for a portion of carbon pricing revenues, which could be used for well-designed direct-support programs centred around key low-carbon R&D needs identified by a jurisdiction, as well as other support throughout the innovation ecosystem.

Carbon pricing paired with public investment in low-carbon innovation offers a compelling opportunity to correct market failures and ensure Canada is well equipped to prosper in the low-carbon transition.

Reducing greenhouse gas (GHG) emissions

Carbon pricing establishes a strong incentive for emissions reductions across the economy. Yet, even with a carbon price in place, there remain large opportunities to generate additional emissions reductions in the near term through deployment of mature technologies, particularly energy efficiency and renewables. Governments can capture these reductions by targeting barriers to deployment that are not fully removed by the carbon price signal. These include the availability and cost of capital, lack of information, and lack of supporting infrastructure (Sagar & van der Zwaan, 2006). Some barriers can be addressed through complementary regulations and standards, such as vehicle efficiency regulations and building codes. Well-designed informational and incentive programs like rebates, behavioural approaches, and retrofit programs can be effective supports as well. Again, taking a complementary approach to carbon pricing allows the broadest set of opportunities to be captured at a lower cost. Deployment programs such as these—particularly those tied to energy efficiency—have often suffered from a lack of dedicated funding, leading to an unpredictable availability. This "stop-start" nature, where programs abruptly cease only to be reinstated later, can significantly reduce their economic efficiency and limit uptake (UNEP SEF Alliance, 2009). Reinvestment of carbon revenues can offer such programs the support and stability they have often lacked.

Not all of these reductions will be cost-effective relative to the current carbon price, but the spending may still be justified by the programs' effectiveness in reducing emissions, preventing lock-in, managing costs, and broadening public capacity and support for decarbonization. Addressing challenges like free-ridership are an important element of program design.

There is also a strong case for strategic public investment in infrastructure that supports decarbonization, such as transmission upgrades, public transit, high-speed rail, smart grids, district energy systems, electric vehicle charging networks (or other low-carbon fuel supply investments), and CO_2 pipelines. These types of infrastructure can enable significant short- and long-term emissions reductions but, similar to low-carbon innovation, are underprovided because of network externalities.

Investments across the innovation chain, from R&D right through to the later stages of demonstration and deployment, are also critical to expand the solution set available in the longer term and to reduce future mitigation costs (IEA, 2015a). As noted above, private actors are likely to underinvest in the development of emerging technologies—particularly when carbon prices are initially low and there remains significant political uncertainty about future carbon pricing policy. Well-targeted public investments can support and enable greater private investment by increasing R&D and innovation ecosystem linkages, addressing perceived technological risks (through demonstration and early deployment programs) and market risks (by co-investing and supporting access to low-cost capital for deployment). A public role is justified by the broad societal benefits of innovation and decarbonization, as well as government's position as a risk-neutral investor, often with lower discount rates than private actors (Torvanger & Meadowcroft, 2011). Greater investment in the development and demonstration of emerging technologies today will make future mitigation much more affordable (IEA, 2015b).

Jobs and economic development

Revenues from carbon pricing can be put to many productive uses. It is important to consider the opportunity cost of dedicating a significant share to technological investment. Studies have found that spending on green programs generally performs as well or better in employment and economic growth terms than alternative uses. A UNEP-commissioned meta-analysis of more than 100 studies finds that stimulus spending on clean energy creates an average of three to four times as many jobs per dollar as an equivalent amount of expenditure in tax cuts, and significantly more than investments in general infrastructure (UNEP SEF Alliance, 2009). These results are consistent with the Canadian studies assessed, which find that spending on efficiency and mass transit programs create averages of 19,000 and 21,000 jobs per billion dollars (2008 USD), respectively, as compared with 10,000 to 12,000 jobs created per billion dollars spent on general infrastructure and 6,700 jobs created per billion dollars spent on tax cuts (UNEP SEF Alliance, 2009).

Detailed ex-post analysis of the macroeconomic impacts of the nine-state Regional Greenhouse Gas Initiative (RGGI) points to the economic benefits investments in efficiency, renewables, and other low-carbon technology can bring. A recent assessment found RGGI added a net US$1.3 billion in economic value to the region during its second compliance period (2012-2014)[3]—equating to a net gain of $31 per resident over the period—while adding a net 14,200 job-years (Hibbard et al., 2015). This is largely a result of states opting to auction nearly all allowances and invest a majority of the nearly US$1 billion in proceeds into energy efficiency programs (see Section 2, below). Economic benefits flowed from program spending itself (e.g., increased economic activity from home weatherization, energy management, renewable power development) as well as reinvestment of the substantial energy savings from RGGI into the local economy. RGGI created a net US$460 million in bill reductions for energy consumers in the region during the three-year period. Not surprisingly, this analysis concludes that energy efficiency "stands out as the most economically-beneficial use of emission allowance revenues," (Hibbard et al., 2015).

A study of the macroeconomic impacts of energy efficiency investment in Canada, commissioned by the federal government, points to similar potential on this side of the border. The efficiency scenarios modelled were projected to increase Canada's net GDP by $5 to $8 for every dollar of program spending on efficiency and add 30 to 52 job-years per million dollars invested (Malone et al., 2014). As found in studies of RGGI, the growth in energy services (and related sectors) from direct program spending drives only part of the economic benefit. In this case, the large majority of macroeconomic impacts (86% of GDP and 74% of employment effects) are expected to result from the persistent stimulus effect of consumer and industry energy savings, which increase investment in the local economy and boost competitiveness by lowering the cost of business (Malone et al., 2014). If all provinces pursued energy savings targets similar to those of current North American leaders, the study projects they would share $144 billion in net savings over the life of the program, with annual GHG reductions reaching up to 69 Mt CO_2e (Malone et al., 2014).

Improved efficiency and accelerated low-carbon innovation across the economy—stimulated by both the carbon price *and* the targeted use of revenues—can also lead to productivity gains and increased export competitiveness (Martin & Kemper, 2012), particularly for high technology or green products. This is in line with the theoretical expectations of the Porter hypothesis and is observed empirically in some recent studies. One study of the European Union, for example, finds that more-stringent environmental policy improved the competitiveness of the manufacturing sector, particularly for green products (Constantini & Mazzanti, 2012). Another study across OECD countries finds similar results: that there is a clear link between the stringency of a country's environmental policy and its share of the global market for environmental goods (Sauvage, 2014).

[3] This does not include the environmental and health benefits of reduced pollution.

Assessments of the relationship between environmental policy, productivity, and competitiveness in the broader economy have been less conclusive, but generally find no significant competitiveness impacts (positive or negative) from carbon pricing.[4] A recent OECD review of *ex post* empirical evaluations found that carbon prices cause emissions reductions, but could not detect any meaningful impact on competitiveness indicators (Arlinghaus, 2015). Another assessment found tightening environmental policy stringency typically led to a temporary increase in productivity growth. Although these effects were not permanent—with productivity growth returning to its earlier rate after about five years—the positive impacts on productivity growth were found to be more robust with market-based environmental policies, such as carbon pricing (Albrizio et al., 2014). Reinvesting revenues in programs to drive efficiency and low-carbon innovation can be expected to further support this productivity growth.

Recycling carbon pricing revenues to targeted technological support can help grow a robust domestic clean-technology sector to serve increased local demand and rapidly expanding global markets. Clean technology was a nearly $1-trillion global market in 2014 and is projected to double in size by 2022. In 2014, Canadian clean-tech companies held a 1.3% share of this market, generating $12 billion in revenues and directly employing nearly 50,000 workers—more than traditional heavyweights forestry and logging, pharmaceuticals, or aerospace manufacturing (Analytica Advisors, 2015). Should our share of the global market grow to 2.5%, by 2022, Canada's clean-tech sector could generate annual revenues of $50 billion and directly employ 100,000 people (Analytica Advisors, 2015).

A portion of revenues can be targeted to related economic development priorities, including innovation infrastructure like laboratories, test centres, and incubators that attract financing and support market development and access.

Mitigate impacts of carbon pricing and rising energy costs

Carbon pricing can lead to increased energy costs of varying magnitudes for consumers and business. This can have a disproportionate impact on low-income households, which spend a greater share of their income on energy. It can also lead to competitiveness concerns from energy-intensive industries.

Mitigation strategies include the use of carbon revenues to directly offset some or all of these impacts through refundable tax credits and lump-sum payments. But revenues can also be invested in programs that address cost increases while supporting impacted sectors in transitioning to a lower-carbon economy. By investing in targeted efficiency programs, clean transportation options and transitional support to industry, revenue recycling can help reduce household costs, and for businesses, address competitiveness concerns while maintaining the carbon price signal and incentive to innovate. The examples cited above show the power of well-designed efficiency programs to mitigate energy cost increases as a result of the program and even create substantial net savings. These programs can be targeted specifically at lower-income groups to increase their direct benefits, address regressive impacts, and improve quality of life. Such requirements can be specified in legislation. California, for example, requires that at least 25% of cap-and-trade revenues[5] invested each year benefit disadvantaged

[4] For a good overview and discussion, see Ambec et al. (2013).

[5] This does not include revenues from the electricity sector, which are auctioned on consignment from utilities and must be used for ratepayer benefit. Residential customers, for example, receive a flat credit of roughly US$35 twice a year, known as the Climate Credit. See http://www.cpuc.ca.gov/climatecredit/

communities (with a minimum of 10% being spent on projects located in the communities themselves) (State of California, 2012).

An example of a transitional program for industry is British Columbia's temporary support for the cement sector. Though not explicitly funded through carbon tax revenue (which goes to general funds), B.C. will offer $22 million in incentives over three years[6] to cement producers that meet or exceed new emissions-intensity benchmarks (B.C. Ministry of Finance, 2015). By supporting increased efficiency and environmental performance, transitional programs like this also reduce exposure to energy or carbon price increases down the road.

2. HOW INVESTMENT OF CARBON PRICING REVENUES CAN TAP OPPORTUNITIES THROUGHOUT THE INNOVATION CYCLE

Before outlining opportunities for carbon revenue investment at each stage of the innovation cycle, it is useful to examine at a high level how jurisdictions with significant carbon pricing revenues currently allocate them.

Current investment of carbon revenues in low-carbon technology and emissions reduction

It is common for existing carbon pricing systems—especially in North America—to allocate some or all of their revenues to investments in low-carbon technology to reduce GHG emissions. These investments most commonly target the later stages of the technology innovation cycle. In most instances, early-stage support tends to be seen through a general "innovation policy" lens rather than a climate policy one and is typically supported from general funds rather than specifically through carbon revenues.

- **European Union**: In 2013, EU Emissions Trading Scheme (EU ETS) auctions raised €3.6 billion (C$4.93 billion) in revenues for member states. The states determine how to allocate the revenues, with the ETS Directive recommending at least half the revenues be used for climate- and energy-related measures. According to European Commission analysis of member-state reporting, 87% of 2013 auction revenue (€3 billion) was used to support climate and energy activities, mostly in domestic programs. Some countries, like France (revenues of approximately €220 million invested domestically in 2013), invested exclusively in energy efficiency programs for buildings. Others, like Germany (revenues of approximately €550 million invested domestically in 2013), placed them in strategic climate and energy funds that make broad decarbonization investments (European Commission, 2014). The EU also has a clean-energy technology demonstration program known as NER 300, funded by auctioning 300 million allowances from the EU ETS's New Entrants Reserve. In two funding calls, NER 300 awarded €2.1 billion (C$2.87 billion) to 38 projects in renewable energy and one in CCS across the EU (European Commission, 2014). The NER 300 program has been challenged by the dramatic decline in the value of EU emissions allowances—something not foreseen when the program was designed—leaving it with a much smaller amount of revenue than anticipated to support demonstration projects (Hood, 2013). This was doubly unfortunate, since the low carbon price further challenged the business

[6] Up to $27 million will be available over the five-year life of the program.

case of the low-carbon technology projects the fund was meant to support, increasing the need for programs like NER 300 at the same time its budget shrank. Beyond the need for price floors, this experience reminds us of the importance of planning for potential volatility in carbon pricing revenues and the ability to adapt to changes in market and technology development.

- **RGGI:** The large majority of RGGI auction proceeds are directed toward investments in emissions reduction. Only 8% of cumulative proceeds from 2008 to 2013 were directed to general revenues, with 15% of the remainder being used for direct bill assistance and 6% for state-level administration and support for RGGI Inc. (RGGI Inc., 2015). The remaining 72% of cumulative proceeds (approximately US$800 million) were invested in programs to reduce emissions. The use of auction revenues is determined by individual states, where most have prioritized energy efficiency programs. Cumulatively, energy efficiency accounts for 62% of investments across all states (57% in 2013), followed by GHG abatement (9% cumulative, 15% in 2013) and renewable energy (8% cumulative, 13% in 2013).[7] RGGI Inc. estimates that these investments will save more than 48.7 million MMBTu of fossil fuels and 11.5 million mWh of electricity over their lifetimes, reducing roughly 10 million short tons of CO_2 and resulting in over $2.9 billion in lifetime bill savings for 3.7 million households and 17,800 businesses (RGGI Inc., 2015). As noted above, these programs have played a significant role in making RGGI a net economic boost for the region.

- **California**: By statute, all auction revenue from California's cap-and-trade program must be directed to further the aims of AB 32, the Global Warming Solutions Act (State of California, 2006). As noted earlier, a quarter or more of annual revenue allocations must benefit disadvantaged communities, with at least 10% being spent on projects located there (State of California, 2006). A quarter of annual revenues are dedicated to financing the California high-speed rail project, 15% to supporting low-carbon public transit and rail integration (including investments in both capital and operations), and 20% to supporting the implementation of sustainable community strategies (State of California, 2014a). The remainder of annual revenues are allocated by the legislature as part of the budget process, following the guidance of triennial investment plans developed by the Department of Finance (Air Resources Board, 2015). The enacted budget for fiscal year 2014-15 allocates three-quarters of the US$832 million in revenues spent that year to programs in Sustainable Communities and Clean Transportation; 13% to Energy Efficiency and Clean Energy; and 11% to Natural Resources and Waste Diversion (State of California, 2014b). 60% of investments in 2014-15 are directly in the transportation sector. The governor's revised budget proposal for 2015-16 proposes allocating cap-and-trade proceeds of over US$2.2 billion in largely similar proportions, with the addition of several new programs (including US$60 million to the University of California and California State University systems for energy efficiency and renewables projects) (Office of Governor Brown, 2015).

- **Quebec**: All proceeds from Quebec's cap-and-trade system are legislated to go to the Green Fund (Fonds vert), from which they are used to implement the measures detailed in the 2013-2020 Climate Change Action Plan. Each of the 30 priorities listed in the plan are allocated a budget amount for the eight-year period, totalling $3.3 billion, of which cap-and-trade revenues are

[7] These figures represent a proportion of total investments (including direct bill assistance and administration), which were US$1.02 billion over 2008-2013. As a proportion of GHG-reducing investments only (US$803 million), 78% of investments were in energy efficiency, followed by GHG abatement (11%) and renewables (10%). State-level breakdowns by program are available in RGGI Inc. (2015).

projected to contribute $2.8 billion. By law, two-thirds of these revenues must go to initiatives in the transportation sector (Assemblé Nationale du Québec, 2014). The plan allocates the remaining budget broadly across other sectors, including industry (8%) and building efficiency (6%). Public and active transportation account for three-quarters of budgeted transportation spending (and 50% of *total* budgeted spending) (Ministère Développement durable, Environnement et Lutte contre les changements climatiques, 2015).

- **Alberta**: Technology fund payments are a compliance option available under Alberta's Specified Gas Emitters Regulation (SGER).[8] The Climate Change and Emissions Management Corporation (CCEMC) manages the fund and its disbursement. Through 2013, regulated firms contributed a total of $503 million in compliance payments to the fund. This was the dominant means of SGER compliance over the period, accounting for 40% of the total, followed by offset credits at 26% (Alberta Environment and Sustainable Resource Development, 2015). The CCEMC invests in a portfolio of projects to reduce emissions and support adaptation responses, aligned with the priority areas in Alberta's 2008 Climate Change Strategy. To date, $246.9 million has been invested in 100 projects, with a total value of $1.7 billion. Overall, the largest allocations have gone to renewable energy (34%), cleaner energy production (27%), and energy efficiency (14%). Funding to date has focused on near-term emissions reductions, with 9% funding to projects at the R&D stage and the remainder to projects in the later stages of maturity (CCEMC, 2015).

Opportunities for investments across the innovation chain

Innovation is more than early-stage research and development. It involves all stages in the development of a technology or process from the lab to the market, right through to widespread deployment and maturity. Increased investment and policy support for low-carbon technologies is needed at every stage (IEA, 2015a). Four broadly applicable stages in technological development can be outlined as:

- **Early Research and Development and Proof of Concept**: *Developing and lab-testing prototypes.*
- **Demonstration and Scale-Up**: *Demonstrating the technology in the field with pilot projects and initial commercial-scale projects or production facilities.*
- **Commercialization and Deployment**: *Increasing market penetration, gaining experience and capturing greater economies of scale.*
- **Diffusion and Maturity**: *Continuing to address barriers to deployment of fully commercialized technologies, innovating to continually reduce costs and improve performance.*

(UNEP SEF Alliance & Bloomberg New Energy Finance, 2010).

These stages are sometimes categorized as research, development, demonstration, and deployment (RDD&D). In reality, of course, technological development is rarely, if ever, linear. Feedbacks and iterations between all steps, as well as interactions with parallel technologies and with the broader environment make innovation much more of an ecosystem than an isolated linear procession from one step to the next (IEA, 2015a). While this section structures potential applications of carbon revenues by the stages outlined above, it is important to consider the many interactions between them and the strength of the broader ecosystem within which innovation takes place.

[8] The SGER was recently amended, extending the program and increasing the cost of technology fund payments from $15 per tonne to $20 per tonne in 2016 and $30 per tonne in 2017. See http://esrd.alberta.ca/focus/alberta-and-climate-change/regulating-greenhouse-gas-emissions/greenhouse-gas-reduction-program/default.aspx.

Early Research and Development and Proof of Concept

In Canada, incentives to increase business spending on R&D have tended to be general and indirect, such as favourable tax treatment for R&D expenses (Independent Panel on Federal Support to Research and Development, 2011). Despite these efforts, Canadian businesses in most sectors continue to invest little in R&D, relative to peers (although the counter-factual is difficult to assess). Carbon revenues could be used to finance sector-specific supplements or additional direct programs,[9] or projects in low-carbon R&D specific to the decarbonization priorities or advantages of a given jurisdiction. Direct incentives can have more quantifiable impacts, although, as with all early-stage investment results, these may not appear for a decade or longer.

Furthermore, carbon pricing revenues can be used to support the broader low-carbon innovation ecosystem by investing in the networks, incubators, testing facilities, skills training, and early-stage capital support that firms need to successfully advance their innovations. The UK-based Carbon Trust,[10] for example, was initially funded with revenue from the Climate Change Levy (CCL) (Holdaway, 2014). Other sector-specific examples—though not funded through carbon pricing revenues—include Ontario's MaRS discovery district (specifically its clean-tech practice and Advanced Energy Centre)[11] and the Massachusetts Clean Energy Center (MassCEC).[12]

Demonstration and Scale-Up

There are numerous opportunities for carbon revenues to support innovation at this stage. A major goal of demonstration, and thus a key role for public investments here, is "de-risking" emerging technologies to enable greater (and more affordable) flows of private investment for commercial roll-out and diffusion. Approaches include:

- **Funds targeting pre-commercial technologies**: Sustainable Development Technology Canada (SDTC; see Case Study),[13] a federal fund that invests in a portfolio of projects at the pre-commercial stage, is often cited as a major factor in Canada's clean technology success to date (Woynillowicz et al., 2013). It funds both development and demonstration projects, and thus straddles the categories presented here, helping innovations cross the "valley of death," where capital needs and risk profiles of clean energy technologies are poorly aligned. Alberta's CCEMC also funds demonstration projects; however, its current portfolio is spread more broadly across the later stages of innovation, including deployment.
- **Specific demonstration programs**: In fiscal year 2014-15, California devoted US$50 million of cap-and-trade revenues to fund an Air Resources Board competitive grant program for low-carbon freight technology demonstration in disadvantaged communities (Air Resources Board, 2015). While not funded from carbon pricing revenues, Ontario's $50 million Smart Grid Fund[14] offers a similar example of a targeted demonstration program.

[9] A leading example of direct early-stage clean-energy R&D support is the U.S. Department of Energy's Advanced Research Projects Agency–Energy (ARPA-E) program. Some states also have programs to match ARPA-E funding for local candidates, such as Massachusetts' AmplifyMASS program run by the MassCEC. Neither of these programs is currently funded through carbon pricing revenues.
[10] See http://www.carbontrust.com. Note: Carbon Trust is now a private organization.
[11] See http://www.marsdd.com.
[12] See http://www.masscec.com.
[13] See https://www.sdtc.ca/en.
[14] See http://www.energy.gov.on.ca/en/smart-grid-fund/.

- **Support for follow-on financing and adoption opportunities**: Programs that help connect demonstration-stage firms to sources of growth capital and early adopters can facilitate progress toward commercialization. SDTC programs for follow-on financing with the private sector (where 44% of the investments came from Canada, 41% from the U.S., and the balance from Europe and Asia), and export opportunities (partnered with EDC) are good examples. Since 2005, 60 of the more mature companies of the roughly 280 supported by SDTC have raised $2.6 billion in follow-on financing (SDTC, 2015).

Commercialization and Deployment

At this stage, carbon pricing revenues can help address barriers that demonstrated technologies continue to face, including cost gaps, lack of information, financing challenges and lack of supportive infrastructure. Governments can also play a role through their own procurement, acting as early customers for relevant technologies.

Many clean-energy technologies face quite different challenges to innovations in other sectors, like ICT. These include much higher capital expenditure requirements; longer hold periods (making returns slower to materialize); volatile energy prices; and typically risk-adverse target customers (e.g., utilities). Lastly, capital markets in Canada have generally been driven by success with investments in traditional commodities that have performed well over the long haul, meaning investors are not tempted to change.

- **Improving capital access**: Carbon pricing revenues can be used to support low-interest loan programs to deploy technologies with higher upfront capital costs. Connecticut's Green Bank,[15] for example, is partly supported by RGGI funds and offers low-cost financing to deploy residential, commercial, and institutional solar PV and fuel-cell systems, as well as offering incentives (RGGI Inc., 2015). Revolving loan funds for efficiency upgrades and clean technologies, as well as favourable tax treatment for clean energy equipment,[16] can help address capital access barriers in industry, where the payback periods required for internal financing are often prohibitively short (Zuckerman et al., 2014). Such investments support decarbonization while improving competitiveness by reducing carbon and energy costs.
- **Incentive programs**: Deployment can also be supported through incentive programs that target the cost gap between the new and incumbent technologies or help improve project bankability by adding predictability to revenue streams. Incentives can take the form of production or investment tax credits, fixed contributions per unit of clean energy generated (or energy saved), or direct rebates. An example of the last is California's use of cap-and-trade revenues to finance rebates for low- and zero-emitting vehicles (US$111 million in 2014/15) and trucks/buses (US$5 million in 2014/15) (Air Resources Board, 2015). Quebec's $28 million Écocamionnage program, which provides grants for commercialization and technology deployment in on-road freight, is a similar example.[17]

Diffusion and Maturity

At this stage, many of the barriers to adoption and the approaches to address them will be similar, but at a much greater scale as technologies become fully commercialized and increasingly affordable.

[15] See http://www.spark.ctgreenbank.com/programs/. For a review of current Green Bank models and results, see Belder et al.(2015).
[16] Revenues from the UK's CCL, for example, are used to fund the Enhanced Capital Allowances program, which accelerates tax relief on capital expenditures for energy-efficient and emissions-reducing equipment.
[17] See https://www.mtq.gouv.qc.ca/partenairesprives/entreprisesservicestransportroutier/programmes-aide/Pages/programme-aide-ecocamionnage.aspx.

- **Energy efficiency**: Carbon pricing revenues can be invested in energy efficiency programs targeting remaining barriers—especially access to capital (Roland-Holst, 2012)—in the residential, commercial/institutional, and municipal sectors. These can include building retrofit programs, incentives for institutional or industrial co-generation systems and street lighting upgrades. As noted earlier, efficiency investments are the primary use of carbon revenues in RGGI states. In 2014-15, California invested US$75 million of cap-and-trade revenues in weatherization and renewable projects for low-income housing units and US$20 million for efficiency in public buildings (Air Resources Board, 2015), and is proposed to allocate the same in 2015/16 (Office of Governor Brown, 2015).
- **Direct infrastructure and operations investment**: Jurisdictions like Quebec and California are investing significant amounts of carbon revenue in public transit and regional low-carbon public transportation projects. Revenues could also be used to support other strategic infrastructure that will enable further reductions, such as transmission and distribution grid upgrades, electric vehicle charging networks, or CO_2 pipelines.
- **Supporting enabling conditions**: Similar to the previous category, revenues can be used to support the design and implementation of sustainable community plans that identify key opportunities for emissions reductions and energy savings. Examples include New York's US$100-million Cleaner, Greener Communities program and Massachusetts' Green Communities Designation and Grant program—both financed through RGGI proceeds—as well as California's allocation of cap-and-trade revenues to support the implementation of Sustainable Community Strategies (US$130 million in 2014/15 and 20% of annual allocations in future years).
- **Project financing**: Lastly, governments can use carbon revenues to create a pool of low-cost capital for commercial projects, including through the issuance of green bonds or the capitalization of a green investment bank that invests in projects on commercial terms and draws in private investors. Since launching in 2012, the UK's publicly funded Green Investment Bank[18] has invested £2 billion in domestic projects, leveraging private sector investments at 3:1 and becoming the most active green investor in the UK.[19] It has invested more than £1 billion in seven domestic construction-phase and operational offshore wind projects, created the first dedicated offshore wind fund, and developed other financial innovations such as a green loan to help municipalities like Glasgow finance energy-saving upgrades to street lighting.

[18] UK programs are not directly financed by carbon revenues, as EU ETS auction proceeds and CCL revenues go into general government funds.
[19] See http://www.greeninvestmentbank.com.

Box: CASE STUDY: SDTC—supporting commercialization through targeted support

An example of a successful direct low-carbon innovation program is Sustainable Development Technology Canada (SDTC). SDTC manages three funds, the largest of which is the SD Tech Fund. This fund provides one-third of project funding—with the private sector providing the balance—for development and demonstration projects that reduce technology risk by testing the technologies in real-world applications. *Market* risk is also addressed by involving all the critical players in the commercialization path to the target market. The fund has about 280 projects underway, valued at $2.7 billion.

By the end of 2014, the in-market SDTC portfolio companies had generated annual revenues of $1.1 billion and created 8,200 direct and indirect jobs. These technologies have broader benefits as well. Of the projects supported, 89% to date have multiple environmental benefits, contributing to climate change mitigation and cleaner air, land, and water. As SDTC portfolio technologies reach the market, these benefits will grow. SDTC projects $1.2 billion of environmental and health-related impact costs will have been avoided as a result of supported technologies by 2025.

Has SDTC been a good investment? The answer is a clear yes. A cost–benefit analysis incorporating costs for more than 70 companies—both successful and failed projects—found a cost–benefit ratio of 1:9. Public dollars invested by SDTC's funds have been leveraged approximately 14 times, and the average compound annual growth in revenues for in-market technologies is twice the rate of that for clean-tech companies in Canada that were not supported by SDTC.

These results demonstrate that well-designed policy delivery programs can "pick winners," even if policy frameworks should not (i.e. should be technology-neutral). This sort of policy delivery requires patience as well as significant longitudinal evaluations to support the program's evolution in line with the market's. Provided strong processes are in place and subject to continuous evaluation, this can be a successful model.

3. GETTING THE MOST OUT OF OUR INVESTMENTS

In Section 1, we made the case for investing carbon pricing revenues in low-carbon technology and outlined the compelling benefits for doing so, from additional emissions reductions to macroeconomic benefits to strengthened innovation and productivity. Section 2 illustrated some of the ways in which jurisdictions are already using carbon pricing revenues to pursue such goals and laid out opportunities and approaches for making investments in low-carbon technology across the innovation chain. This section will seek to briefly examine some of the practical implications for Canadian governments.

Benefiting from investment in low-carbon technology depends on carefully designing an approach to making these investments. In order to maximize the opportunities for a "virtuous cycle" of invested carbon pricing revenues supporting and extending the benefit of the program—and vice versa—these investments must be closely and thoughtfully aligned with a jurisdiction's needs, goals, and reality. This is important. Poorly designed investments not only risk providing limited value for public funds, but can also erode support for the carbon pricing program itself.

A central, high-level lesson is the importance of diversity. No jurisdiction focuses exclusively on one sector, one technology, or one segment of the innovation chain—nor should it. Diversity spreads risk. A portfolio approach also spreads impact, by targeting improvements in multiple priority sectors (and, perhaps, technologies) at different points in the innovation cycle. There is no one-size-fits-all template for how such portfolios of programs should be weighted, however. Jurisdictions can and should design an approach that suits their unique context and goals. Not all technology investments and approaches will be relevant to every region. Some will focus more on certain segments of the innovation chain or on specific sectors, for example.

In determining how to craft a portfolio of investment types and targets that works best for them, policymakers should consider the following six factors:

Goals

A jurisdiction should have clear investment goals from the use of revenue, outlining the specific out-comes they are seeking. As outlined in Section 1, these include near-term emissions reductions, innovation, and economic growth. These goals inform the sorts of investments a portfolio should include and may differ significantly between jurisdictions. They also provide a basis for evaluation, assessment, and accountability.

Jurisdictions' investment plans may be oriented toward economic development goals—seeking to build further strengths in a specific clean-energy sector with a high potential for growth and exports, for example—or may prioritize broader macroeconomic benefits through a heavy focus on energy efficiency, as many of the RGGI states have done. Each jurisdiction will also have a unique balance between short- and long-term mitigation goals to consider.

Which goals are most appropriate (and which approaches are best to pursue them) will depend on context.

Context

Each jurisdiction has a unique context that will inform its goals. Its current energy systems, technology base, renewable energy potential, economic structure, and long-term decarbonization goals; the relative importance of co-benefits; and many other factors will inform its priorities, opportunities, and areas of competitive advantage (Torvanger & Meadowcroft, 2011). Alberta, for example, has a near-term opportunity to reduce emissions in the electricity sector (through improved efficiency and reduced use of coal power), but faces significant innovation challenges related to GHG performance in the oil sands, where broad deployment of important longer-term technology options like CCS cost far more than the current carbon price (or any price level likely in the near term) supports (Jacobs Consultancy & Suncor Energy, 2012). Quebec, with a largely decarbonized electricity system, should focus on reductions from the transportation sector, which will likely include significant electrification and demand for advanced biofuels, in addition to mode-shifting and efforts to reduce overall travel demand.

Designing a carbon revenue investment plan with a well-informed analysis of opportunities and gaps will help target resources where they can best support a jurisdiction's climate policy framework and broader goals.

As above, some level of diversification is important. This is particularly true for investments aimed at longer-term reductions or emerging technologies where the specific pathways technology will follow remain highly uncertain.[20] Diversifying investments and supporting technology areas with broad applications, such as energy storage and grid quality, can help minimize risk (and increase potential gains) (OECD, 2015).

Focus

Despite the importance of diversity, no jurisdiction can—or should—invest in every low-carbon technology area. Relative focus is an important aspect of using revenues wisely, especially for smaller jurisdictions with fewer revenues to invest (Torvanger & Meadowcroft, 2011). Targeting resources to specific priority areas means programs can scale sufficiently to have the desired impact.

Collaboration

While individually focusing on their comparative advantages and needs, jurisdictions can also can draw on one another's successes through collaboration, pooling their knowledge, or developing joint initiatives (Torvanger & Meadowcroft, 2011). As the IEA notes, such technological collaboration—whether between jurisdictions or across sectors—can be highly productive (IEA, 2015b). A recent example of such collaboration at work within Canada is the agreement between Nova Scotia and British Columbia to work together to advance marine energy (Government of Nova Scotia, 2015a). Nova Scotia has a similar agreement with the United Kingdom, under which the two governments recently announced the first joint research funding (Government of Nova Scotia, 2015b).

Adaptability

The flexibility for investment plans to evolve over time and adapt to changes in technological development, policy, and program performance is important to their continued success (Sustainable Prosperity, 2011). California's first triennial investment plan, for example, foresees that future investment plans will evolve in phases as programs are developed and revised, informed by initial research and results (State of California, 2013). A recent discussion paper exploring concepts for the state's second triennial investment plan outlines some of these directions, including a focus on longer-term goals and low-carbon transformation, emerging technologies, integration across systems, increasing participation from small business and rural areas, and exploring innovative financing tools to stretch carbon revenues further (State of California, 2015). Such changes are a natural part of program evolution and should be facilitated through regular program evaluations and broader reviews of the plan and its context.

Transparency and governance

Lastly, transparency and accountability[21] in the use of revenues is crucial for maintaining the public's confidence in the value of investments made on their behalf. This openness should extend from the principles the jurisdiction is using to guide investment and any reviews and justifications of program selection, right through to regular, detailed, public reporting on spending and the results achieved.[22] Investments cannot be a funding pot for supporting a government's pet projects, and transparency on principles, processes, and outcomes is vital to ensuring the public does not see them that way. This is an important element in maintaining trust and broader support of the carbon pricing program.

[20] Deep decarbonization in the passenger transportation section is one example, where several different combinations of highly efficient internal combustion engines, electric vehicles, fuel cell vehicles, and very low-carbon biofuels are seen as equally possible pathways. See U.S. National Research Council (2013)
[21] See Sustainable Prosperity (2011) for a good discussion of governance needs.
[22] See Air Resources Board (2015) for an example.

CONCLUSION

Experience to date shows the enormous potential of using carbon pricing revenues to further support decarbonization and directly engage thousands of homes and businesses to share in the opportunities of the clean-energy economy.

Of all options for the use of revenues, investing in low-carbon technology offers the strongest link to the ultimate goal of carbon pricing, which is swiftly transitioning to a low-carbon economy at the lowest overall cost. By using revenues to support and amplify the carbon price, provinces can reduce market barriers, accelerate low-carbon innovation, increase carbon productivity and green jobs, cut emissions faster, and expand the possibilities and affordability of future climate action. These positive results can further increase market and societal support for decarbonization.

There are opportunities to invest revenues in low-carbon technologies across the innovation chain, from early-stage R&D and ecosystem support through to demonstration and to deployment of mature technologies at scale. Each of these can deliver a different mix of benefits, from near-term energy and cost savings to facilitating longer-term reductions in priority sectors and, importantly, to fostering competitive, export-oriented clean-technology firms ready to tap a rapidly expanding global market.

Each province will have its own optimal mix of where along the chain these investments will be most effective. Their goals and unique context will determine which types of investments make sense for them—and which do not. Decisions over how to invest carbon revenue will require transparent assessment of options and clear justification of decisions. An overall structure to plan, measure, and regularly report results to the public strengthens accountability and can build engagement and trust. While each will design an approach best suited to its unique context, provinces should also capitalize on the strength of Confederation, learning from one another's experience, collaborating on shared goals, and increasing the domestic market.

As with all aspects of carbon pricing, the design details are critical. Policymakers must strike a balance between robust planning and processes on the one hand and the flexibility to respond to new opportunities or correct course on the other. Investment plans should be grounded in clear principles but designed to evolve, continually drawing in results, updating programs, engaging with stakeholders. Experience shows this balance can be struck, and that investing carbon pricing revenues in climate solutions can create a powerful and lasting framework for driving innovation and long-term prosperity in a low-carbon economy.

About the Authors

P.J. Partington is a policy adviser who has worked in the public and non-profit sectors to advocate, design, and implement effective climate change policies. He holds degrees in environmental policy and political science from the London School of Economics and University of Toronto, and is only slightly embarrassed to think about policy for most of his waking hours. P.J. currently works at a provincial environment ministry. Any views expressed here are personal and in no way reflect government positions or thinking.

Vicky Sharpe is a long-term champion of integrating the environment and the economy, and has 35 years of diverse energy and natural resource sector experience, extensive investment networks, and international exposure. She is also a seasoned director. She built SDTC, whose more than 280 companies deliver increased productivity and competiveness to primary economic sectors in Canada. Vicky took public funding of SDTC from $100 million in 2001 to $1.4 billion in 2014 and mobilized private capital for project and commercialization financing of more than $4 billion.

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4. Using Carbon Tax Revenues to Support Climate Action: The Case for (Green) Infrastructure

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ABSTRACT

This paper argues for using carbon tax revenues to support investments in infrastructure, specifically public infrastructure to reinforce climate action and underpin prosperity in a world without fossil fuels. Addressing climate change is a collective action problem, and public infrastructure investment can play an important role in overcoming structural barriers to individual behavioural change. The use of carbon tax revenues for infrastructure essentially amounts to scaling up existing actions, such as the Federal Gas Tax Fund.

The paper looks at the economic impact of infrastructure and other revenue-recycling options. Arguments for a "double dividend" (carbon tax revenues financing tax cuts) are not empirically supported. There is both a short-term macroeconomic advantage to infrastructure spending (stimulus) and potential long-term benefits, to the extent infrastructure supports increased productivity and economic activity. Well-designed infrastructure improvements will also lead to many additional co-benefits beyond greenhouse gas emissions reduction, in particular improved health outcomes.

Not all infrastructure is green, however, so key areas for a green infrastructure program are reviewed, in particular urban, intercity, and freight transportation; clean electricity and district energy networks; and, to a lesser extent, adaptation, waste, and buildings.

Finally, it is argued that an infrastructure approach would engender greater public support for carbon pricing. In British Columbia, the only jurisdiction to have a revenue-neutral carbon tax, it appears that revenue neutrality is less popular than the tax itself. People may grumble about paying taxes, but when they do, they want to see those revenues put to good use.

INTRODUCTION

This paper argues for using carbon tax revenues to support investments in infrastructure, specifically public infrastructure, to reinforce climate action and underpin prosperity in a world without fossil fuels.[1] Carbon pricing is a

[1] In past work, I have argued in favour of carbon taxes but against revenue neutrality: that half of carbon tax revenues should be used to support a broad-based tax benefit for low- to middle-income households to counter regressive tax impacts, and the other half to support climate action initiatives. See Lee (2011).

widely supported policy tool to reduce greenhouse gas (GHG) emissions, although complementary regulations and public investment are also needed to achieve deep emissions reductions. A rising carbon tax would increase the cost of using fossil fuels, but could also be a more effective financial engine of transformation by simultaneously financing needed infrastructure.

The term "infrastructure" is widely used, although there are some differences in how it is defined, as well as what is included as "public infrastructure." Recent work in Canada highlights some key characteristics of public infrastructure, such as being fixed structures that last for long periods of time (two decades or more), and have long gestation periods. Once built, infrastructure provides services to the population, facilitates economic activity by enabling new and/or more goods and services to come to market, and increases the productivity of capital and labour inputs (Baldwin & Dixon, 2008). Top areas historically are "engineering assets," such as highways and roads, bridges, sewer and water systems, electricity generation and transmission, and communications.[2]

Addressing climate change is a collective action problem, and public infrastructure investment can play an important role in overcoming structural barriers to individual behavioural change. Infrastructure choices can lock in a particular GHG emissions profile for many decades (Lecocq & Shalizi, 2013). For example, a key difference in the per capita emissions of Canada's lowest-emission provinces (British Columbia, Manitoba, and Quebec) and highest-emission provinces (Alberta and Saskatchewan) is the legacy of choices around electricity generation (hydropower in the former provinces, coal in the latter). The presence of natural gas distribution networks also affects emissions associated with space and water heating in urban areas. Perhaps the most significant infrastructure lock-in related to climate change mitigation is the system of freeways and highways built out since the 1950s, enabling the development of resource-intensive, auto-dependent suburbs.

In current energy policy debates, infrastructure is central, in particular proposed new pipelines to transport Alberta bitumen, liquefied natural gas terminals, and coal-fired power plants. The International Energy Agency (IEA) has noted the importance of near-term infrastructure decisions, in the context of keeping global temperature increase below two degrees (IEA, 2013). Canada's now defunct National Roundtable on the Environment and the Economy (NRTEE) modelled these impacts: "The infrastructure and equipment in place today [2012] and by 2020 could be responsible for 40% to 56% of Canada's emissions by 2030, with their share of emissions declining to between 4% and 7% by 2050" (NRTEE, 2012).

Rather than new fossil fuel infrastructure, significant alternative investments in low-carbon or green infrastructure are needed, with many of these in the public sector. Based on Canada's 2013 national GHG inventory, some key areas for infrastructure reinvestment include public electricity and heat production (12% of emissions); residential, commercial, and institutional buildings (10%); transportation (28%); and waste (3%) (Canada, 2015). Thus, green infrastructure investments have applicability to more than half of Canada's emissions, with most of the remainder being industrial emissions. In addition, we should consider adopting infrastructure to guard against the impacts of climate change, such as investments in storm sewer upgrades in the face of extreme precipitation events, and dykes to protect against rising sea levels.

[2] This paper follows Baldwin and Dixon (2008) in excluding "social" and "environmental" infrastructure, which are intangible, although clearly of importance and interest to economists. Broader conceptions could also encompass buildings, but not machinery and equipment.

These investments are ultimately complementary to carbon pricing, which influences economic decisions on the nature of capital investment. Low-carbon infrastructure can lower the private costs of mitigation, and this may mean lower carbon prices are required to achieve a given amount of emissions reduction. In areas such as transportation and coal-fired electricity, there are also important co-benefits, health in particular. Yet, these investments cannot generally be accomplished through personal and/or corporate tax reductions—they require we pool our resources through taxes. Revenue from carbon pricing represents an opportunity to fund these necessary investments.

A secondary rationale for infrastructure investment is that Canada has pent-up demand for new infrastructure, and maintenance and repair of existing infrastructure. This underpins commerce, mobility, and connections among people, all of which have important economic and social benefits. These are called "network externalities," and represent gains to society at large from lower transactional costs, and reduced barriers to access or entry. Thus, beyond specific green investments, there is an economic case for infrastructure that improves productivity and creates new markets.

The next section notes the current context and that using carbon tax revenues for infrastructure essentially amounts to scaling up existing actions. The paper then looks at the economic impact of infrastructure and other revenue-recycling options. There is both a short-term macroeconomic advantage to infrastructure spending and potential long-term benefits, to the extent infrastructure supports increased productivity and economic activity. Not all infrastructure is green, however, so we review key areas for a green infrastructure program to underpin sustainable prosperity, in particular renewable energy and transportation, and, to a lesser extent, adaptation, waste, and buildings. Finally, it is argued that an infrastructure approach would engender greater public support for carbon pricing.

1. INFRASTRUCTURE AND CARBON PRICING CONTEXT

Canada's municipalities have long called for increased infrastructure funding from senior governments. Urban transportation challenges, such as congestion, are paramount in the infrastructure gap, but upgrades for water and sewage systems are also important. Most public infrastructure (60%) is held by local governments (Federation of Canadian Municipalities, 2006), and growing urban populations are putting strain on infrastructure built decades ago. A fiscal imbalance is a major factor, as local governments are reliant on the property tax base, unlike federal and provincial income and consumption tax bases that grow in line with the economy.

Over the past decade, this concern has triggered a series of federal announcements, starting with a five-year $1-billion per year Federal Gas Tax Fund in 2005. This was made permanent in 2011, and increased to $2 billion per year. The Federal Gas Tax Fund is part of the Building Canada Plan, established in 2007 and renewed in 2013, which also includes a $900-million annual rebate on municipal GST, and approximately $15 billion in additional funding over 10 years (but 75% of new funds coming after 2019) (Federation of Canadian Municipalities, 2014). The 2015 federal budget adds some funding for transit, but not until 2017/18, with $250 million, rising to $1 billion per year in 2019/20 (Canadian Labour Congress, 2015).

These funds represent important first steps, but are inadequate relative to infrastructure needs. In the short term, $4 billion to $5 billion per year is about 2% of the $240-billion federal budget, and 0.3% of Canada's $1.6-trillion economy. The Federation of Canadian Municipalities (2012) notes that local governments already spend $12 billion to $15 billion per year of their own-source revenues on infrastructure. Moreover, there are time lags and other stipulations (cost sharing, requirements for controversial public–private partnerships, availability of new funds to universities and colleges) that diminish the real importance of these funds.

To properly bridge the infrastructure gap (to maintain and restore infrastructure), Mackenzie estimates that between $60 billion and $75 billion annually would be required. He further notes the importance of a strong federal role: "When it comes to Canada's physical infrastructure, the federal government has the money, the provincial governments have the constitutional authority, and local governments have the responsibility for making the actual investments" (Mackenzie, 2003). Provincial moves toward carbon pricing could change this revenue dynamic.

The Federal Gas Tax Fund support of infrastructure is analogous to using carbon tax revenues for infrastructure. While it is often stated that Canada has "no price on carbon," existing federal and provincial fuel taxes are carbon taxes with a smaller tax base. The federal excise tax on gasoline is 10 cents per litre, and raises over $5 billion per year.[3] Only $2 billion is recycled back to municipalities for infrastructure, although given the magnitude of new investments in the Building Canada fund, one could argue that almost all fuel tax revenues are recycled into infrastructure (though not explicitly designed this way).

The City of Vancouver's Neighbourhood Energy Utility (more below) is an example of a green infrastructure project that has received capital support from these funds (Lee, 2015). Others include a new bus terminal in Dartmouth, N.S., and solar panels in the Northwest Territories. As of the end of 2011, about $2.4 billion in gas tax funds went toward public transit, and $0.2 billion to community energy systems (Infrastructure Canada, 2013).

Provincially, British Columbia is known for its revenue-neutral carbon tax, equivalent to 6.67 cents per litre of gasoline. But this tax is actually much smaller than other federal and provincial fuel taxes. B.C.'s motor fuel taxes range from a general rate of 14.5 cents per litre of gasoline to 25.5 cents per litre in Metro Vancouver. The recycling of fuel taxes in support of transportation services and infrastructure is notable. Of the basic B.C. motor fuel tax, 6.75 cents per litre is dedicated to the BC Transportation Financing Authority, while the additional regional taxes in Vancouver and Victoria are allocated to support regional transportation, including roads and public transport (Government of British Columbia, 2015).

While Canada's cities have a pent-up demand for new and upgraded infrastructure, not all of this is green. It would be unfortunate to use infrastructure funds to lock in additional carbon-intensive development. Faced with growing populations and finite road and parking space, many Canadian cities are pushing to expand public transit in particular. Translink in Metro Vancouver has studied numerous options for the financing of transit improvements, with top-ranked choices being road pricing, fuel tax, and carbon tax (Translink, 2012).

[3] Statistics Canada, CANSIM Table 385-0033.

Finally, it is worth noting briefly the U.S. context, where state and federal fuel taxes finance a large share of transit and road infrastructure. Federal fuel taxes comprise 90% of the Highway Trust Fund, the primary fund for federal investment in surface transportation infrastructure (Haven, 2013). In regard to carbon pricing, California's 2014-15 budget permanently allocates 60% of cap-and-trade auction proceeds to high-speed rail, public transit, affordable housing, and sustainable community projects (with an emphasis of the last on disadvantaged communities); the remaining 40% is allocated annually and includes investments in energy efficiency, environmental projects, and recycling (State Government of California, 2014).

In sum, in the context of an infrastructure gap, there is already precedent for using fuel (carbon) tax revenues in support of infrastructure. Using carbon tax revenues would be an ideal way of expanding these efforts and financing a Canadian renewable energy transition.

2. ECONOMIC IMPACTS

How carbon tax revenues are recycled has both short- and long-term economic impacts. In this section, we review evidence about the relative efficacy of different recycling options, contrasting personal and corporate income-tax cuts, on the one hand, with public infrastructure. Revenues could also be used to reduce public debt, support general government expenditures, support a credit or dividend paid to households, or reduce other types of taxes, or some mix of all of the above. But the key critique made below is of revenue-neutral carbon taxes.

A common argument for using carbon tax revenues to finance tax cuts is that there is a "double dividend"—that is, the carbon price drives reduced emissions, while reductions in taxes lead to improved economic performance. However, this "tax the bad, not the good" argument is too simplistic. A more nuanced view is that what matters for economic growth is the mix of taxes and how proceeds are spent (Lee, 2004). Personal income-tax cuts, for example, are argued to increase productivity and economic growth, largely by reducing disincentives to work. However, this view is not supported empirically. People cannot easily alter their hours of work in response to personal income tax (PIT) rates, and studies show that the behavioural response to changes in marginal tax rates is very small, and thus the efficiency cost of income taxes is very low.[4]

In terms of corporate income-tax cuts, the channel of interest is whether tax savings are reinvested in new productive capacity. Growing surpluses in corporate Canada over the past decade suggests this is not likely to be the case. Stanford (2011) estimates this dynamic and finds that public investment in infrastructure would have more than 10 times the economic impact as corporate tax cuts. If we want new investment, particularly public investment in green infrastructure, corporate tax cuts should be rejected.

Infrastructure investments also have longer-term impacts on productivity and economic growth, and these may be stronger than tax reductions. This is because infrastructure serves as an input into firms' production functions, and improves the productivity of other labour and capital inputs. Some studies

[4] Other margins matter as well, in particular tax avoidance and shifting strategies for high-income households. Saez et al. (2012).

have posited that half of productivity gains can be attributed to public infrastructure.[5] A key aspect of public infrastructure is to lower costs for private sector agents—faster truck deliveries with less wear and tear using a public road, for example. Statistics Canada estimates 17 cents in private savings for every $1 of public infrastructure capital (Harchaoui et al., 2003).

A literature review of the impact of infrastructure for the Institute for Research on Public Policy concludes:

> Most of the published studies find that increases in the stock of infrastructure are strongly associated with reducing manufacturing costs, and hence improving manufacturers' competitive posture. These cost reductions are substantial, with transportation, construction, trade, and automotive manufacturing reaping the largest savings. (Brox, 2008)

While these studies emphasize the positive externalities of infrastructure investment, we could also consider the aversion of negative external costs. Consider the costs imposed on third parties in the area of transportation: air and noise pollution; time lost due to congestion; accidents leading to injury and death; other environmental costs of extracting and processing fuel; and opportunity costs of parking spaces.[6] This suggests that low-carbon transportation investments have potential to improve quality of life in a variety of ways besides reducing GHG emissions. Congestion in urban areas is a top example, with longer and less reliable travel times estimated to cost more than $5 billion per year, plus several billion more in forgone economic benefits (increased productivity from agglomeration in cities, increased labour force participation, and greater access to higher-wage jobs).[7]

Coal-fired electricity generation is another area where negative costs could be averted. An extensive body of research documents the adverse health consequences of air pollution from burning coal. In Alberta, where almost two-thirds of electricity generation is from coal, these costs were estimated at around $300 million per year. If included in the cost of electricity, these costs, plus damages from GHG emissions, would increase prices by 3.6 to 13.7 cents per kWh (relative to 2012 base price of 6.6 cents/kWh) (Anderson et al., 2013).

In addition to long-run economic impacts, there are also important short-run considerations, as different types of public expenditure (or tax reduction) flow through the economy in different ways. These include the direct impacts of expenditures (e.g., building a highway or transit line), indirect impacts (gains to supplier industries), and induced impacts (workers spending their incomes in the local economy). These economic impacts are reduced by leakages due to savings and expenditures on imports.

Table 1 shows this dynamic through estimated economic stimulus (or multipliers) for an additional $1 billion of public expenditure (or tax reduction), based on the Department of Finance's Canadian Economic and Fiscal Model (CEFM). Infrastructure investment has a much stronger economic impact than income-tax cuts, which are more likely to be saved or spent on imported goods.

[5] Literature surveyed in Conference Board of Canada (2010).

[6] These external costs are estimated to be three times vehicle operating costs by Litman (2010). [FIX ORPHAN]

[7] Estimated forgone economic benefits at between $1.5 billion and $5 billion per year for the Greater Toronto and Hamilton area, in Dachlis (2013). And in subsequent work, $0.5 billion to $1.2 billion per year for Metro Vancouver, in Dachlis (2015).

Table 1: Multipliers for $1 Billion in Additional Expenditure

	1st year	after 8 quarters
	billions	
Infrastructure investment	1.0	1.6
Housing investment	1.0	1.5
Other spending measures	0.8	1.4
Measures for low-income households	0.8	1.7
Reduce EI premiums	0.2	0.6
PIT cuts	0.4	1.0
CIT cuts	0.1	0.3

Source: Canada (2009).

Similar conclusions come from Informetrica's macroeconomic model of the Canadian economy (Informetrica Limited, 2009). Infrastructure is among the most stimulative for GDP and employment impacts, substantially stronger than personal tax cuts (although similar in impact to a GST cut). Infrastructure also better supports direct job creation, and these jobs are well matched in labour market terms to those that would be displaced through mitigation efforts.

A notable critique of infrastructure spending is that it can take a long time to get projects off the ground, whereas tax cuts can have rapid impact. However, our concern is not immediate fiscal stimulus in response to an economic downturn, but instead, multiple years of steady funding to develop well-planned infrastructure projects.

3. A GREEN INFRASTRUCTURE AGENDA

Effective climate policy must overcome the inertia of our current infrastructure of highways and roads, auto-dependent suburban patterns, and fossil fuel energy sources. In a hierarchy of energy decisions, research finds that foundational decisions around urban form and infrastructure are more important than improvements in the energy efficiency of equipment or buildings (Jaccard et al., 1997). Bataille et al., (2010) demonstrate emissions reductions of 5% to 12% by 2050 through the application of policies that encourage integrated urban energy solutions (higher-density, mixed-used development served by rapid transit and district energy systems).

Below, we take a look at key areas for a green infrastructure program, with an emphasis on achieving emissions reductions and other co-benefits that would not be achieved solely in response to a carbon price. While indicative of infrastructure directions, it is important to note that the type and quality of infrastructure matters. Any particular project would need to pass a cost–benefit test, one broadly considered to include health, environmental, and GHG impacts.[8] Below are key areas of attention for policymakers, which represent economically sensible options related to (1) emissions reduction; (2) productivity enhancement; (3) co-benefits and fairness objectives.

Urban transportation

The most important infrastructure investments historically were associated with transportation, including rail, highways, bridges, and ports. Currently, more than one-quarter of Canada's GHG emissions are from transportation, which includes moving people and freight.

Getting to a low- or possibly zero-emission transportation system will primarily mean powering transportation with clean electricity (with some niche applications for biofuels or hydrogen). Charging stations in both urban and rural areas, for example, could replace gas stations to enable private electric vehicles to have similar range to existing vehicles. However, shifting from internal combustion engines to electric ones is only part of the picture for mitigating GHGs.

With dedicated funding for transit expansion, more efficient and much higher-capacity transit networks could be built throughout Canada within a decade. Existing public transit infrastructure could be more efficiently utilized if funding is made available and accompanied by measures to discourage private vehicles by reducing available road and parking space. There is much room for performance improvement and economic benefits by investing in new infrastructure to speed up transit connections, if there is sufficient demand and supportive land-use policies (Litman, 2010).

In the post-World War II era, abundant cheap energy enabled the growth of North American cities and the sprawl of energy-intensive suburbs (Thompson, 2013). For urban planners, a rethink of these patterns has typically meant integrating land use and transportation decisions in order to achieve deep energy consumption and GHG emissions reductions. The ideal of "complete communities" emphasizes walking, biking, and transit modes of transportation, supplemented by car sharing, and greater proximity of homes to work, shops, entertainment, parks, and public services (Condon et al., 2010). Such a shift is already evident in parts of Canadian cities, with the City of Vancouver recently reporting that half of all trips are now by bike, walking, or transit (Lee, 2015).

Conversion of auto-oriented highways into mixed-use main streets, and parking-heavy malls into town centres offers the prospect of enhanced livability and greater employment in suburban areas, which would enable a range of mobility options, depending on circumstance (car sharing is a game changer here), and reduce the need for extreme commutes (Dunham-Jones, 2011).

Intercity and freight transportation

New transportation infrastructure should also include intercity transportation, such as the often mentioned Quebec City to Windsor high-speed rail corridor,[9] plus inter-connections to U.S. high-speed rail corridors. While a full coast-to-coast high-speed rail network may not be likely owing to the cost of covering such vast distances, a wide range of short-haul air travel could be displaced by high-speed rail corridors powered by clean energy sources along the route.

[8] See framework in Shaffer (2010).

[9] A 2011 study estimated the cost at $19 billion to $21 billion for the Windsor to Quebec City route, and $9 billion to $11 billion for the Montreal-Ottawa-Toronto portion. The latter would generate a positive net economic benefit, while the former would not. Ministère des Transports du Québec & Ministry of Transportation of Ontario & Transport Canada (2011).

Likewise, low-carbon transportation infrastructure for freight could be developed. The well-proven and cost-effective electric train could become the dominant mode of longer-distance freight movement and passenger travel, a trend that is already well under way in Europe on its largely electric railway network (United Kingdom Department for Transport, 2009). For long-haul bus and truck transportation, electric vehicles may require innovative new technologies such as large, interchangeable battery packs, hydrogen fuel cells, or direct connections to the electricity grid through overhead trolley wires on major highways (Gilbert & Perl, 2010). Freight systems could also be optimized to ensure that goods move by low-carbon modes such as rail and short sea shipping until near their final destination. Inland intermodal rail/truck terminals are sometimes referred to as “inland ports,” and could play a major role in reducing truck traffic and GHG emissions.

Clean electricity

Clean electricity supply is at the heart of a zero-carbon economy. Demand will likely grow in all provinces owing to shifts to zero-emission transportation and buildings. A remarkable story in recent years is that the cost of new renewable electricity generation in many parts of the world is now about the same or less than using fossil fuels.[10] Jacobson and Delucci (2010) of Stanford University argue that it would be technically possible to provide all the world’s energy with renewable sources (wind, water, and solar technologies, with no nuclear and biomass generation) by 2030,[11] and have been articulating state-by-state case studies in the U.S. (The Solutions Project, 2015).

The NRTEE makes the case:

> During the 1960s and 1970s, Canada invested heavily in expanding its electricity system with average yearly growth rates in capacity of 6%. Growth has been much slower in recent decades: 0.5% per year during the 1990s and 2000s. After an extended period of very limited investment, there is a need for Canada to upgrade existing and build new generation, transmission, and distribution infrastructure—to the tune of $294 billion between 2010 and 2030. (NRTEE, 2012)

Conversion of existing generation to fossil fuel-free sources has an important regional dimension within Canada, as it is a major mitigation project for provinces currently using coal. This aligns with the regional distribution of carbon tax revenues, and relatively more electricity infrastructure investment in these areas could ease concerns about the fairness across different provinces of a national tax and recycling regime. In Ontario, phase-out of coal-fired power is driving emissions reductions, and there is clearly room for similar mitigation efforts in Alberta, Saskatchewan, and the Atlantic provinces. East-west transmission infrastructure—to enable the transfer of hydropower from Newfoundland to the Maritimes, British Columbia and Manitoba to Alberta and Saskatchewan, and improved transmission capacity between Ontario and Quebec—could also support significant emissions reductions.

[10] Biomass, hydropower, geothermal, and onshore wind are estimated to be price competitive against fossil fuel-fired electricity generation. Solar photovoltaic power has also become increasingly competitive, with significant price drops in recent years. International Renewable Energy Agency (2015).
[11] However, they note that inertia of existing policies mean that achieving this goal by 2050 is more realistic (Jacobson & Delucchi, 2010)

District energy

District energy (centralized production of thermal energy for heating and hot water) has a long history in urban areas. Modern, hydronic (water-based) systems offer a green infrastructure platform to reduce carbon emissions from buildings. Because space and water heating account for a large share of the energy used in buildings (72% of residential and 53% of commercial/institutional energy use in 2012), district energy can do much of the heavy lifting of mitigating emissions from buildings in urban areas (National Resources Canada, 2013).

The City of Vancouver's Neighbourhood Energy Utility (NEU), for example, provides heating and hot water to new buildings in Southeast False Creek, with 70% of energy demand met through recapture of waste heat from the sewer system (Lee, 2015). The NEU system uses some natural gas for peaking and backup, but could be converted to biomass (several biomass-only facilities exist in other parts of Canada). The NEU also demonstrates a utility model for the ongoing support and maintenance of infrastructure. Of note, about one-third of the upfront capital investment was supported by a $10-million federal grant out of gas tax revenues.

Other infrastructure

Zero waste: Shifting from linear production systems—that extract excessive amounts of raw materials and convert them into waste for landfill or incineration—to circular ones starts with greater recycling of materials and composting of organics. Additional gains can be had from dematerialization, more effective reuse policies (think beer bottles) and sharing economies (car sharing, for example). These efforts require regulatory changes as well, but could dramatically reduce the upstream emissions associated with extraction, processing, manufacturing, and transport. These emissions are much larger than the "waste" category (3% of emissions) in the National Inventory Report. Key infrastructure opportunities could be in collection depots, various stages of recycling, and reuse, although there is likely to be a mix of public and private solutions (Lee et al., 2013).

Adaptation infrastructure: Climate change is reducing the life span of various infrastructure investments, and infrastructure needs to be more resilient to climate-related hazards. Canada needs to invest in capacity to deal with short-duration extreme precipitation and wind events, which have implications for water, sewer, electricity, and communications infrastructure. Adaptation also includes improving dykes for longer-term patterns such as sea level rise. How these will be affected by local conditions in extreme events or over longer time frames should be integrated into infrastructure planning exercises (Adaptation to Climate Change Team, 2009).

Complete communities: The need for new housing for a growing and aging population also provides an opportunity for redevelopment plans that reinforce complete communities. Public sector investments can help shape this transition, with libraries, child care, and community health centres. For our growing ranks of seniors, a range of smaller residential homes and supported care units, close to community health centres, would reduce mobility challenges.

Building retrofit programs: Buildings are not infrastructure in the traditional sense but are also long-lived capital structures. Federal and provincial efforts to support retrofits have ebbed and flowed over the years, and there is much experience that could be built on. In particular, a retrofit program should target older (leakier, less efficient) housing stock, and move beyond single-family housing to include multi-unit buildings, rental housing stock, and public institutional buildings (e.g., schools, hospitals). Minimally, energy retrofits of public buildings could be financed.

4. PUBLIC OPINION

In a survey of public opinion in Canada on taxes, pollster Frank Graves (2013) argues that while taxes are not popular, "The public clearly rejects the notion that they should be cut at all costs, and that all taxes are bad."

Canadians accept taxes as a precondition for a good quality of life and a healthy society, and support the notion, embodied in carbon taxes, that polluters should pay. On the other hand, there is distrust in government, and people may support tax cuts on the grounds that the difference can be made up by reducing (perceived) waste. But support plummets if tax cuts are linked to cuts in expenditures. Canadians also support the proposition that richer households and corporations should pay more in taxes. Graves concludes that "A conversation on taxes, then, will have to be a conversation about how to make government work for the majority, how to strengthen public services and make wise investments—how to make government more responsive, accountable, transparent, and focused on the future." (Graves, 2013)

In broad strokes, Canadians support infrastructure investment as a public priority. A more recent (Fall 2014) poll by Graves' company, Ekos, found that 57% of Canadians say the best option for moving Canada forward is by "increasing the role of government to invest in new areas such as job creation, public infrastructure, and stronger social security," while only 44% said "reducing the size of government and providing targeted tax relief in order to allow the private sector to propel growth and jobs" (Kennedy, 2014). Research in British Columbia for the Canadian Centre for Policy Alternatives (CCPA) in 2012 found that a majority of British Columbians are willing to pay more income tax in support of a variety of specific policy outcomes (more accessible and convenient public transit was the only infrastructure option tested, with 51% willing to pay more, while many other services had higher support) (Daub & Galawan, 2012).

There is limited research, however, on carbon pricing and preferred revenue-recycling options. In British Columbia, the only jurisdiction to have a revenue-neutral carbon tax, it appears that revenue neutrality is less popular than the tax itself. People may grumble about paying taxes, but when they do, they want to see those revenues put to good use. Shortly after the announcement of B.C.'s carbon tax in 2008, the CCPA conducted focus groups, with a key finding that ordinary people do not get revenue neutrality, with comments including "Stupidest thing I've ever heard of—why collect it if you're just going to give it back?" and "Why not use the [money] for policies that would actually help?" In contrast, there was strong support for concrete target solutions, such as transit.

A 2010 opinion poll commissioned by the CCPA found high levels of concern and belief regarding climate change, strong support for public policies that would aggressively reduce GHG emissions, and the view that such policies should not take a back seat to economic concerns during a recession. Strong majorities (between 80% and 95%) supported a range of climate action policies for British Columbia, such as investments in mass transit, transition programs for workers in fossil fuel industries, and subsidies for home and building retrofits (Tindall et al., 2010).

Polling research sponsored by the Pembina Institute about the B.C. carbon tax found support for the carbon tax, but that “British Columbians do not appear to place a high priority on making the carbon tax revenue neutral.” In 2011, they asked, "What would be appropriate uses for any new revenue from B.C.’s carbon tax?” (check all that apply): 49% said “Investing in projects that help to reduce pollution like public transit and more energy-efficient buildings” compared with 40% for “reducing personal income taxes,” and only 4% for “reducing corporate income taxes.” The top choice, 56%, was for “investing in other government priorities like health care and education” (Pembina Institute, 2011).

In a subsequent poll in 2012, the question read: “No further increases are currently planned for B.C.’s carbon tax. Please indicate if you would support or oppose future increases in the carbon tax rate if the revenue was used to …” The results were as follows:

- Invest in projects that help to reduce pollution like public transit and more energy-efficient buildings: 36% strongly support and 31% somewhat support.
- Invest in other government priorities like health care and education: 40%, 31%.
- Protect low-income households from increased energy prices: 29%, 29%
- Reduce personal income taxes: 32%, 30%
- Reduce corporate taxes: 5%, 7% (Pedersen et al., 2012).

In British Columbia, this disconnect around revenue neutrality is exacerbated by the fact that two-thirds of carbon tax revenues are recycled as corporate income-tax cuts, the least popular option by far.

The case for revenue neutrality is often made on the grounds that people won’t support a carbon tax otherwise. However, this presumes a demand for tax cuts that may not be nearly as important as previously thought. While limited public opinion research is available, given public attitudes on taxes and public spending, there is a strong case to be made that linking carbon tax revenues to infrastructure investments (and therefore visible changes in their landscape) will improve public approval of carbon pricing.

CONCLUSION

In this paper, I have argued that green infrastructure is a necessary part of a transition off fossil fuels and that carbon pricing is an ideal way of financing those expenditures. As a society, there is a lot of work involved in this transition, something that should be embraced as a generational project. This regime is likely to have positive economic benefits, in macroeconomic terms and in terms of long-run standard of living.

Well-designed infrastructure improvements will also lead to many additional co-benefits beyond GHG emissions reduction, in particular improved health outcomes. Substantial benefits from shifting off fossil fuels include reduced commuting time, more active lifestyles, reduced air and noise pollution, and reduced accidental death and injury. A carbon price based on the premise of lowering GHG emissions due to the "social cost of carbon" is limited and would miss out on these aspects of a transportation shift. This approach may fare better than tax cuts in terms of public opinion, and recent nods to infrastructure in federal and provincial budgets suggest that politicians know this, but lack for financing in conventional budget terms.

The recent collapse of the market prices for oil should give pause for thought about the efficacy of carbon taxes alone. Historically, price swings due to market forces swamp carbon pricing efforts. Vancouver is a good example, even on a weekly basis as the price of gas fluctuates by more than the amount of the carbon tax. At the time of writing (Spring 2015), to boost gas prices back to levels of June 2014, before the price crash, would require a carbon tax of more than $100 per tonne.

On the other hand, even a low value of a carbon tax would generate substantial revenues that could advance mitigation efforts by building the infrastructure Canada needs for future prosperity. For example, a modest $10 per tonne carbon tax would yield about $5 billion per year (assuming, in similar proportion to British Columbia's carbon tax, that 500 Mt of Canada's approximately 700 Mt per year would be covered by the tax). At the $200 per tonne by 2020, some analysts have estimated as necessary for Canada to get on a deep decarbonization pathway, and assuming Canada met its 2020 target, the tax would raise $87 billion.[1]

At some future point of an annually rising carbon tax, we would anticipate that total carbon tax revenues would begin to fall, but in the interim period, the tax would support Canada to shift electricity generation and transportation to low or zero emissions. In other words, it is well timed to Canada's actual infrastructure needs. Reductions in income taxes, on the other hand, would need to be reversed as carbon tax revenues fell in order to meet needed public expenditures, and there would be a political fight about whether to keep taxes low and accept higher levels of inequality.

While not the topic of this paper, in previous work I have recommended that half of revenues fund a broad-based credit that would flow to most households, with design based on that of the Canada Child Tax Benefit system, with a maximum amount at low incomes, then phasing out slowly as incomes rise. This combination of transfer funds to low- to middle-income households, combined with infrastructure

[1] Assuming coverage of 71.5% of emissions and Canada's 2020 target of 611 Mt in 2020.

build-out, would support high levels of demand and employment in the transition period, alleviating a principal source of economic insecurity felt by many households.

Ultimately, climate action is a matter of political will. The good news is that if we choose to act, there is much to be gained in economic benefits and in terms of quality of life by building the infrastructure for “the good life” while living within a carbon budget.

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5. Recycling Carbon Pricing Revenues to Reduce Public Debt

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ABSTRACT

Most provincial governments have faced persistent deficits and mounting debt since the recession in 2008/09. For example, the net debt-to-GDP ratio of Canada's two largest and most indebted provinces, Ontario and Quebec, both increased by about 15 percentage points since 2007/08. Furthermore, the unfunded liability associated with future health-care costs compounds the fiscal imbalance. Revenues from carbon pricing can help restore fiscal sustainability in Canada and reduce public debts to prudent levels. Debt reduction as a target for carbon revenue recycling has three distinctive merits relative to other potential uses of the revenues. First, the size of the public debt affects intergenerational equity. Second, the size of the public debt impacts economic performance. Servicing high debt levels may necessitate future increases in marginal tax rates, which would discourage investment and labour effort. Third, high debt levels increase the danger of fiscal unsustainability and insolvency, which can disrupt the economy by precipitating a financial crisis. With $1 billion in revenue recycling applied to debt reduction in each year starting in 2016/17, and taking into account provincial budget plans, the debt-GDP ratio is expected to be lower by 2019/20 by 1 percentage point in Quebec and half a percentage point in Ontario, compared with the debt ratios that would prevail if the carbon pricing revenues were spent.

INTRODUCTION

Carbon pricing can provide an important source of public revenues that could be used in various ways, such as for tax cuts or program spending. However, this paper makes the case for using the revenues to reduce government debt.

Most provincial governments and the federal government have faced persistent deficits and mounting debt since the recession in 2008/09. The unfunded liability associated with future health-care costs adds to the fiscal imbalance. Fortunately, revenues from carbon pricing can help restore fiscal sustainability in Canada and reduce public debts to prudent levels.[1]

Debt reduction as a target for carbon revenue recycling has three distinctive merits relative to other potential uses of the revenues. First, the size of the public debt affects intergenerational equity. Public debt is an obligation that is passed from current generations to future generations. Since much of the

[1] To be clear, debt reduction requires annual budgetary surpluses. For provincial governments that continue to have budget deficits, meaning their annual expenses outstrip their revenues, carbon pricing revenues can help with *deficit reduction*, but the debt level will continue to rise until a balanced budget is achieved.

recent run-up in debt is attributable to current spending, rather than to building up infrastructure that would generate future benefits, we owe it to future generations to now draw down the debt.[2]

Second, the size of the public debt impacts economic performance. Servicing high debt levels may necessitate future increases in marginal tax rates, which would discourage investment and labour effort. Government borrowing also reduces national saving, resulting in less capital accumulation or greater foreign indebtedness.[3] Each of these channels diminishes the incomes of Canadians. For example, the availability of less capital harms the productivity of Canadian workers and thereby restrains wage growth.

Third, high debt levels increase the danger of fiscal unsustainability and insolvency, which can disrupt the economy by precipitating a financial crisis. Debt spirals occur when rising interest rates, required by lenders as compensation for higher probabilities of default, cause a government to have to borrow even more. While the debt levels of Canadian governments are currently well below those of Greece and several other European examples that feature in the news headlines, the economic and social strains those countries are facing serve as a reminder of how intractable debt spirals can become.

The paper will expand on the three special features of debt reduction. The bottom line is that debt reduction to prudent levels is desirable on equity and efficiency grounds. Debt reduction cannot be achieved without either spending cuts or revenue hikes. Carbon pricing revenues carry a comparatively low marginal cost of public funds, making them an ideal source of new revenues to improve the state of public finances in Canada.

The paper proceeds as follows: Section 2 summarizes the literature on carbon revenue recycling for fiscal sustainability or debt reduction. Section 3 provides background information on the state of government indebtedness in Canada. Section 4 discusses in more detail the three distinctive features of debt reduction. Section 5 briefly discusses political constraints on using carbon pricing revenues for provincial debt reduction. Section 6 concludes.

1. REVIEW OF THE LITERATURE

There have been a few previous articles advocating the use of carbon taxes for deficit and debt reduction.

In a submission to the National Commission on Fiscal Responsibility and Reform in the United States, Metcalf (2010) argues that a carbon fee could contribute substantially to reducing the federal debt. He recommends a phased implementation of a carbon fee that grows over time in a predictable manner. During the transitional phase to a low-carbon economy, the revenues would be used to assist low-income households and workers in carbon-intensive industries. Over time, the use of the revenues would be shifted from addressing the distributional impacts to debt reduction.

[2] In Ontario, 66% of the run-up in public debt from 2009/10 to 20014/15 is attributable to current expenses (Wen, 2014), rather than to public capital expenditures. This increase amounts to almost $78 billion.
[3] For evidence, see Doménech et al. (2000).

Gale et al. (2013) note that the U.S. debt-to-GDP ratio averaged 37% for half a century before the 2008 recession, but it is now projected to pass 108% by 2035 under the current policy baseline. The authors point out that all uses of carbon tax revenues involve some form of giving the money back to taxpayers, but each policy option differs in which taxpayers receive the funds. Recycling carbon pricing revenues for deficit and debt reduction implicitly gives the money to future citizens by reducing the extent to which they have to pay higher taxes or bear the burden of spending cuts. They note that the regressive nature of carbon taxes—namely, low-income households spend a higher proportion of their income on consumption than high-income households—could be addressed with a refundable tax credit, like the GST tax credit in Canada.

Numerical simulations of an overlapping-generations model are used in Carbone et al. (2013) to evaluate the impacts of alternative uses of carbon tax revenues in the United States. The study helps to identify the opportunity cost of pursuing a policy of deficit and debt reduction. In one set of experiments, carbon taxes are introduced in 2015 and the revenues are either rebated to consumers or used to reduce other taxes (capital taxes, labour taxes, or consumption taxes) in a revenue-neutral manner. The simulations suggest that rebating the carbon taxes to consumers leaves every generation born after 1945 worse off financially, due to the reduction in GDP caused by the carbon taxes.[4] Similarly, using the carbon pricing revenues instead to reduce consumption taxes (state sales taxes) provides net benefits only to generations born before 1956. The greatest *dynamic efficiency gain*, among all the revenue-neutral tax-swap scenarios, is a cut to capital taxes (corporate income taxes and personal income taxes on capital income), because capital investment rises. With a $30 per ton carbon tax, revenue-neutral cuts to capital taxes raise the *level* of GDP by about almost 5 percentage points in the long run, compared with rebating the revenues to consumers, with most of the gain occurring after one decade.[5] The swap of carbon taxes for capital taxes benefits mainly the middle-aged generations, as the oldest generations have already divested themselves of income-generating capital assets, while the younger and future generations hold few assets, though they do benefit from the higher GDP.

In another set of experiments, the authors suppose the revenues from a carbon tax, in combination with a balanced package of spending cuts and non-carbon tax increases, are used each year to reduce the federal deficit beginning in 2015, as a "down payment" on a further package of austerity measures starting in 2035, designed to reach a stable debt-to-GDP ratio of 60% by 2115. This scenario contrasts with the revenue-neutral tax swaps, discussed above, which do nothing to address the existing problem of unsustainable fiscal policy. In each of the tax-swap scenarios, the debt-to-GDP ratio rises to 168% by 2050. The consequences of such an explosive debt trajectory are not modelled, but as the authors note, in the real world, it would lead to substantial negative effects on the economy. If, more realistically, fiscal policy were changed to stabilize the debt-to-GDP ratio several decades down the road, albeit at a much higher debt ratio than 60%, tax rates would have to be permanently higher, causing GDP to decline in the long run. Furthermore, interest payments on the debt would occupy a much larger portion of total revenues.

[4] The expected reduction in carbon emissions is quantified in the study, but it is not part of the welfare calculation. Hence, the financial losses of individuals from the carbon tax does not imply that they are worse off in the broader sense.

[5] Among all the revenue-neutral tax-swap scenarios, the reduction in capital taxes is the only one to generate sufficient dynamic gains to more than offset the economic costs of the carbon taxes, suggesting a large so-called double dividend from carbon pricing.

The "down payment" scenario, where carbon pricing revenues are immediately used to address the debt with substantial deficit-reduction packages starting in 2015, can also be compared with a scenario of postponing of debt reduction until 2035, but with the same 60% debt-to-GDP target in the steady state in both cases.[6] The authors find that postponing debt reduction until 2035 necessitates large tax increases in 2035 to compensate for the delay, even if between 2015 and 2035 the carbon tax revenues are used to reduce capital taxes. Interestingly, the effects of the tax increases in 2035 begin as early as 2020, as households and firms start changing savings, consumption, work, and investment decisions in anticipation of the looming changes in fiscal policy. Paying down the deficit sooner rather than later is predicted to make older generations worse off (more of the deficit reduction occurs during their lifetimes) and younger generations better off (less of the burden of paying down the deficit falls on them).

The study does not provide a direct comparison between alternative fiscal packages leading to different, but *stable*, debt-to-GDP ratios. However, the scenarios discussed above suggest the following trade-offs. In the short and medium run, there would be dynamic gains from swapping carbon taxes for capital taxes, compared with using the carbon revenues to help address the debt. In the longer run, permanently higher tax rates would be required to finance the higher debt ratio, almost certainly causing GDP to fall below the level achieved with the lower debt ratio. In that case, using carbon pricing revenues for immediate deficit and debt reduction would be more efficient overall, but the benefits would accrue primarily to the young and future generations, which could be politically challenging unless the middle-aged current generations are altruistic.

Finally, it is noteworthy that Sustainable Prosperity, a national research and policy network at the University of Ottawa, recognizes the potentially important role carbon pricing revenues can play in reducing the debt burdens of the federal and provincial governments in Canada (Sustainable Prosperity, 2010).

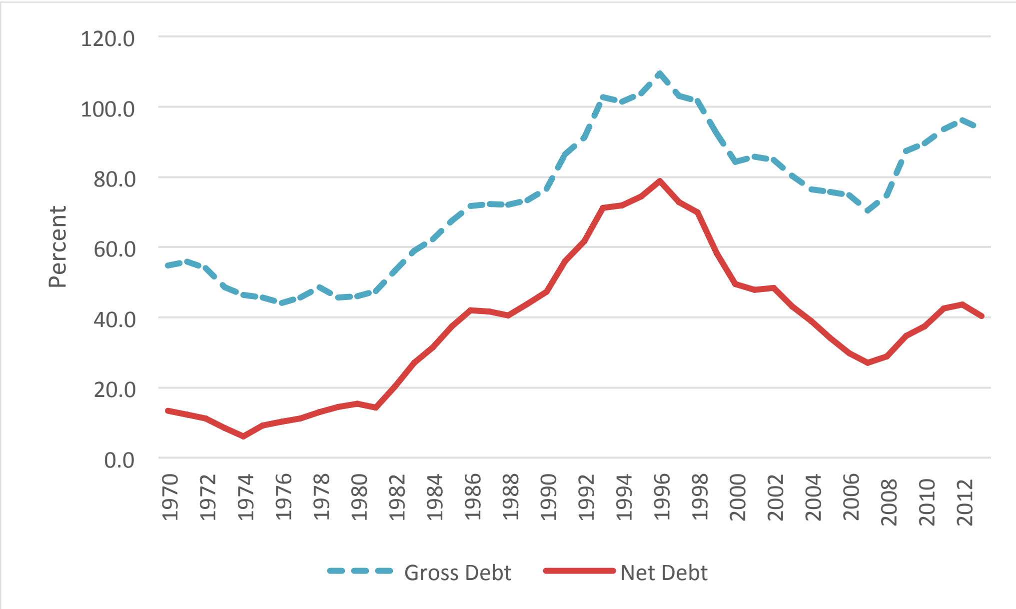
2. THE STATE OF PUBLIC INDEBTEDNESS IN CANADA

Figure 1 depicts the history of government debt in Canada since 1970. The graph shows both the gross debt and the net debt for the consolidated levels of government, as a percentage of GDP. Net debt refers to the government's total financial liabilities minus its total financial assets. If the assets are relatively illiquid, then the gross measure of debt is more pertinent for assessing solvency.[7] If the government's financial assets are relatively liquid, then the net debt measure is more useful, because a government could sell assets to meet maturing debt obligations, if necessary.

[6] Between 2015 and 2035, the carbon tax revenues would replace other taxes, as in the revenue-neutral tax-swap scenarios discussed above.

[7] Gross debt is considered especially important for evaluating the risk that currently maturing debt can only be rolled over at higher interest rates.

Figure 1: General Government Debt in Canada (Percentage of GDP)



Source: Constructed by the author using the Fiscal Reference Tables and GDP figures from CANSIM Table 384-0038.

The IMF proposes a gross debt-GDP target of 60% or a net debt-GDP target of 45% (IMF Fiscal Monitor, 2010). Most countries are either above or below both of the IMF targets at the same time. Canada is unusual in that its gross debt in 2013 is significantly above the target, while its net debt is below it. Canada's gross debt in 2013 is similar to the United States and the United Kingdom, while its net debt is substantially lower than in those comparator countries. This fact poses some ambiguity in assessing the severity of Canada's debt problem.

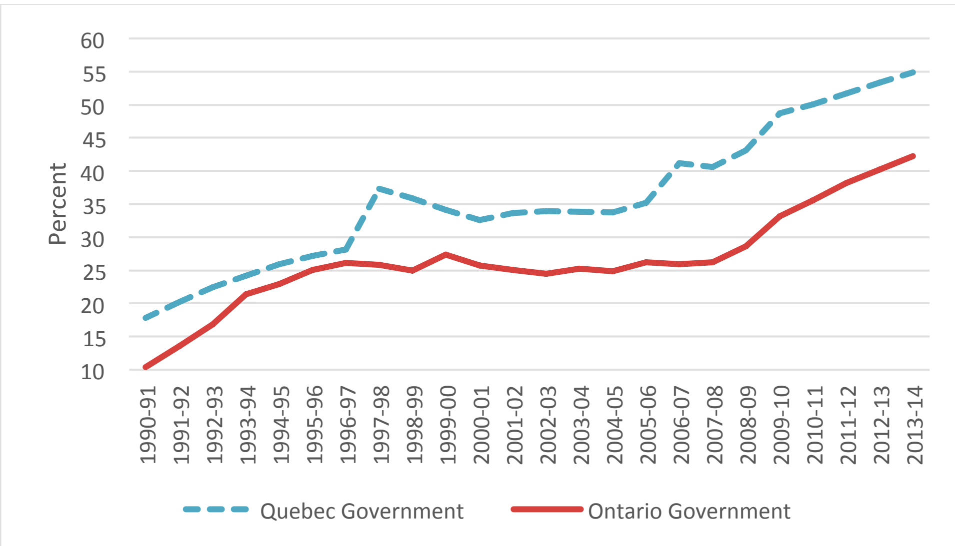
There are other salient features in Figure 1. From just prior to the 1982 recession until the peak debt year in 1996, the persistent deficits of Canadian governments caused a more than fivefold increase in the net debt-to-GDP ratio. The debt crisis in Canada during the 1990s finally led to a concerted effort by the federal and provincial governments to run surpluses and lower the debt. Recall that the late 1990s was a difficult period of austerity in Canada. The trajectory of debt reduction after 1996 turned abruptly in 2008/09 as a result of the global economic crisis. Figure 1 suggests that the overall level of government debt in Canada is moderate, but rising rapidly in the post-crisis period. Thus, although the debt situation in Canada as a whole is not near the crisis point of the 1990s, the fiscal path since 2008 is unsustainable. Furthermore, even as governments withdraw their fiscal stimulus over the next few years, the ongoing retirement of baby boomers is projected to lift the net debt-to-GDP ratio back to the high levels of the 1990s by 2040, unless programs are scaled back or tax rates are increased.[8]

Let us now turn specifically to the debts of provincial governments. Figure 2 shows the net debt-to-GDP ratio for Canada's two largest and most indebted provinces: Quebec and Ontario. In both provinces, the

[8] See the fiscal projections in Ragan (2012).

net debt ratio increased by about 15 percentage points since 2007-08.[9] The debt ratios in both provinces are substantially higher than in the 1990s. Ontario government bonds were downgraded by different credit rating agencies in 2012, 2014, and 2015.[10] Although the government of Ontario aims to balance its budget in 2017-18, its debt will continue to rise as a result of planned infrastructure expansions. Quebec is expected to post a balanced budget in 2015-16, and the government has indicated a course of action to cut the province's massive debt over the next decade.

Figure 2: Government Net Debt in Quebec and Ontario (Percentage of GDP)

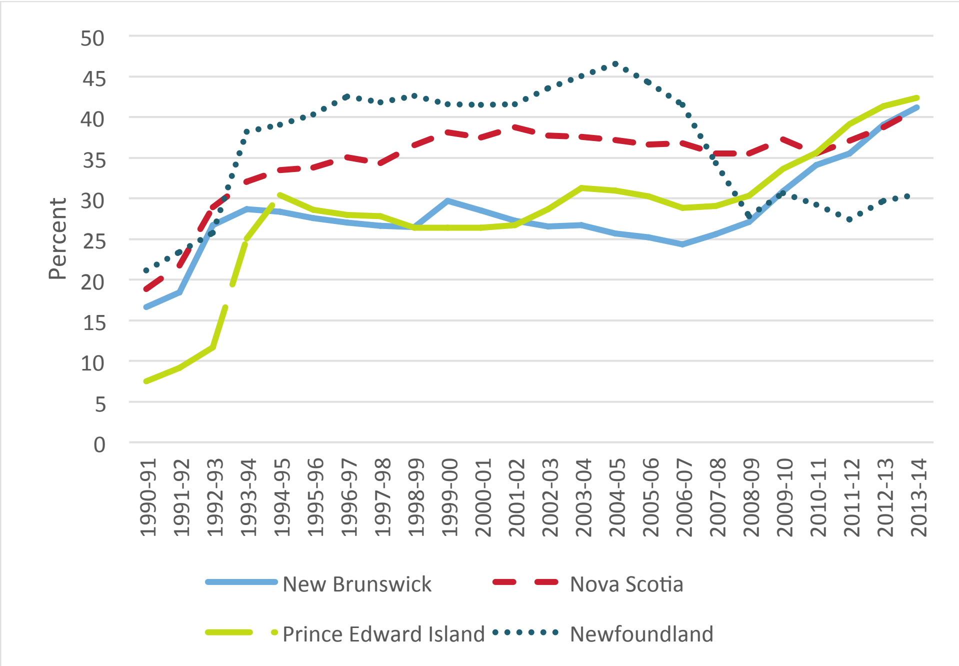


Source: Constructed by the author using the Fiscal Reference Tables and GDP figures from CANSIM Table 384-0038. GDP figures have been restated to correspond to a fiscal year; for example, GDP in 1990-91 consists of 75% of the GDP reported in 1990 and 25% of the GDP reported for 1991.

Figure 3 shows the net debt-to-GDP ratios for the Atlantic provinces. Since 2007-08, the debt levels in New Brunswick and Prince Edward Island rose by 15 and 13 percentage points, respectively. Although Nova Scotia's debt did not expand by nearly as much, all three Maritime provinces have net debt ratios now exceeding 41%. Newfoundland is an exception in Figure 3, with its net debt remaining stable at around 30% of GDP.

[9] The data for provincial net debt is based on fiscal years and uses a different accounting system than the consolidated government debt depicted in Figure 1.
[10] Standard & Poor's credit ratings for Ontario and Quebec on debt maturities of at least one year are identical, as of the time of writing.

Figure 3: Government Net Debt in Atlantic Provinces (Percentage of GDP)

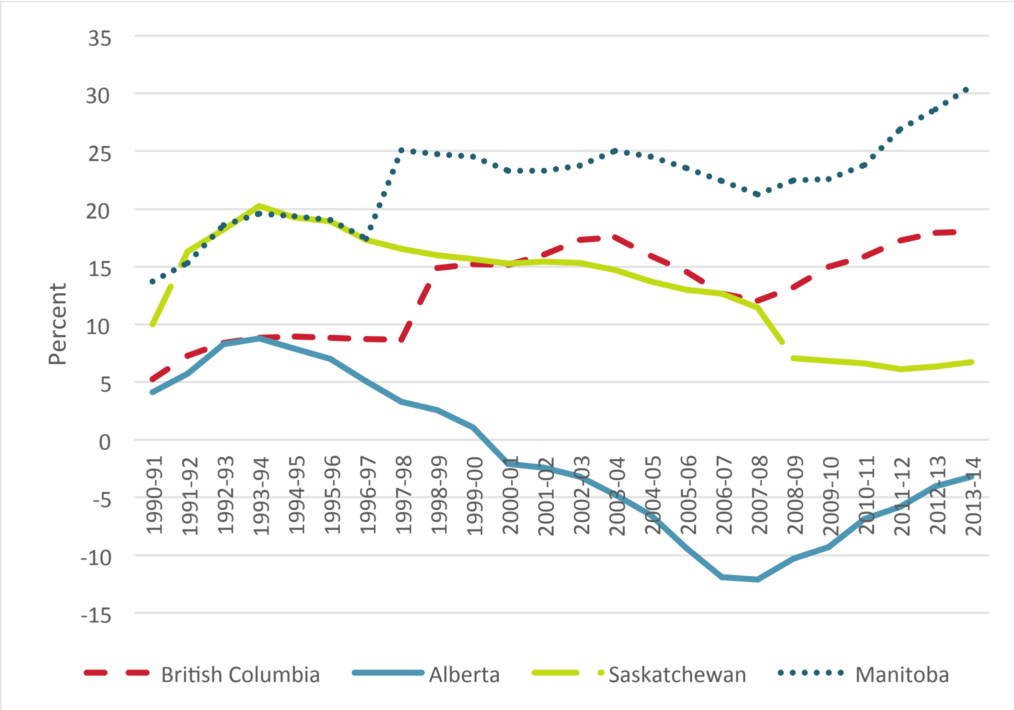


Source: Constructed by the author using the Fiscal Reference Tables and GDP figures from CANSIM Table 384-0038. GDP figures have been restated to correspond to a fiscal year; for example, GDP in 1990-91 consists of 75% of the GDP reported in 1990 and 25% of the GDP reported for 1991.

Figure 4 shows the net debt-to-GDP ratios for the Western provinces. Debt ratios in British Columbia and Manitoba increased in the post-recession years and have attained their highest levels since at least 1990-91. However, Figure 4 shows that not all provinces are facing high or mounting debts. Saskatchewan's debt ratio decreased relative to 2007-08 and Alberta's net debt is negative, owing to its large stock of financial assets, fuelled by natural resource revenues.

Figures 2 to 4 indicate that most provincial governments have experienced sharp increases in their public debts since the recession. However, given that not all provincial governments have large net debt ratios, there are potential political ramifications of using carbon pricing revenues for debt reduction at the provincial level. These are considered in Section 5. It is also important to recognize that the debt of the federal government is relevant to assessing the severity of provincial debts. This is because fiscal pressures at the federal level can be transmitted to the provinces, through reduced cash transfers or intergovernmental competition for tax revenues. Indeed, the paths of fiscal sustainability of the federal government and the provincial governments are expected to diverge unfavourably for the provinces as a result of the federal decision to reduce the annual growth of the Canada Health Transfer from 6% to the rate of nominal GDP growth, starting in 2017-18 (Ontario Ministry of Finance, 2015).

Figure 4: Government Net Debt in Western Provinces (Percentage of GDP)



Source: Constructed by the author using the Fiscal Reference Tables and GDP figures from CANSIM Table 384-0038. GDP figures have been restated to correspond to a fiscal year; for example, GDP in 1990-91 consists of 75% of the GDP reported in 1990 and 25% of the GDP reported for 1991.

What impact can the revenues from carbon pricing have on provincial public debt levels? Take the cases of Quebec and Ontario and suppose that $1 billion of additional revenues is generated by carbon pricing in each province. Quebec's 2015 annual budget forecasts its debt-to-GDP ratio to equal 42.6 in the year 2019/20. With $1 billion in revenue recycling applied to debt reduction in each year starting in 2016/17, I calculate that the debt-to-GDP ratio would be 1 percentage point lower by 2019/20. Ontario's annual budget reports only as far as 2017/18, when the provincial debt-to-GDP ratio is expected to be 39.2%. Again, if the additional revenues are applied to debt reduction in each year, as of 2016/17, my calculations suggest that Ontario's debt-to-GDP ratio would decline by half a percentage point by 2019/20, compared with what it would otherwise be.[11]

3. DISTINCTIVE FEATURES OF DEBT REDUCTION

Intergenerational Equity

One definition of intergenerational equity is equality in treatment and opportunities for different generations (Foot & Venne, 2005). The definition affirms the rationale for engaging in ecologically sustainable development. That is, every generation should manage its activities without degrading the quality of the environment available to the next generation. The idea accords with the benefit principle of

[11] I make the "neutral" assumption for Ontario that all non-carbon revenues and spending will grow at the rate of GDP growth in the years 2018/19 and 2019/20. The calculations are based on the model described in Wen (2015).

fairness in public finance, which says that taxes should be borne in direct relation to the program benefits received from the government. In a generational context, we may take this to mean that over their lifetimes, citizens must receive appropriate value for the taxes they pay.

Under the benefit principle, it is legitimate for governments to use debt to finance long-lasting infrastructure, because the benefits flowing in the future from the projects coincide with the taxes levied to pay the interest and principal on the debt. But when governments borrow to pay for current spending, such as expanded services or higher public sector salaries, then the benefit principle is violated: the present generation benefits, while a portion of the costs of servicing the debt falls on future generations. The benefit principle is often invoked to justify user charges for public services. In the same vein, current generations should finance their government's operating expenses with taxes instead of debt, just as they should avoid degrading the ecological environment. Doing otherwise shifts the costs of current consumption onto others.

The potential argument, that it is fair to run up the debt, provided that climate change is addressed, is inconsistent with the benefit principle. The mitigation of climate change with carbon pricing should be viewed purely as a correction to an externality, not as a public service for future consumers. The revenues from carbon pricing can be regarded as being rebated back to the current generations of taxpayers.[12] The argument for using the revenues to reduce public debt, based on the benefit principle, then lies with the observation that the recent run up in debt stems in part from excessive operating expenses, rather than public capital investments.[13]

A very different concept of fairness is vertical equity, which states that tax burdens should be distributed according to the ability to pay. In a generational context, the implication is that if future generations are expected to be wealthier than the current generation, perhaps due to technological advances, then some borrowing to pay for current spending is acceptable.

There are good reasons to be skeptical that the next several generations will enjoy higher standards of living than the generations currently alive. The aging of the baby boomer, born in the decade and a half following the Second World War, means that taxes on future working-age individuals must increase to support a relatively large proportion of the population that is retiring. Average annual growth in real GDP per capita is expected to decline by 0.3% as the labour force shrinks (Ragan, 2012). Another consideration for the growth of future disposable incomes is the trend in productivity, defined as output per worker. Productivity growth in Canada has been falling for decades and middle-class incomes have been stagnant. Consider that, from 1961 to 1980, output per worker in Canada averaged 2.9% annual growth,

[12] This presumes that current generations have the "right" to create global warming, and that future generations must "pay" for mitigation. If, instead, the legal or moral right to a sustainable climate belongs with future generations, then using carbon pricing revenues to reduce the debt requires no appeal to equity principles. Moreover, as Ronald Coase famously argued, the allocation of property rights would have no effect on the optimal degree of environmental mitigation. The allocation would only affect the intergenerational distribution of income.

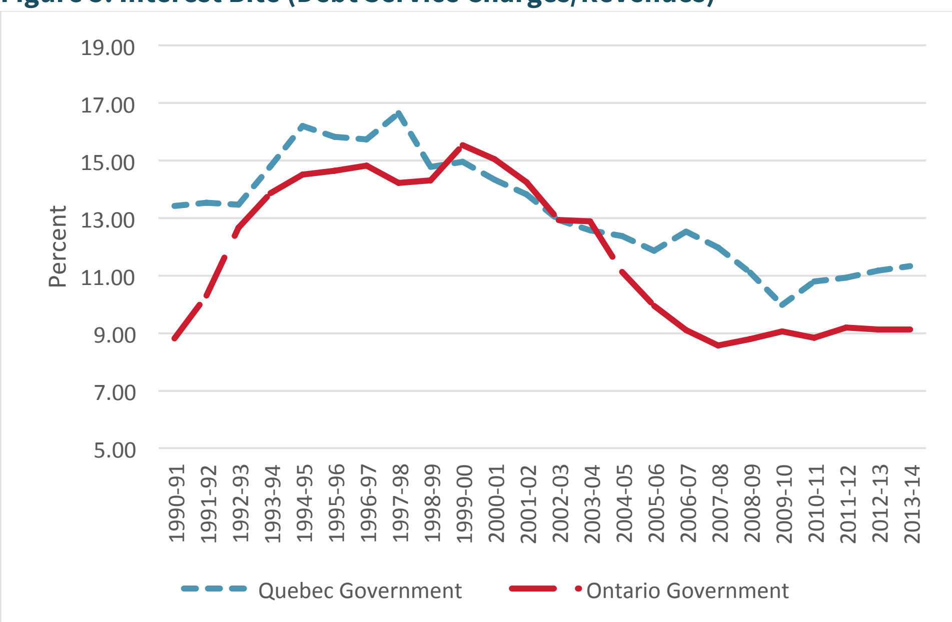
[13] The post-recession increase in public debt is not necessarily attributable to operating expenses in *every* province. Wen (2013) finds that British Columbia's recent debt rise is explained by the province's capital investments.

while from 1980 to 2000, the rate was 1.6%, and just 0.7% from 2000 to 2008 (Baldwin & Gu, 2009).[14] The inflation-adjusted median family income level in Canada is unchanged between 1976 and 2011.[15]

Thus, it is not at all clear whether the vertical equity perspective supports more current spending or less debt. Median income has improved, since its trough in 1997, and it is certainly conceivable that a resurgence in productivity growth could occur in the ensuing decades. Nevertheless, the vertical equity justification for not dealing with rising public debt in Canada is speculative at best. It seems akin to assuming that global environmental problems will somehow resolve themselves in the future even without collective action.

High public debt requires future generations to divert revenues to interest payments instead of funding government programs. Figure 5 depicts the so-called interest bite in Quebec and Ontario, which is the proportion of government revenues devoted to servicing the debt. The interest bite reached peaks of 15.5% in Ontario in 1999-2000 and 16.7% in Quebec in 1997-98. In 2013-14, the interest bite is about 11 cents per dollar of revenues in Quebec and 9 cents per dollar in Ontario. These are lower amounts than in the past, as a result of the historically low interest rates in the post-recession period. If interest rates were to rise to more normal levels, the interest bite would increase, possibly substantially. To illustrate, *Ontario Budget 2010* forecasted an interest bite for 2015-16 of 11.9 cents, whereas the rate is now projected to be 23% lower, at 9.2 cents, largely due to unexpected declines in market interest rates (Ontario Ministry of Finance, 2015).[16] Clearly, a return of interest rates to normal levels would have large adverse effects on the size of interest payments on the public debt.

Figure 5: Interest Bite (Debt Service Charges/Revenues)

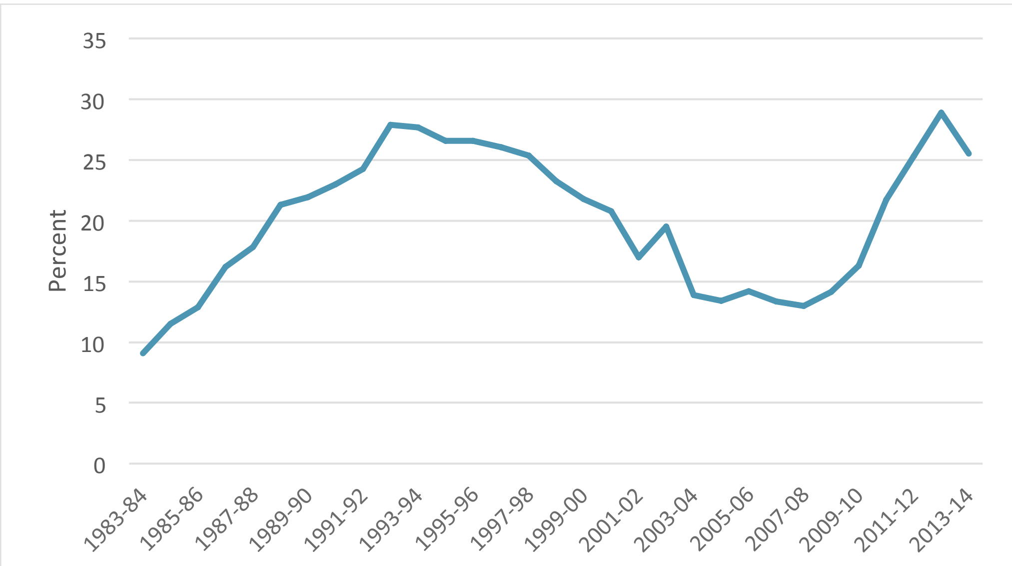


Source: Constructed by the author using the Fiscal Reference Tables.

[14] Productivity growth in Canada is below the rate in the United States, and the problem of low productivity has only worsened since 2008 (Hodgson, 2013).
[15] The data for constant dollar median family income are from Statistics Canada, CANSIM Table 101-0401.
[16] *Ontario Budget 2010* did not state its interest rate forecast for 2015-16, but the rate expected on Government of Canada 10-year bonds in 2013 was 5.1%. In contrast, *Ontario Budget 2015* anticipates an interest rate of 1.8% in 2015 and 2.7% in 2016.

Another way that high public debt hurts taxpayers, including the future generations, is the leakage of revenues out of the hands of Canadians, required to pay foreign asset holders. Figure 6 depicts the interest-bearing unmatured federal government debt held by non-residents. The rapid increase in foreign-held federal government debt since the recession is evident in Figure 6. More than one-quarter of federal debt is external. Provincial governments also have substantial portions of their debt held by foreigners.

Figure 6: Interest-Bearing Unmatured Federal Government Debt Held by Non-Residents



Source: Constructed by the author using the Fiscal Reference Tables.

So far, we have looked only at public debt, which is a narrow indicator of government liabilities. Future generations of taxpayers will need to pay for more than the interest and principal on debt. They will also have to finance the public pensions and public health-care costs of older Canadians. The proportion of seniors in the Canadian population is expected to increase from just over 15% in 2015 to 25% over the next few decades, as a result of the fall in fertility rates and the rise in life expectancy.[17] With population aging, the ratio of benefit recipients to workers is rising, placing an ever greater tax burden on the working-age population. The method of "generational accounting" invokes a broader concept than public debt by including unfunded liabilities[18]; unfunded liabilities are obligations of the government arising from promises made to the current generation. The most important of these promises in Canada is the ongoing availability of publicly funded medical care.

The approach of generational accounting is to distinguish between the tax burdens on generations currently alive and on unborn generations. The key to the analysis is the government's inter-temporal budget constraint, which states that a government is solvent if the government's current net financial

[17] See Ragan (2012). The average fertility rate in Canada declined from 3.7 children per woman during the post-World War II baby boom to 1.7 children per woman in 2007. Meanwhile, the average years of life expectancy in Canada increased from 68.5 in 1951 to 80.5 in 2006.

[18] Generational accounting originates with Auerbach et al. (1991). See also Gokhale and Smetters (2003).

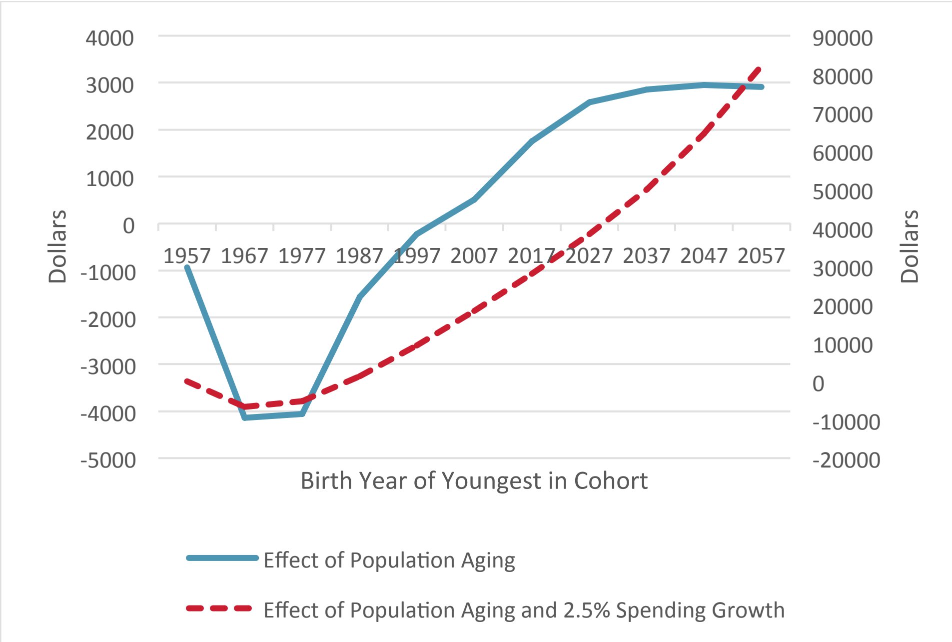
debt plus the present value of future spending equals the present value of future tax revenues. The present value of future tax revenues is divided between the amount falling on the various living generations and the amount falling on future-born cohorts. The present value of taxes falling on future-born cohorts is calculated as a residual amount, such that the inter-temporal budget constraint is in balance, given the current stock of net debt, the existing structure of spending programs and tax policy, and the demographic trends. Generational inequity arises if the future-born generations must bear a higher tax rate than the currently alive generations to obtain the same per capita amounts of public goods and services. Notice that the larger the current net public debt, the greater must be the tax burden on future-born generations for the same per capita level of service. Thus, to address the looming generational inequity, it is incumbent on the current generation to reduce the size of the public debt.

The generational accounting approach has been used to study the implications of unfunded health-care costs in Canada (Emery, et al. 2012).[19] Health care is unfunded in Canada because the government pays for health costs each year from taxes collected in that fiscal year, without saving money to match the projected rising health-care costs in the future, as the population rapidly ages. Consequently, the substantial late-life health-care costs of the baby boomers will be paid by the taxes levied on smaller-sized future working-age cohorts. The authors of the study find a large fiscal imbalance stacked against future generations.

Figure 7 shows the net fiscal imbalance for health-care costs across 10-year cohorts born from 1948-1957 to 2048-2057. The horizontal axis indicates the birth year of the youngest person in a given 10-year cohort. The dashed curve is measured on the left-hand axis and represents the fiscal gap between the net present value of taxes required to finance health care and the net present value of health spending over the expected lifetimes of individuals in each cohort, assuming that Canadians born in 2008 or after will receive the same average public spending on health care at each age from 2008 onward. This is a very conservative assumption, because it ignores cost increases that are not driven by population aging. The solid line is measured on the right-hand axis and assumes, more realistically, that per capita health spending at each age increases by 2.5% (inflation-adjusted) per year. Even without an assumed 2.5% annual increase in spending, there is a fiscal imbalance, beginning with the generation born between 1997 and 2008, which reaches nearly $3,000 per capita for the youngest in the cohort born between 2048 and 2057. When a 2.5% annual spending increase is factored in, the gap grows to a whopping $82,000 per capita by 2057. Thus, intergenerational equity provides a compelling motive for recycling carbon pricing revenues into reducing the current stock of public debt in Canada.

[19] The paper by Emery et al. (2012) focuses on health care rather than all government programs. See Palacios et al., (2014) for a breakdown of financial debt and the various implicit financial liabilities of each provincial government.

Figure 7: Net Fiscal Balance for Health Care (Spending Minus Taxes) by 10-Year Birth Cohorts



Source: Constructed by the author from Tables 1 and 2 in Emery et al. (2012).

Economic Performance

The increased indebtedness of many governments around the world as a result of the global financial meltdown in 2008 has stimulated empirical research on the effects of public debt on economic performance. There appears to exist a turning point at a gross debt-to-GDP ratio of about 90%, after which growth is shown to slow considerably (Reinhardt & Rogoff, 2010; Checherita & Rother, 2010; Kumar & Woo, 2010; Cecchetti et al., 2011; Padoan et al., 2012). However, research by IMF staff also finds evidence of adverse effects of debt on growth at medium gross debt levels (30% to 60% of GDP) (IMF Fiscal Monitor, 2010); and Egert (2012) uncovers negative impacts at gross debt ratios as low as 20% to 40%. The IMF research suggests further that a 10 percentage point increase in the initial debt-to-GDP ratio is associated with a slowdown in real per capita GDP growth of around 0.15 per year in advanced economies.

The empirical study of the non-linear effects of debt on economic growth is still in its infancy, but there are plausible channels through which debt could hamper growth. The higher tax rates needed to service larger debts can reduce growth by distorting the allocation of resources. Higher public debt can crowd out private investment by raising interest rates, with long-term negative impacts on labour productivity. The IMF research suggests that a 10 percentage point increase in the debt ratio is likely to lead to an increase in long-term real interest rates of around 50 basis points over the medium run (IMF, 2009a). The higher interest rates arise partly because of the government competing with the private sector for domestic savings and partly because of the increased probability of default as public debt levels rise. While, for a small open economy like Canada’s, inward foreign investment can compensate for lower domestic saving caused by government borrowing, there is a commensurate loss as profits earned in Canada are repatriated abroad.

Moreover, higher debt ratios reduce the capacity of governments to respond to future economic downturns with countercyclical increases in their non-interest public expenditures. This observation was apparent in cross-country comparison of the size of fiscal stimulus during the period 2008-2010, which was inversely related to the size of public debt in large countries (IMF, 2009b). Similarly, high debt constrains the ability of future governments to engage in capital spending. Even though investments in infrastructure, such as highways and hospitals, can provide long-term benefits for the economy, the debt required to finance the expenditures becomes problematical when the debt level is already high. Standard & Poor's cited Ontario's multi-billion dollar 10-year plan for infrastructure spending in combination with its "very high debt burden" as the reason for the bond rating agency's downgrade of the province's credit rating in July 2015 (Taber, 2015). Finally, excessive debt can be detrimental to growth because of the risk that the federal government will attempt to inflate away the public debt by selling treasury bills and bonds to the Bank of Canada.[20]

The potential for even moderate debt levels to have negative long-term growth effects underscores the importance of restraining public debt levels. Recycling carbon pricing revenues toward debt reduction stands to improve the performance of the domestic economy over long term.

Sustainability and solvency

The theory of fiscal sustainability is premised on satisfying the government's inter-temporal budget constraint. Fiscal policy is sustainable over a given interval of years if the government's planned tax-and-spend policies can be maintained without causing the debt-to-GDP ratio to rise. Since, in principle, the institutions of a well-functioning society have no foreseeable future end point, the inter-temporal budget constraint can be satisfied over an infinite future time horizon even if there are long periods of rising public debt. This is because one can usually devise a future fiscal plan to eventually reverse the debt accumulation. In reality, the debt level may reach a point at which it is simply impossible to generate sufficient future primary surpluses (the excess of revenues over non-interest expenditures) to offset the debt. This can happen if tax rates are raised to the point at which higher rates cause revenues to decline instead of increasing—the "wrong" side of the so-called Laffer curve[21]; or budgets cannot be cut further without provoking massive social conflict.

Since the promises of governments to generate primary surpluses in the future are subject to error or disingenuousness, financial markets look at short- and medium-term fiscal plans for signals about the credibility of the government's pronouncements about the long term. High debt levels raise the perceived probability that a government will eventually default on its debt. A debt spiral can occur when investors demand higher bond yields to roll over government debt, as compensation for the rising risk of default. The resulting higher cost of debt service can easily push governments into even greater debt. Debt spiral dynamics were evident in Canada during the 1990s. Kneebone (1994) documents the provincial debt downgrades during that challenging period of Canadian fiscal history.

[20] Under the Bank of Canada Act, there is a legal provision for the Bank of Canada to make loans to the federal government or to the government of any province, in its capacity as lender of last resort.

[21] Indeed, the calculations of Dahlby and Ferede (2012) imply that corporate tax rates in Ontario are already on the downward portion of the Laffer curve: corporate tax-rate hikes in the province would reduce tax revenues by discouraging investment and shifting the tax base to other provinces.

There is no doubt that most provincial governments have been on an unsustainable fiscal trajectory since 2008. The government's *Commission on the Reform of Ontario's Public Services* (the "Drummond Report") calculated in 2012 that, if no substantive changes were made to the government's fiscal plan, the debt-to-GDP ratio would reach almost 51% by 2017/18 (Ontario Ministry of Finance, 2012), and the projections by Kneebone and Gres (2013) show Ontario's debt ratio reaching 66% by 2019/20.[22] The potential for unfavourable debt dynamics creates uncertainty for businesses, which might otherwise undertake capital investments in the debt-ridden provinces. Marginal policy action will not address such doubts. Committing carbon pricing revenues to provincial debt reduction provides an important signal to the commercial and financial markets, which will contribute to restoring a favourable outlook for the provincial economies.

The post-recession default risks of the provincial governments are estimated by Joffe (2012). An interesting finding from his work is that the current bond yield spreads suggest that the markets expect the federal government to bail out provinces if they become insolvent. In other words, the actual opportunity cost of financing provincial debt exceeds the cost charged by financial markets to the provincial governments. Since Canadians are ultimately on the hook for both provincial and federal debt, Joffe's observation can be interpreted as evidence of an externality leading to excessive provincial debt. It is a further reason why collective action to reduce provincial debts is appropriate.

4. POLITICAL CONSIDERATIONS

The argument for debt reduction at the provincial level, rather than at the federal level, stands on two points. First, the federal debt problem since the 2008/09 recession has not been as severe as the problem in most provinces. In fact, the provincial and local levels of government combined have been more indebted than the federal government every year since 2002, and they have made comparatively little progress in reducing their debts during the economic boom of the past two decades (Cross, 2013). Second, it is simpler and politically more attractive to avoid intertwining carbon pricing recycling with interprovincial income transfers.

However, since not all the provincial governments are faced with high or mounting public debt, it seems unlikely that the provinces in relatively sounder financial positions would agree to tie their hands to using carbon pricing revenues for debt reduction. It may, however, be possible to have all 10 provinces agree on the principle of using carbon pricing revenues to reduce their own provincial debts, whenever the ratios exceed some agreed upon level. The key to such an agreement is the understanding that it is in a province's own interest to signal to its citizens and businesses that their government is committed to maintaining prudent debt levels. Dedicating at least a substantial proportion of carbon pricing revenues to debt reduction can serve as a commitment device that kicks in when debt ratios trip over a line. Moreover, the low *net* debt levels of the provinces that are rich in extractive resources can mask accumulations of large *gross* debts. For example, Alberta, which was debt-free as recently as 2009, had a

[22] See Emes and Speer (2014) for an assessment of fiscal unsustainability in Quebec, and Wen (2013) for an analysis of British Columbia.

gross debt of about $14 billion and total liabilities of $55 billion in 2015 (Alberta Treasury Board and Finance, 2015). The debt would have risen faster if not for the fact that no oil revenues have been added to the Heritage Savings Fund in recent years. The implication of these observations is that the province's low (in fact, negative) net debt figure is procured by sacrificing the share of natural resource wealth that would otherwise go to future generations of Albertans. The intergenerational inequity of using all of the royalties to pay for operating expenses, since the recession, is one reason to believe that "even" the governments of the provinces endowed with natural resources could prioritize debt reduction as a usage of carbon pricing revenues.

Another political consideration is whether debt reduction has sufficient popular support. If the electorate perceives carbon pricing as detrimental to its own economic interests, voters may oppose using the revenues for debt reduction in favour of augmenting current consumption. Many of the benefits of debt reduction would occur during the lifetimes of current voters. Nevertheless, the largest benefits are expected to accrue to those currently too young to vote and to unborn future generations. The court of public opinion over the use of the revenues for debt reduction depends on the persuasiveness of the principles of fairness—the benefit principle and vertical equity. Thus it is hoped that this article has provided Canadian voters with compelling philosophical and practical reasons to press their elected officials to recycle carbon pricing revenues toward provincial debt reduction.

CONCLUSION

Three reasons are given for why revenues from carbon pricing should be allocated to provincial debt reduction rather than for financing new spending or revenue-neutral tax cuts.

First, the existing high debt levels in most provinces compounds the intergenerational fiscal imbalance that is already present due to the costs of future health care as the baby boomers age. Second, recent research has identified non-linear effects of public debt on economic growth at even moderate debt levels. Third, high levels of debt raise the likelihood of insolvency, which makes governments vulnerable to debt spirals in the event of future recessions and adverse demographic trends. Taken as a whole, a strong case is made on both equity and efficiency grounds for committing carbon pricing revenues to provincial debt reduction.

Since not all 10 provinces have faced high or mounting debt to the same extent since the recession of 2008/09, it is politically necessary and desirable to allow flexibility to the provincial governments in their use of own-source carbon pricing revenues, even if there is agreement on the general principles. The main point is that the provinces with high or mounting debt can use the opportunity of recycling carbon pricing revenues as a commitment device to signal their determination in restoring health to their public finances. Carbon pricing revenues can serve this function because they are expected to be a large source of revenue and because the aim of debt reduction is harmonious with an intergenerational equity argument that also lies at the heart of ecological sustainability.

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6. The Political Economy of Free Allocations

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ABSTRACT

This report contributes to the Ecofiscal series on revenue-recycling instruments by discussing the free allocation of emissions permits. Free allocation has similarities to other forms of revenue recycling in that it confers a benefit upon its recipients, reducing their financial burden associated with climate policy. There are three main reasons for using free allocation: (1) it is a more precise mechanism to compensate those who are harmed the most from the introduction of carbon pricing; (2) it can help build political support by ameliorating competitiveness risks for vulnerable firms and building constituencies with a vested interest in seeing carbon markets maintained; and (3) free allocations are a useful tool for managing through a period of patchwork climate policy by mitigating emissions leakage—the shifting of polluting industry from jurisdictions with stringent climate regulations to those with lax or non-existent policies. The manner in which permits are allocated matters and we contrast two main methods: grandfathering and output-based allocations. While in the case of grandfathering, firms are incentivized to reduce emissions, which allows them to sell their allowances, it also creates a moral hazard, as firms might discount the value of free allowances or reduce production for the purpose of selling unused allowances, potentially exacerbating the problem of emissions leakage. Under an output-based allocation, firms are incentivized to reduce their emission intensity (i.e., produce more while emitting less), but the incentive to reduce emissions by simply curtailing their production is weakened. To realize the full economic advantages of free allocations, including limiting emissions leakage, it is important that they be allocated on an output basis that is updated regularly rather than grandfathered on the basis of historical emissions.

INTRODUCTION

Putting a price on carbon leads to two broad outcomes. First, it leads individuals and firms to rationalize their energy use and drives emissions reductions—the intended goal. Second, it raises a substantial amount of revenue.

British Columbia's carbon tax, for example, raised an estimated $1.24 billion in budget year 2014-15 (Government of British Columbia, 2015b). Revenues generated through the auction of Quebec's emissions allowances are expected to generate $0.43 billion per year through 2020 (Purdon et al., 2014). If used wisely, this revenue represents a major opportunity to contribute to public welfare in addition to the climate mitigation benefits resulting from reducing emissions. However, there is a genuine concern that governments might misuse such funds, as recent revelations in Quebec remind us (Hébert, 2016; Lecavalier, 2016). To minimize such concerns, a number of climate policy instruments are designed to smartly administer carbon funds in a manner that minimizes interference in the economy while also offering economic and political incentives to promote the involvement of individuals and firms.

This paper explores the risks and benefits of one such policy instrument—the free allocation of emission permits.[1] In contrast to both a carbon tax and the auctioning of emission permits, free allocation actually forgoes the collection of government revenue. Free allocation might therefore appear out of place in the Ecofiscal Commission's current series on carbon pricing revenue recycling. However, free allocation has certain characteristics similar to revenue recycling. Allocations have value, and providing them for free is therefore analogous to a subsidy in that they confer an economic advantage to recipients.

The first question one should ask is why should permits be freely allocated? If the goal is cost-effective emissions reductions, the free allocation of permits appears contradictory. But there are two main reasons why free allocation is worthy of consideration. The first is the prevention of emissions "leakage"—the shifting of polluting industry from jurisdictions with stringent climate regulations to those with lax or non-existent policies. As we will discuss later in this paper, the method by which permits are allocated plays a significant role in the degree to which leakage is discouraged. Second, free allocations can help build political support for climate policy by ameliorating competitiveness risks of vulnerable firms and building constituencies with a vested interest in seeing the carbon market maintained. While the extent of competitiveness risks should not be overstated (see Beale et al., 2015), supporting emissions-intensive trade-exposed firms in a climate-regulated jurisdiction through free allocations is politically expedient. Overall, given the reality of imperfect global market conditions and patchwork of global climate policy (Asselt & Zelli, 2014), forgoing climate revenues and granting vulnerable firms allowances for free promises to lead to a more economically and politically effective climate policy.

But there are challenges involved in the use of free allocations. First, it is important to identify for which sectors of the economy free allocations are genuinely needed. While numerous analyses have demonstrated that the competitiveness risk for certain Canadian industries is real—including lime, cement, and certain other forms of natural resource extraction—the broader effects on the service-based sectors of the Canadian economy can easily be exaggerated (Beale et al., 2015). Second, not all strategies for allocating free allowances are equal. Specifically, different allocation methods affect firm behaviour in different ways, and thus so too the resulting emissions. Our review of the literature indicates that to realize the full economic advantages of free allocations, including limiting emissions leakage, it is important that they be allocated on an output basis that is updated regularly rather than grandfathered on the basis of historical emissions. Yet such output-based allocations (OBAs) need to be used with restraint since, in contrast to grandfathering, they raise the price of carbon permits to achieve the required level of emissions reduction under a cap (Fowlie, 2012; Fischer & Fox, 2010).[2] Finally, providing more free permits than necessary forgoes revenue that could be used to support other objectives.

This paper proceeds as follows: We first discuss the similarities between free allocations and revenue-recycling components of carbon pricing. Second, we describe the economics underlying free allocations, and distinguish the effects of the two primary allocation methods: grandfathering and OBAs. Third, we highlight domestic and international political economy dimensions that further justify the use of free allocations. Fourth, we examine selected examples of free allocations in practice in Quebec, Alberta,

[1] While this paper focuses on the free allocation of permits under a cap-and-trade system, similar concepts are applicable through targeted and/or output-linked rebates or credits under a carbon tax policy.
[2] Or put another way, in the case of a carbon tax or Alberta's hybrid policy, output-based rebates or credits reduce the amount of emissions reductions for a given carbon price.

California, and British Columbia. And fifth, we conclude with recommendations regarding the appropriate use and scope of free allocations.

1. SIMILARITIES BETWEEN FREE ALLOCATIONS AND REVENUE RECYCLING

As mentioned above, free allocations as a policy instrument may appear out of place in an Ecofiscal series on revenue recycling. Given that permits are freely allocated, there may be no revenue to recycle.

However, free allocations are similar to policies that recycle revenue collected through a carbon tax or auctioned emissions allowances in that they offer benefits to regulated entities, though they differ from revenue recycling in the way in which the costs of climate policy are imposed.

We focus first on similarities between free allocations and revenue-recycling carbon pricing instruments in how they confer benefits to recipients. Consider Canada's prototypical example of a revenue-recycling climate policy tool, the B.C. carbon tax, which covers approximately 70% of British Columbia's emissions (Harrison, 2013). Unique to the B.C. carbon tax, *all* revenue collected by the government through the carbon tax is earmarked to be returned to individuals and firms in the form of tax breaks and rebates (Government of British Columbia, 2012). As discussed by Beck et al. (2015), carbon tax revenue in B.C. is disposed through two channels. First are personal tax reductions and transfers to low-income and rural households, which constitute nearly 40% of recycled carbon tax revenues. Second are corporate tax-rate reductions for both small and large businesses, and other business tax credits, which amount to the remaining 60%. The B.C. carbon tax policy, therefore, consists of two distinct mechanisms: the price on carbon and the recycling of revenue via tax cuts and transfers. Firms and households receive benefits from the revenue recycling to, at least on average, offset the costs from the carbon tax.

Now consider a cap-and-trade system with free allocations. When emissions are capped, all emissions allowances carry an opportunity cost and a firm surrendering its allowances for compliance with its emissions-reduction target loses the opportunity to sell allowances (Jegou & Rubini, 2011). Consequently, when government provides these permits for free, they are conferring financial advantages on those firms receiving them. Because these permits have value, governments' allocation of free permits is analogous to a subsidy. Instead of auctioning permits and redistributing revenue, the (valuable) permits themselves are distributed. This reduces the initial financial burden of climate policy on the recipient firms, lowering their average cost of compliance. As we discuss further below, *how and to whom* allowances are distributed can have important economic and political implications.

But free allocation differs from revenue recycling in terms of how it imposes the cost of carbon throughout the economy. Under a carbon tax or auctioned emissions trading system, governments generate revenue that can then be recycled back to the economy—for example—to reduce existing taxes, reduce government debt, or invest in public infrastructure. In this case, firms face directly the marginal cost of emissions. In order to emit one tonne of CO_2 or equivalent, firms must purchase a permit or pay the tax. Free allocation imposes costs differently. Firms no longer directly pay the marginal cost of carbon to the government, as represented by the price paid during the government auction of permits or the tax.

Instead, firms face the marginal *opportunity cost* of carbon by forgoing the sale of freely allocated permits. If firms choose to emit—even with 100% free allocations, where the *average cost* of compliance may be zero—they are forgoing the sale of the freely allocated permits and thus eschewing the value they could receive. In both cases, from an economic perspective, firms face the same marginal price signal from the carbon policy.[3] Furthermore, in both cases the *average cost* of complying with the carbon policy is reduced by the benefits received through revenue recycling—either directly from the receipt of free allowances or indirectly through a reduction in taxes.

Free allocation can be appropriate under certain conditions. Similar to broad-based revenue recycling, free allocation is a means to achieve political support for climate policy by offsetting some of its cost. However, in contrast to broad-based revenue recycling, free allocation can be used in a more targeted manner to confer benefits to those most affected. This precision improves the usefulness of free allocation as a tool to offset emissions leakage to lax or non-regulated jurisdictions. However, not all strategies for freely allocating emissions permits are equal, and rules for initial allocations are important. The literature tends to contrast free allocations based on grandfathering with those allocated on the basis of economic output (Fischer & Fox, 2007; 2010). The question then becomes, on what basis might the scope and approach to free allocations be selected? We respond to this question in the following section.

2. THE ECONOMICS OF FREE ALLOCATIONS

This paper discusses the two most common methods of free allocation: output-based allocation (OBA) and lump sum (grandfathering). The answer as to how to select the scope and method of free allocation is related to objectives of the allocation instrument itself—namely, whether the aim is to address emissions leakage in addition to industry competitiveness concerns and building greater political support for climate policy. Output-based and grandfathering allocation methods address these three related objectives in different ways.

The grandfathering method allocates permits in a lump-sum manner based on historical emission profiles. Firms receive their allocations and are free to use them to cover their emissions, or sell them to others. Grandfathering has no direct effect on efficiency—economic activity is left undistorted, but for the intended reduction in emissions. Rather, it is largely distributional. A firm that has historically optimized its production process in the absence of climate policy will have the cost of imposition of the policy mitigated by the receipt of free allocations. By allocating permits in a lump-sum manner, the motivation to reduce emissions is independent from the receipt and amount of the allocation; this maintains the incentive of the policy to reduce emissions while leaving non-emissions-related production decisions undistorted. However, there are concerns that without a clear time frame for their use, firms might grow accustomed to receiving them in lieu of taking strong action on climate change—a veritable moral hazard

[3] From a standard economic perspective, the explicit payment for a permit and the opportunity cost of forgoing its sale provide an equivalent signal at the margin, assuming trading frictions (transaction costs) are low. However, from a behavioural economics perspective, there can be differences in people's willingness to pay versus their willingness to accept. There can also be differences in outcomes due to relative differences in salience of the two methods (Chetty et al., 2009).

(Grubb & Neuhoff, 2006; Hepburn et al., 2006). Also important, as we discuss in further detail below, grandfathering is less effective in limiting emissions leakage, as regulated firms will reduce their output, resulting in an increase in market share for firms in unregulated jurisdictions and associated transfer of emissions.

In contrast, OBAs do distort production decisions and, as a result, affect the efficiency of the climate policy. By linking allocations to output, firms have an added incentive to produce goods: the more they produce, the more permits they are allocated. Therefore, a firm's production decision is no longer independent from its receipt and amount of freely allocated permits. In effect, the clearest way to understand climate policy with OBA is to break it down into its two component mechanisms: a price on carbon and a production subsidy. The distortion introduced by the production-linked subsidy is both good and bad. On the positive side—and central to the argument for OBAs—is its effect on minimizing emissions leakage. The implicit production subsidy confers an additional benefit *at the margin* of production decisions, thus maintaining market share for regulated firms despite the imposition of climate policy. Also, in the presence of pre-existing distortions that have left output inefficiently low (for example, from distortionary taxes or imperfect competition), production subsidies can be efficiency-improving. On the negative side, OBAs are less efficient than lump-sum allocations in terms of emissions reductions in that they weaken the motivation to reduce emissions via reduction in output. This reduces the overall cost-effectiveness of climate policy as a trade-off to achieve the aforementioned goals. Permit prices are higher (in a cap-and-trade system) and emissions reductions are lower (under a carbon tax) with the use of OBA as compared to lump-sum allocation or auctioning (Fowlie, 2012; Fischer & Fox, 2010).

In comparing the two methods, OBAs are capable of addressing all three objectives (leakage, competitiveness, and political support), whereas grandfathering achieves only the last two, albeit with reduced cost.

Effects of Free Allocations on Marginal and Average Cost of Carbon

In order to understand the effect of free allocations on the costs and benefits of various climate policy strategies, it is important to first distinguish between marginal and average costs (Beugin, 2015; Leach, 2012). Often, the stringency of climate policy is considered only in terms of marginal costs—the price of emissions permits in a cap-and-trade market or the price at which a carbon tax is set. The marginal cost is important because firms base many of their business decisions by thinking at the margin—whether to add a new boiler to increase output or buy a new fleet of vehicles to improve delivery times.

The OBA method introduces another dimension to marginal costs. Both OBA and grandfathering share the same price signal to reduce carbon emissions; however, by linking the allocation of an allowance to a firm's output, OBA includes an implicit production subsidy that counteracts this by increasing the marginal *benefit* of production. The motivation to decrease emissions while maintaining production (i.e., reduce along the *emissions-intensity margin*) is maintained in full in both OBA and grandfathering; however, the production subsidy component of OBA weakens the incentive to reduce emissions by curtailing production (i.e., along the *output margin*). In short, OBA weakens some of the emissions-reduction incentive as a trade-off for protection from leakage and international competition. We return to this in more detail later.

But it is insufficient to only consider marginal costs when gauging the stringency of a carbon pricing instrument involving free allocations, which might leave the marginal price untouched (at least along the emissions-intensity margin) while having important implications for the average costs of climate policy. Marginal prices affect what economists call the *intensive margin*—the decision to reduce output or emissions intensity; whereas average prices affect the *extensive margin*—the decision to enter (or exit) a market, and how much to invest.

The average cost of carbon measures the costs that all emitters across a jurisdiction incur as a result of climate policy. Average cost is the total cost of complying with climate policy (in terms of physical abatement costs, carbon tax paid, and/or permits purchased) less the revenue from the sale of any freely allocated permits, divided by the amount of emissions. Critically, free allocation has the potential to reduce average costs; in some cases, to drive them negative.

Average costs matter in two key ways. First, they affect decisions about new facilities: when a firm must decide whether or not to build a new power plant, for example, it is not only the incremental cost of the final tonne of carbon associated with the plant that matters, but all emissions costs. This is what we referred to above as the *extensive margin*. Second, average costs determine the overall scale of the costs of policy for firms. If average costs are very low, it may not be worthwhile for large firms to optimize their emissions reductions to minimize costs, even if marginal costs are high. Under low average costs, it may simply be easier (and cheaper) to pay the carbon price.

Domestic economic performance of two allocation strategies

When free allocations are grandfathered, firms are allocated a fixed number of allowances based on their historical emissions instead of their current output. As a lump-sum allocation, grandfathered allocations have little if any effect on go-forward production decisions.[4] As a result, grandfathering is less effective in dealing with emissions leakage and international competitiveness concerns. As indicated above, some economists have also argued against grandfathering in that it rewards the status quo if firms expect future allocations to reflect historical emissions (Grubb & Neuhoff, 2006; Hepburn et al., 2006). Further, in some cases, emitters' full carbon costs continue to be passed on to final consumers via higher prices, with the result being that grandfathered allocations represent a windfall profit to the emitter (Sijm et al., 2006; Fabra & Reguant, 2014).

In contrast to grandfathering, OBAs are a method for distributing free allowances that can be updated to account for changing market conditions (Fischer & Fox, 2007, 2010). Firms are allocated permits proportional to their output; in effect, this acts as an output subsidy. In general, output subsidies reduce allocative efficiency of an economy by providing support for a specific sector. But this assumes perfect market conditions. The distortion induced by OBAs can be beneficial in the presence of (i) imperfect competition and firm market power, (ii) pre-existing distortionary taxes, and (iii) trade exposure to less regulated jurisdictions. OBAs can outperform the grandfathering method under the reality of these imperfect market conditions. By providing a subsidy to output, OBAs encourage more production, counteracting the incentive for firms to respond to the carbon price by reducing production. Increasing production reduces the deadweight loss associated with inefficiently low levels of production observed under imperfect competition (market power) and in the presence of distortionary taxes. Importantly, OBA limits emissions leakage by incentivizing domestic production, which might otherwise be replaced by comparable production in jurisdictions with weaker climate policy.

[4] Grandfathering can, by reducing average costs, affect the extensive margin of production decisions.

The strength of OBAs in inducing production is also its weakness. This is because OBAs weaken the incentive for recipient firms to reduce their production and associated emissions, meaning that the bulk of emissions reductions must be realized by the unallocated sectors in the economy. This raises permit prices and thus the overall cost of climate policy. In other words, if an emissions-intensive industry is being subsidized in its production (and thus emitting heavily), this increases the burden on the other sectors. Under a carbon tax, where the price is fixed, an output-based rebate results in less emissions reductions as compared to lump-sum, or grandfathered, rebating. This is the cost of the trade-off for protection from leakage and international competition.

To put some numbers on the effects of the two allocation methods, Fischer and Fox (2010) develop a quantitative model using computable general equilibrium analysis. They consider several different allocation strategies in their model analyzing a 20% reduction in economy-wide emissions in the United States. First they consider two different OBA scenarios, which we refer to as Narrow OBA (15% OBA allocations) and Broad OBA (50% OBA allocations), against a cap-and-trade system where all allowances are auctioned. The Narrow OBA involves granting 15% of total allowances to emissions-intensive trade-exposed (EITE) sectors. In the Broad OBA scenarios, in addition to the 15% first granted, an additional 35% is allocated to the electricity sector. In this first set of comparisons, all allowances not freely allocated by OBA are auctioned. In the second set of comparisons, the two OBA scenarios are compared with a scenario where all permits are grandfathered instead of auctioned. In this second set, all allowances not freely allocated by OBA are freely allocated by the grandfathering method. Altogether, Fischer and Fox model six different permit allocation strategies.

The clearest result from free allocations, as shown in Table 1, below, is their effect on average costs. Comparing the 100% grandfathering to 100% auctioning strategies, we see clearly the effect of the free allocations, with average costs being reduced by approximately 20%, from roughly $33 to $26 under grandfathering. The difference in average costs between 100% auctioning and 100% grandfathering gives one a sense of the trade-off required in exchange for political support.

As the extent of OBA increases, so too does the average cost. This is due to the rise in permit prices. As explained by Fischer and Fox (2010), the choice of auctioning or grandfathering has little effect on permit prices, while the implicit production subsidy of OBA changes the relative prices of emissions-intensive goods. The Narrow OBA scenario appears to only add $1 to the permit price of the complete auctioning/grandfathering scenarios; however, under the Broad OBA scenario, the price rises by nearly $10 per t$CO_2$e. Broader coverage weakens the incentive to reduce emissions via production curtailments on a larger share of the economy, thus the marginal cost to achieve the required emissions reduction rises. In turn, average costs also rise as OBA coverage increases, and, as expected, average costs are substantially lower in the grandfathering/OBA cases as compared to auctioning/OBA.

Table 1: Percentage Change Summary Economic Indicators for the U.S. in order to Meet 20% Emissions-Reduction Target

	Auction and Revenue Recycling (ARR)				Grandfathering		
	100% ARR	Narrow OBA, 85% ARR	Broad OBA, 50% ARR		100% Grandfather	Narrow OBA, 85% Grandfather	Broad OBA, 50% Grandfather
Welfare	-0.16	-0.13	-0.18		-0.33	-0.27	-0.29
Production	-0.56	-0.57	-0.57		-0.96	-0.92	-0.83
Employment	0.17	0.13	0.02		-0.48	-0.43	-0.40
Real Wage	0.52	0.39	-0.04		-2.0	-1.8	-1.6
Labour tax change (%)	-3.2%	-2.7%	-1.8%		1.1%	1.0%	1.0%
Permit Price ($US/tCO2e)	$33.2	$34.3	$43.9		$32.1	$33.3	$42.9
Average Cost* ($US/tCO2e)	$33.2	$33.3	$39.5		$25.7	$26.6	$34.3

Source: Fischer and Fox (2010)
*Estimated by authors based on Beugin (2015) and modelled on a relative reduction of emissions by 20%.

Effects on international leakage

Studies by Fischer and Fox (2010) and Demailly and Quirion (2006) suggest that international leakage is a real issue in the absence of free allocations. Any domestic reductions that carbon pricing achieves, even in their most stringent and revenue-neutral forms, can be easily outdone by rising emissions of international competitors selling into the domestic market. Significantly, while grandfathering does improve the profitability of firms, as discussed above, it does very little to address international leakage. Rather, as a number of studies show, to effectively combat leakage, the use of OBAs as the basis of free allocations is the more appropriate allocation strategy.

A first study by Fischer and Fox (2010) finds that auctioning and grandfathering have almost equivalent leakage rates, while output-based free allocations show considerable improvements. In their study, for EITE sectors, OBA leads to a leakage rate of under 14% versus a 28% rate for auctioning and grandfathering. Looking outside the EITE sector to the global economy, overall leakage rates are approximately 10% without OBA, which is brought down to 8% when limited OBAs are used to protect vulnerable sectors of the economy. OBAs generate these ameliorative effects because they act as subsidies to vulnerable industries and protect them from international competition, but also incentivize them to seek out emissions-intensity reductions within the firm in order to sell allowances on the carbon market.

Similarly, in their comparison of grandfathering and OBA free allocations in the European cement sector, Demailly and Quirion (2006) find leakage rates of 50% under grandfathering, while under 10% when OBAs are used. Also important, leakage rates increase with the price of carbon under grandfathering, while actually declining under OBA. These trends can be explained by the differences in how these two allocation strategies work. Under grandfathering, cement production in the EU declines and is replaced to a significant extent by imports coming from, they assume, states without comparable climate policy. Under OBA, there is no drop in production due to the implicit output subsidy; emissions reductions are due to greater carbon efficiency in the cement sector.

Overall, the literature indicates that not all strategies for allocating free allowance are the same. Indeed, grandfathering does relatively little to address international leakage and constitutes little more than a transfer of resources that protects the profit margins of firms. While the profitability of firms is an important issue in light of competitiveness concerns resulting from carbon pricing, other strategies for free allocation such as OBAs appear to do a better job of addressing leakage while also improving economic welfare.

Competitiveness pressures among Canadian provinces

As suggested above, the key concern in designing the scope and method of free allocations is to know which sectors or provinces are most vulnerable, based on their emissions intensity and trade exposure. In other words, which sectors would be most at risk of international competition if a province went ahead with carbon pricing? Which Canadian provinces might harbour the most EITE industries where free permits might be particularly important? These are questions that we only treat cursorily by examining provincial-level data. The devil is in the sectoral- and firm-level details, a level of analysis that is beyond the scope of our current study.

We begin by using two key criteria to identify potentially vulnerable provinces using a modified methodology used by Beale et al. (2015): carbon cost and trade exposure. Carbon cost measures the dollar value of a province's carbon-price payments as a share of that province's GDP—assuming a carbon price of $30 per tonne of CO_2e. This value is also equal to the carbon price multiplied by the province's emissions intensity. Carbon cost is measured here as a share of each province's GDP, assuming that firms' production methods are unchanged. A province's trade exposure measures the extent to which firms in that province compete with firms from outside their province. Trade exposure for a sector is defined as the sum of the province's imports and exports divided by the sum of the province's production (i.e., GDP) and imports (California Air Resources Board [CARB], 2012).[1] A province with a trade exposure of zero thus has neither imports nor exports. All data are derived from 2013.

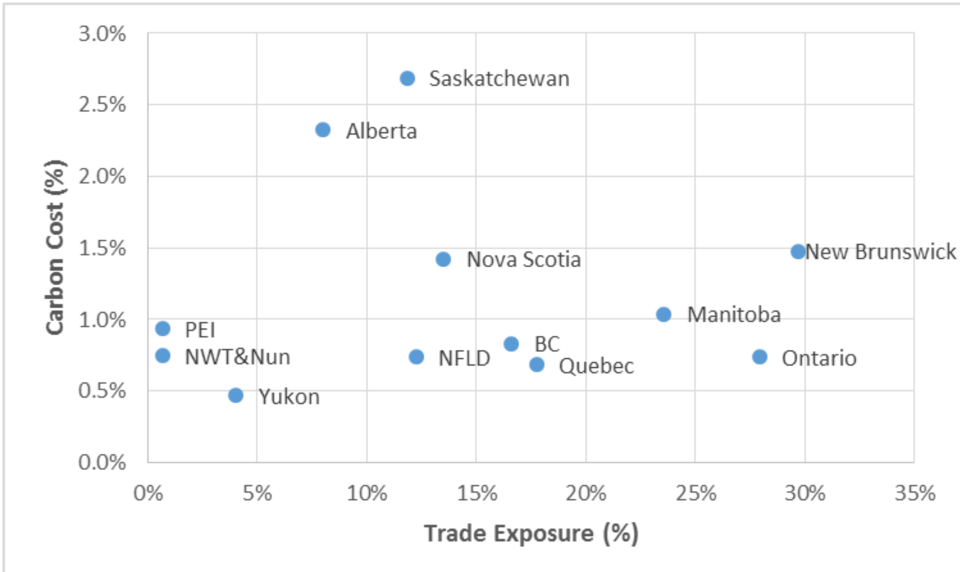
Results presented in Figure 1 suggest that Alberta and Saskatchewan are the two most emissions-intensive provinces, given their relatively high carbon cost. This is not surprising given the relative importance of oil and natural gas production. However, the most trade-exposed provinces, New Brunswick and Ontario, have only moderate carbon cost. It should be noted that all provinces demonstrate relatively modest carbon costs (under 3%), indicating the important role of the low-emissions service sector—a finding consistent with Beale et al. (2015). The implication is that if a national system of emissions trading were implemented, Alberta and Saskatchewan might have grounds for receiving more free allocations than other provinces. As indicated above, this would increase the costs of reducing emissions elsewhere, which, if shared outside of Alberta and Saskatchewan, might complicate the politics of interprovincial burden sharing.

Further politically sensitive questions are likely to arise when considering individual sectors and firms. Should free allocations be granted to growing sectors of the economy, including the Alberta oil sands (CAPP, 2015) and shale gas in British Columbia (Campbell & Horne, 2011)? Emerging evidence suggests that the hard cap of emissions-trading systems deters jurisdictions with such growth from joining cap-and-trade in favour of intensity-based systems (Houle et al., 2015). Free allocations are ostensibly the

[1] Source of 2013 total provincial exports and imports was Industry Canada's *Trade Data Online* website: https://www.ic.gc.ca/app/scr/tdst/tdo/crtr.html?&productType=HS6&lang=eng.

solution for both systems. Yet it is worth repeating that Canada has proposed an economy-wide target to reduce its emissions by 30% below 2005 levels by 2030 (Canada, 2015)—an absolute and not an intensity-based reduction. If this commitment is to be maintained, real reductions will need to come from somewhere.

Figure 1: Competitiveness Pressures by Province



3. THE POLITICS OF FREE ALLOCATIONS

Domestic political factors

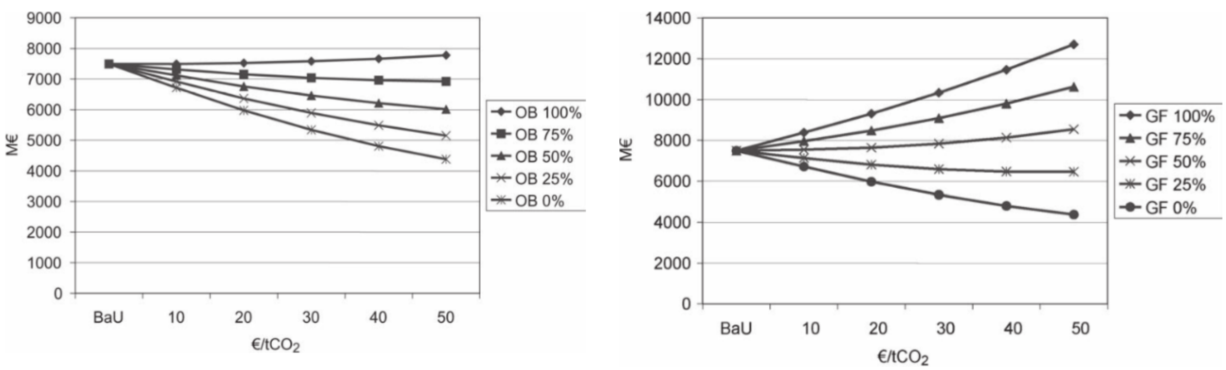
Free allocations are also important because they confer certain political advantages. As indicated earlier, certain sectors of the economy might genuinely require free allocations to mitigate competitiveness risks. Yet, if one sector is allocated more free permits than another, this will create a distributive impact, in the sense that one sector will receive a benefit that the other will not have access to. It is important for governments to be able to clearly explain why only certain sectors of the economy receive free allocations and why others do not.

Once sectoral coverage has been determined, another challenge is to determine the most effective allocation strategy. Earlier we reviewed the literature on free allocations, concluding that OBAs address international leakage much better than does grandfathering, while also having welfare impacts comparable to revenue-neutral carbon pricing instruments. Yet we know that grandfathering has dominated as a *de facto* allocation strategy. In political terms, the reason that grandfathering by participants has historically been championed over OBAs is that they represent a lump-sum payment that directly boosts profitability.

Demailly and Quirion (2006) find that grandfathering at least 50% of past emissions is enough to maintain aggregate profitability of the European cement sector at its business-as-usual level while grandfathering all emission-allowances firms to significantly increase profitability (Figure 2b). The story is quite different for OBAs. Relative to grandfathering, OBAs transfer surplus from producer to consumer as a result of higher production levels (and thus lower prices for goods), rather than strictly affecting firm profitability. Only at an allocation rate of 75% OBAs did Demailly and Quirion (2006) find that OBAs kept firm profitability at pre-policy levels (Figure 2a). At lower allocation rates, OBAs tend to reduce firm profitability. Governments will need to weigh the impact of OBAs on firm profitability against the broader welfare gains they deliver, particularly in contrast to grandfathering. However, where OBAs really distinguish themselves from grandfathering is with regard to their impact on international leakage, discussed earlier.

Figure 2: Comparison of Two Types of Free Allocation on EU Cement Firm Profitability

(a) Output-Based Free Allocations **(b) Grandfathered Free Allocations**



Source: Demailly and Quirion (2006). Note profitability measured as EBITDA (Earnings Before Interest, Taxes, Depreciation, and Amortization).

There is a tendency for environmentalists and economists alike to pan grandfathering as an inappropriate strategy for allocating emissions, particularly relative to OBAs in light of challenges of international leakage. However, from a political point of view, even grandfathering has the advantage of coaxing reluctant firms into a cap-and-trade system and offering them an incentive to reduce emissions. It is important to recall that, even when freely allocated, emissions allowances represent an incentive to reduce emissions (Jegou & Rubini, 2011). Most emissions-trading systems have made use of grandfathering in their initial stages.

In the EU emissions trading system (ETS), grandfathering was the dominant strategy, where it constituted 95% of all allocations during Phase 1 (2005-2007) and 90% in Phase 2 (2008-2012) (Hepburn et al., 2006). Yet in the most recent Phase III (2013-2020) of the EU ETS, auctioning is now the dominant strategy, constituting 40% of all allowance in 2013 and set to gradually increase (European Commission, 2016a). At the same time, grandfathering has been replaced with free allocations based on performance standards (European Commission, 2016b), which bear certain similarities with OBAs (Fischer & Fox, 2007). Similarly, as discussed in further detail below, in Quebec, the amount of free allowances stood at approximately 80% of emissions regulated under the cap in its initial stages, but currently stands at under 30%.

But looking outside large emitters that are currently the main beneficiaries of free allocations, it appears possible to generate greater acceptance of emissions reductions and expanding a cap-and-trade system by allocating permits to smaller firms for free as well. One strategy would be to lower the threshold at which facilities are brought under the cap as low as is practically feasible and offer them emissions permits for free. Consider the coverage of climate policy instruments in Quebec, which is currently set at a threshold of 25 $ktCO_2e$. Only firms that produce more than 25 $ktCO_2e$ are included under Quebec's cap, while small and medium businesses are essentially asked to bear the costs associated with cap-and-trade in terms of rising energy prices without receiving any of the newly created assets. For example, drivers in Quebec were poised for nearly a $0.02 per litre increase in gasoline prices in early 2015, when the cap was extended to liquid fossil fuel distributors (Desjardins, 2014), though any such possible price increase was quickly overshadowed by the global drop in oil prices during that same time (Baffes et al., 2015). Under these conditions, small emitters therefore have a vested interest to mobilize against the cap-and-trade system. The situation facing small and medium enterprises is similar to that of gasoline, oil, and natural gas distributors in Quebec, which have also not received any free allocations. However, with gasoline, oil, and natural gas distributors, much of the additional costs associated with the cap-and-trade system are passed on to the consumes, given the relative inelasticity of demand for these products in Quebec (Ryan & Razek, 2012). This appears to have dampened resistance. Such an option will not be available for many small and medium businesses because, in comparison to fuel and gas distributors, consumers are much more sensitive to the prices at which these goods and services are provided. Under these conditions, it is perhaps strategic to also freely allocate allowances to these sectors of the economy, even if they are not necessarily at competitive risk. Such an argument finds support in the political economy literature. For example, Hahn & Stavins (2011) observe that governments design emissions trading to build a constituency that supports the system.

Lowering the threshold level to include emitters under the cap would not be without obstacles, including increasing the complexity of the cap-and-trade system. A simpler alternative to build support for cap-and-trade while also addressing its impact on small and medium businesses is through complementary policies, such as dedicated financial assistance, tax exemptions, or reduced corporate tax rates. This appears to be the approach finally taken by Quebec Finance Minister Leitão, in his December 2014 economic update, where the impact of the carbon market on small and medium businesses was acknowledged and several measures proposed (Ministère des Finances du Québec, 2014).

International political factors

Free allocations are not the only way to address competitiveness concerns, but they might be among the most politically feasible. Among environmental economists, there is general agreement that free allocations have attributes that are comparable to a border carbon adjustment as a means of addressing competitiveness concerns, though the latter has considerable broader sweep and hence greater potential to reduce emissions (Fischer & Fox, 2012; Monjon & Quirion, 2011). The fundamental difference between border carbon adjustments and standard free allowance approaches is the effective extension of the carbon pricing regime to entities outside the implementing jurisdiction, which dramatically increases its impact.

However, it is generally acknowledged that a border carbon adjustment would be difficult to implement under current international trade rules (Condon & Ignaciuk, 2013; Holzer, 2014; Zane, 2011). Nonetheless, Stiglitz (2006) argues provocatively that *not* pricing carbon is a *de facto* domestic subsidy that should be illegal under international trade law, while Nordhaus (2015), a prominent climate change economist, sombrely concludes that current international climate change regime, largely comprising carrots, will continue to prove unable to deter strong incentives toward free-riding without the big stick that a carbon tariff can represent. Because this paper focuses on provincial climate policy options, we do not address these border tax issues; tariffs and international trade are generally understood to be federal jurisdiction.

We also know that barriers to interprovincial trade exist in Canada (Agnosteva et al., 2014; Harmes, 2007; Tombe & Winter, 2014; Wilford, 2015), largely in the form of duplicated regulatory burden between various levels of government.

There have been very few attempts to impose a carbon border tax adjustment, yet California has certain rules for regulating emissions associated with electricity produced out of state and is also currently experimenting with other climate policy tools that extend its reach beyond U.S. international borders. These are discussed in further detail below. For present purposes, it is worth noting that, similar to the international trade regime, there are considerable concerns about the constitutionality of California's attempt to regulate emissions related to the production of electricity in other U.S. states (Alcorn, 2013). Particularly important is the so-called dormant Commerce Clause, an important U.S. federal power that restricts states from passing legislation that improperly burdens or discriminates against interstate commerce. While the Obama administration appears disposed to the idea that California's climate policy does not infringe on the dormant Commerce Clause, this could change under a new administration. The intricacies of California's electricity emissions accounting system are beyond the scope of this study. However, the implication is that a border tax adjustment might face similar accounting and legal challenges, which is another reason to consider the relative ease of free allocations.

4. FREE ALLOCATIONS IN PRACTICE

Free allocations in Quebec's cap-and-trade system

In Quebec, the Ministry of Sustainable Development, Environment and the Fight Against Climate Change (which goes by the French acronym MDDELCC) determines each year the number of emissions units that will be allocated freely to emitters, based on efficiency benchmarks that are calculated using criteria elaborated in the climate policy regulations.[2] Free allowances were allocated based upon an emitter's average historical emissions intensity between 2007 and 2011, and adjusted for production output: 100% allocation for fixed process emissions, 80% combustion emissions, and 100% for emissions from other sources (EDF & IETA, 2012). Sectors perceived as being trade vulnerable and eligible to receive free allocations include aluminum; lime; cement; chemical and petrochemical industry; metallurgy; mining and pelletizing; pulp and paper; petroleum refining; glass containers, electrodes, gypsum products; some agri-food establishments (MDDELCC, 2014b). However, certain other sectors of the economy are allocated only a certain number of free allowances. Unfortunately, it is not clear how many free allowances are allocated to specific firms in Quebec—only the total number of free allowances is published in the *Gazette officielle du Quebec* (Clean Energy Canada, 2015). In practice, the firms have received approximately the same amount of free allowances since 2013, with the number of freely allocated units gradually dropping by between 1% and 2% each year beginning in 2015 (MDDEFPQ, 2013).

We estimate the total number of free allocations stood at 18.9 $MtCO_2e$ in 2013 and approximately 17.7 $MtCO_2e$ in 2016 (Table 2).[3] Given the small coverage of the cap in 2013 and 2014—set at 23.2 $MtCO_2e$ in

[2] Sections 39 to 44 "Allocation" and Appendix C, Part II, "Calculation methods for allocation of emission units without charge", *Regulation respecting a cap-and-trade system for greenhouse gas emission allowances*, (CQLR, chapter Q-2, r.46.1).

[3] The precise amount of total free allocations granted in 2016 will not be known with certainty until the end of the year. MDDELCC retains 25% of free allowances until the following year for which they are to be used, allowing the emitter's emissions to be verified and adjusts the allocation amount accordingly. The 25% retention of allowances addresses perceived weaknesses

both years—these free allocations constituted more than 80% of total covered emissions. However, the share of free allocations in Quebec dropped considerably in 2015, when emissions associated with the distribution of gasoline, diesel fuel, propane, natural gas, and heating oil were brought under the cap—sectors themselves ineligible to receive free allowances. Consequently, free allocations now constitute less than 30% of total covered emissions.

The change in the share of free allocations has a considerable impact on average costs of the Quebec cap-and-trade system. While the marginal cost—the market price of a permit—has increased gradually over time from \$10.8/tCO_2e in 2013 to an estimated \$17/tCO_2e in 2016, average costs have seen much more significant increases. Average costs have risen from \$2/tCO_2e in 2012, when free allocations constituted the majority of allowances circulating in the system, to over \$12/tCO_2e in 2016.

Table 2: Change in Marginal and Average Costs of Quebec's Cap-and-Trade System, 2013-2016

	Free Allocations* $MtCO_2e$	Covered Emissions ("Cap")** $MtCO_2e$	Coverage*** %	Share Free Allocations %	Marginal Cost ("Market Price")[¥] $CDN	Average Cost $CDN
2013	18.9	23.2	28%	81.4%	$10.8	$2.0
2014	18.7	23.2	~28%	80.4%	$12.0	$2.3
2015	17.9	65.3	~80%	27.4%	$15.9	$11.5
2016	17.7	63.2	~80%	28.0%	$17.0	$12.2

* MDDELCC (2014a, 2015a, 2015b, 2016). Note that for 2015 and 2016, only an estimated 75% of free allocations have been granted and feature in the MDDELCC reports. A transformation was necessary to estimate total free allocations.
** *Determination of annual caps on greenhouse gas emission units relating to the cap-and-trade system for greenhouse gas emission allowances for the 2013-2020 period* (CQLR, chapter Q-2, r. 15.2).
*** Based on 2013 emissions in Quebec of 82.6 $MtCO_2e$, the latest reported (ECCC, 2015).
[¥] Average annual settlement price. Historically, settlement prices have tacked closely to carbon floor price (Purdon & Sinclair-Desgagné, 2015), though it is possible that this changes in 2016. Quarterly joint California–Quebec carbon auction prices can be found at http://www.mddelcc.gouv.qc.ca/changements/carbone/avis-resultats.htm.

Output-based allocations in Alberta's proposed climate policy

Alberta's recently announced climate change policy can be broadly separated into two components: (1) an end-use carbon levy, and (2) a tradable permit scheme for the electricity sector and large industrial facilities—those emitting more than 100 $ktCO_2e$ per year (Leach et al., 2015). The policy for large industrial facilities uses OBAs as a central feature of the policy; for the purposes of this paper, it is this component of the policy we will discuss here.

In many ways, Alberta's policy is similar to a carbon tax. Like a tax, the carbon price is known: \$20/tonne in 2017, rising to \$30/tonne in 2018, and escalating thereafter at 2% annually plus the rate of inflation (or at a similar rate to comparable/competitor jurisdictions). However, unlike a tax, Alberta's policy requires that emitters obtain permits to cover all their emissions. These can be procured via the purchase of offsets (a validated reduction of emissions in an uncovered sector); by trading with other covered entities

of the early phases of the EU ETS, which was bedevilled with over-allocation attributed to a reliance on historical emissions data for setting firm-level allowances (Ellerman & Buchner, 2008).

that hold allowances greater than their needs; or by purchasing permits directly from the government at the above-posted backstop price. There is no cap set on the total amount of emissions (except for a targeted 100 Mt cap on one sector—the oil sands).

To address the significant concerns of an emissions-intensive province with several trade-exposed sectors, Alberta's policy makes use of OBAs. Specifically, the policy sets sector-specific emissions-intensity benchmarks as the rate at which permits are allocated. While precise details on the benchmarks are not yet available (at the time of writing the final legislation has not yet been written), the climate panel recommendations reference top quartile performance as an appropriate sectoral benchmark (Leach et al., 2015). To get a sense of what this means, Table 3 offers the following stylized example of representative oil sands facilities.

Table 3: Carbon Costs of Representative Oil Sands Facilities Under Alberta's Proposed Policy

	High Emitter	25th Percentile Emitter	Low Emitter
Facility Emissions Intensity	0.1 tCO_2e/barrel	0.055 tCO_2e/barrel	0.045 tCO_2e/barrel
Sectoral Benchmark Intensity	0.055 tCO2e/barrel		
Marginal Carbon Price	$30/tCO2e		
Average Carbon Cost (after OBA; per barrel)	$1.35/barrel	$0	($0.30)/barrel; i.e., gain
Average Carbon Cost (after OBA; per tonne)	$13.50/$tCO_2e$	$0	($6.66)/ tCO2e; i.e., gain

This simple example highlights how the OBA strategy drives a wedge between marginal and average costs of climate policy. All three representative facilities face the same $30/$tCO_2e$ marginal cost of carbon. In this manner, all facilities have the same incentive to reduce their emissions intensity: every one less tonne emitted in the production of a barrel of oil benefits all facilities equally by $30. However, along the output margin, the incentives differ greatly. The high emitters still have an incentive to reduce output, as they face a cost of $1.35 for each barrel of production, whereas the low emitters actually *receive* additional revenue from production. At first glance, for environmentalists and many others, this may appear unpalatable; it is, however, a necessary consequence of the goal to protect competitiveness of a trade-exposed sector and limit leakage. Over time, these divergent costs increase the competitiveness of the low emitters, vis-à-vis high emitters, changing their relative market share and reducing overall emissions. Furthermore, the panel recommends that the benchmark intensity be reduced over time to increase the overall stringency of the policy.

The key to Alberta's policy is its incentive to reduce the emissions intensity of its economy. Output-based allocations encourage emissions reduction by reducing the emissions intensity of both existing production as well as in the design phase of new facilities, while purposefully protecting the competitiveness of trade-exposed sectors and limiting emissions leakage. The panel's report expresses this succinctly:

> The use of output-based allocations of emissions permits lowers the average cost of compliance for trade-exposed sectors, while ensuring that the carbon price provides a reward for all emissions reductions achieved, except for those which occur due to decreases in production. (Leach et al., 2015)

Alberta's policy highlights another trade-off between efficiency and distributional concerns. For an efficient policy, facilities should face the same marginal cost of emissions. This is the so-called *equimarginal principle*. In other words, a tonne is a tonne is a tonne. We have already discussed the reasons to alter the prices at the output margin to protect trade-exposed firms and limit leakage. But Alberta further alters the relative costs on the output margin inter-sectorally by applying sector-specific performance benchmarks. For example, if one was concerned with lowering the emissions intensity of overall oil sands production, a single performance standard could be applied, resulting in a relatively large cost to emissions-intensive steam-assisted gravity drainage (SAGD) facilities, while effectively subsidizing lower-emissions mining operations. This would create a transfer of wealth and market share from SAGD to mining. If the sole concern were emissions reductions at lowest cost, the single benchmark would be desirable, as it would increase the market share of the lower emissions form of production and encourage more future facilities to be built according to this design.[4] However, to alleviate distributional competitiveness concerns, Alberta's policy offers an architecture that allows the government to set sector specific benchmarks so that relative costs are incurred *within* a narrow sector (e.g. a separate benchmark for SAGD as for mining), rather than across sectors. This reduces the overall efficiency of the policy, but is a useful feature to satisfy distributional (and *ergo* political) concerns.

Overall, Alberta's proposed policy is a significant improvement over the Specified Gas Emitters Regulation (SGER) carbon policy that is currently in place. In contrast to the proposed policy that uses sectoral benchmarks, the SGER uses historical *facility level* emissions as its basis for OBAs.[5] This grants more emissions allocations to facilities that have historically been higher emitters, effectively conferring a cost advantage on the higher emitters. With the sectoral benchmarks, the reverse is true—those with lower emissions gain a cost advantage, creating a greater incentive to both increase their market share and encouraging new investment with their lower emissions technology. Further, the expectation of continued facility-level benchmarking in the SGER weakened the incentive to reduce emissions intensity; the new policy changes that.

The cement sector in British Columbia and Quebec

Comparison of the cement sector in British Columbia and Quebec is illustrative of the importance of addressing competitiveness concerns in trade-exposed sectors of the economy. As very real examples of the political challenges involved with the implementation of Canadian climate policy, we briefly touch on these matters. However, we caution that the effects of climate policy on the cement sector in B.C. and

[4] This conclusion, however, assumes that there are no other market failures present in the economy. For example, a shift toward lower-emissions mining operations could exacerbate tailings ponds and other surface disturbance externalities.
[5] One could, in effect, characterize SGER as using sectoral benchmarks, but with the sectors being defined at the extremely granular facility level.

Quebec are debatable and currently the subject of more sophisticated econometric analysis by the Ecofiscal Commission.

As originally implemented, the B.C. carbon tax applied to domestic cement producers but not cement imported from the U.S. and Asia. As a result, the Canadian Cement Association has argued that the purchase of imported cement has increased in B.C. to the detriment of local industry (McSweeney, 2011). Facing criticism, the B.C. government committed $22 million in transitional incentives to encourage the B.C. cement industry to adopt cleaner fuels and further lower emissions intensities (Government of British Columbia, 2015a; Cement Association of Canada, 2015). In Quebec, the cement industry was among the industries targeted by the first Quebec carbon pricing policy, the annual Green Fund duty, which was implemented in 2007, though phased out in 2013. At even this modest carbon tax, Quebec cement companies claimed to be at a competitive disadvantage to firms in Ontario, the U.S., and Asia (Banerjee, 2007). The cement industry in Quebec currently benefits from free allocations under the current cap-and-trade regulation.

More detailed analysis by the Ecofiscal Commission will attempt to shed light on the relationship between climate policy and the cement sector in B.C. and Quebec.

Free allowances in California

In the first compliance period, 2013-14, California will freely allocate most allowances to regulated entities. Between 2015 and 2020, the percent of freely allocated allowances will gradually decrease as more and more are auctioned off. For each industrial facility, except for refineries and the electricity sector, allowance allocations are determined by Equation 1, below:

California Free Allowances =	**(1) Total product output or energy consumed * (2) emissions benchmark * (3) cap adjustment factor * (4) industry assistance factor**	**(Equation 1)**

First, for emitters using a product-based methodology, CARB will use a facility's annual output and emissions benchmark from the previous two to four years to determine annual allowance allocation in a specific year. For a facility using an energy-based methodology, CARB will use the facility's historical annual arithmetic mean for fuel, electricity, and/or steam consumed to determine initial allowance allocation. Second, CARB determines two types of benchmarks. For a product-based benchmark, CARB calculates an emissions allowance per unit produced, using an emissions-efficiency benchmark identified for specific industries in the regulations (Table 9-1 of the *California Cap Regulation*). For energy-based benchmarks, CARB calculates an emissions allowance per unit of fuel, electricity, and steam over historical baseline period. Third, the cap adjustment factor is a fraction that decreases to reflect a tightening emissions cap. Finally, an industry assistance factor is a percentage of free allowances an emitter is provided based on the industry's leakage risk (Table 4). CARB divides the industrial sector into three leakage classifications: high, medium, and low. While all three leakage classifications are allocated 100% free allowances in the first commitment period, those in the medium and low classes will see their free allowances decrease over the remaining two compliance periods. California has special rules for allocating allowances for refineries, which are slightly more complicated.

Table 4: California's Industrial Assistance Factors

Leakage Classification	First Compliance	Second Compliance	Third Compliance
High Leakage			
Such as oil and gas extraction, paper mills, and chemical and cement manufacturing	100%	100%	100%
Medium Leakage			
Such as petroleum refineries and food manufacturing	100%	75%	50%
Low Leakage			
Such as pharmaceutical manufacturing	100%	50%	30%

Source: Adapted from *California Cap Regulations*, Table 8-1.
Note: CARB has recently proposed amendments to the regulation that would extend the transition assistance from the first compliance period into the second compliance period for the industrial sector. What would have been the allocation scheme for the second compliance period would then become allocation in the third compliance period.

Allocating emissions allowances in California's electricity sector has proven particularly challenging because of the need to balance electricity prices with climate policy. There have also been very active efforts in California to make electricity accessible to all segments of the population, which is at odds with efforts to increase prices on emissions. The need to balance emissions reductions with affordable electricity has resulted in a considerably more complex system for allocating emissions allowances in California's electricity sector. Here, free allocations are first awarded to publicly and privately owned electricity distribution utilities; however, these must actually be re-auctioned. Auction proceeds generated in this manner are used to compensate electricity customers for increased electricity prices resulting from the cap-and-trade program.

California's climate policy beyond borders

California is also unique in that certain elements of its climate policy are designed to achieve effects beyond its borders. First, in an effort to level the playing field with surrounding states, California requires that emissions associated with imported electricity comply with the provisions of its cap-and-trade program in the same way as emissions from electricity generated in California (Bushnell et al., 2014). In 2008, imported electricity accounted for approximately one-third of electricity supplied to the California grid, and half of electricity sector emissions; all together, imported electricity is estimated to constitute 9% of the state's total emissions (CARB, 2015). Such emissions are to be included under California's cap. So-called first deliverers—firms that import electricity into California—are accountable for emissions associated with electricity produced out of state.[6] While this may appear straightforward, there is considerable concern that even if California importers switch to low-emissions out-of-state electricity, this might not represent a real emissions reduction (Cullenward, 2014). For example, California might import electricity from a new low-emissions plant built in addition to the older high-emissions out-of-state plant, which continues to serve other non-Californian customers. Such "resource shuffling" is prohibited under California's cap-and-trade regulations, though many experts are concerned that the system can be easily scammed.

[6] *California Code of Regulations*, title 17, Article 5: California Cap on Greenhouse Gas Emissions and Market-based Compliance Mechanisms § 95852(b).

Second, there is the prospect of California's potential border carbon adjustment for the cement sector (CARB, 2014a). CARB considers the cement industry to be at high risk of emissions leakage, and cement firms will continue to receive freely allocated allowances to cover a majority of their emissions through 2020 (Zuckerman et al., 2014). In addition to free allocation, California has considered a number of additional border carbon adjustment options to level the playing field in the cement sector (CARB, 2014b). These include (i) including cement importers in the cap-and-trade program, (ii) imposing a cost on cement importers based on allowance prices, and (iii) creating an independent, "mini" cap-and-trade system for importers with equivalent program stringency. It is not clear at this point which option CARB has decided to pursue, but it is currently developing an incremental border carbon adjustment measure that would effectively make all cement suppliers to California responsible for their full carbon footprint (EDF, 2015).

Given that Quebec has partnered with California on emissions trading, a relevant question to ask is whether Quebec should also take part in the border carbon adjustment in solidarity with California. This will require review of trade policy in Quebec and Canada, especially in light of NAFTA (Selin & VanDeveer, 2009).

CONCLUSION

Free allocations offer considerable economic and political advantages, and, under certain conditions, are more appropriate than revenue-neutral climate policy as generally understood. Most importantly, they allow governments to address competitiveness concerns, especially for the emissions-intensive trade-exposed sectors of the economy, and limit emissions leakage.

Free allocations borrow certain elements of revenue recycling—namely, reducing the burden of climate policy by conferring economic advantage to recipients; however, free allocation offers the opportunity to do so in a more targeted manner, better aligning the recycled revenue with the economic burden of a firm or sector.

Like revenue recycling, free allocation is a tool to build political support for climate policy and offset its economic costs. The grandfathering method does this explicitly by allocating allowances in proportion to historical emissions in a lump-sum manner. In doing so, historically high-emitting firms are initially protected from the cost of climate policy while maintaining the incentive to reduce emissions. The method of output-based allocations (OBAs) links the allocation of allowances to economic output, creating a production subsidy to mitigate international competitiveness and leakage concerns. OBAs are particularly useful given the reality of trade-linked markets and a patchwork of global climate regulations with differing stringency (and existence).

For most of the world's existing cap-and-trade systems, grandfathering has been the norm at initial stages, though most, including the EU ETS and Quebec–California emissions-trading systems, are well on their way to reducing the reliance on this method in favour of greater use of auctioning and OBAs. The real challenge will be to ensure that the transition away from free allocations is successfully achieved.

We recommend the following principles to ensure that free allocations are effectively used. First, they should be allocated through a transparent process only to a limited number of sectors genuinely representing a competitive risk with trade exposure. Second, free allocations should be allocated to individual firms on the basis of economic output when international competitiveness and leakage are real concerns. Calls for grandfathering must be used sparingly and fleetingly. Third, free allocations need to be implemented with a long-term vision that clearly establishes that the amount of free allocations declines over time. Free allocations are key to overcoming political and economic hurdles to implementing domestic carbon pricing—a necessary step in fostering broader global action on climate change. Growing momentum toward greater climate action in competitor countries themselves, including China (Lo, 2012; Tollefson, 2015), will be promoted by a credible and transparent free allocation process here in Canada.

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