Intensity-Based Climate Change Policies in Canada

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Pour réduire les émissions de gaz à effet de serre (GES) des grandes industries, le gouvernement canadien propose d’adopter une approche utilisant une norme standard de rendement d’émissions négociables ; dans un tel cas, c’est l’intensité des émissions, plutôt que leur niveau absolu, qui est réglementée. À la différence du système de plafonnement et d’échange, ce type d’approche ne garantit pas un niveau global de réduction des émissions, et c’est ce qui a entraîné beaucoup de critiques. Toutefois, étant donné la dynamique des normes de rendement, cette approche peut permettre d’améliorer la baisse de compétitivité internationale d’un pays qui adopte, en matière de GES, des politiques plus fermes que certains de ses partenaires commerciaux. De plus, la norme standard de rendement peut s’ajuster plus efficacement à des mesures fiscales existantes et ainsi produire un impact économique global moins important qu’un système de plafonnement et d’échange.

Dans cet article, en ayant recours à un modèle dynamique d’équilibre général appliqué au Canada, nous considérerons les arguments théoriques qui militent pour ou contre la norme standard de rendement intégrale, et nous comparons celle-ci au système de plafonnement et d’échange.

Mots clés : changements climatiques, politiques publiques, compétitivité, norme de rendement, modèle informatique d’équilibre général

To reduce greenhouse gas emissions from large industries the Canadian government proposed using a tradable emissions performance standard approach, where the intensity of emissions, rather than the absolute level, is regulated. Unlike a cap and trade system, an emissions performance standard does not guarantee a certain overall level of emission reductions, a fact that has led to significant criticism. However, because of the dynamics of performance standards, they may reduce concerns over reductions in international competitiveness in cases where a country has climate policies that are more aggressive than those of some of its trade partners. Likewise, a performance standard may mesh more efficiently with existing taxes and therefore cause less overall economic impact than an absolute cap and trade system. This paper considers the theoretical arguments for and against such a performance standard system and evaluates it in comparison to a cap and trade system using a dynamic general equilibrium model applied to Canada.

Keywords: climate change, policy, competitiveness, performance standard, computable general equilibrium model

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INTRODUCTION

Although command and control regulations have historically dominated environmental policy, market-based approaches are becoming increasingly prominent, including for climate policy. Several northern European countries implemented carbon taxes in the early 1990s; Europe implemented a cap and trade program covering industrial greenhouse gas (GHG) emissions in 2005; Alberta implemented a tradable emissions performance standard covering emissions from large industrial sources in 2007; several US states implemented a cap and trade program for emissions from electricity generators in 2008; and British Columbia implemented a carbon tax in 2008.

Because they send a uniform price signal, encouraging all firms and consumers to reduce emissions with a similar level of effort, but still provide significant flexibility in the choice of abatement technology, market-based approaches to reducing GHG emissions have long been promoted by economists. However, all market-based approaches are not the same, and differences in design can have large implications for relative economic outcomes. Given the potential scale of the “carbon market”—with a price of $75/t CO$_2$, the value of carbon permits would be equivalent to almost 5 percent of gross domestic product in Canada—these design differences could be important for overall economic performance.

Carbon taxes involve government setting the level of the tax and collecting revenue from its application, and leave the level of emissions to be determined by the responses of firms and consumers to the tax. In contrast, cap and trade systems involve government stipulating an allowable level of emissions, and leave the market to determine where those emissions should be emitted and the price that firms and consumers pay for emitting. A variant on the cap and trade approach involves government setting an allowable intensity of emissions for firms, measured in emissions per unit of product output. Firms that achieve an emissions intensity lower than the requirement obtain permits that can be traded to other firms that fail to meet it. Like cap and trade, the permit price is set by the market rather than by government directly. This approach is referred to as a “tradable emission performance standard” or an “intensity-based regulation” (Newell 2007).

For many years Canada’s national climate policy proposals have focused on the design and implementation of an intensity-based approach to reducing industrial GHG emissions. The intended policy as of 2009, called Turning the Corner, required an 18 percent improvement in emission intensity from 2006 levels by 2010, and a further 2 percent improvement in every year following (Government of Canada 2008). Facilities unable to reduce emissions sufficiently to comply with the regulation would be required to purchase emission permits to cover any shortfall. These credits would be generated by other firms achieving an emission intensity lower than stipulated by the regulation, and by both domestic and international offset providers.

Additionally, the federal government proposed to create a technology fund that would sell credits to firms for a government-set price. The fixed price for these credits would serve as a price ceiling (safety valve), ensuring industry that the price of emission permits would not exceed this level.

The proposed policy attracted a large amount of criticism from academics, environmental non-government organizations, and the media. Critics noted (1) that the proposed regulatory framework would only cover half of Canadian emissions, leaving the other half to grow more or less as normal; (2) that its allowance of unlimited domestic offsets and payments to the technology fund were in effect loopholes that would allow industries to avoid reducing their own emissions; and (3) that the targets embodied in the regulatory framework would be far too weak, since they required stabilizing emissions at 1990 levels by 2020, as compared to much more aggressive goals.
promoted in European legislation and advocated by the scientific community (Partington 2009).

Perhaps the most resonant critique of the policy related to Canada’s intention to regulate the emission intensity of large industrial emitters using a tradable emissions performance standard rather than an absolute cap and trade, since critics charged that the overall amount of emissions would still be able to grow along with economic output rather than being strictly limited as in a cap and trade system (Bramley 2007).

However, a tradable emissions performance standard may be attractive depending on the objectives and constraints facing a given government. In particular, this approach can be desirable in cases where a government wants to give a clear GHG emissions price signal that will motivate its industry to reduce emissions, but is unwilling to require industry to pay for every unit of emissions, perhaps because it suspects that major trading partners will not impose substantial emissions costs on their own industries. In this paper we explore the issue by assessing Canada’s proposed industrial emissions performance standard under alternative objectives and constraints facing policy-makers. We outline the theoretical aspects of tradable emissions performance standards that might make them especially attractive to the Canadian government. Following this, we highlight results from an economic model of Canada that we have developed for empirically comparing a performance standard system with a cap and trade system. Both the theoretical and empirical analyses suggest that under certain circumstances the tradable emissions performance standard could reduce the overall cost and competitiveness losses compared to a traditional cap and trade system. These potential advantages come at a price, however, since this approach reduces the probability of hitting strict emissions reduction targets. Additionally, the performance standard approach is much less transparent to the public than the absolute cap and trade system.

THEORETICAL EXPOSITION

The following discussion is divided into three parts. First, we compare a cap and trade system to an emissions performance standard in terms of the level of certainty each policy provides in (1) reaching a given emissions target, and (2) reducing emissions at a predictable cost. We conclude that while only a cap and trade system assures a given level of emissions in the future, a performance standard system is better able to reduce the chance that policy compliance costs will be higher than expected. Second, we compare the static efficiency of the two policies under different scenarios: (1) a “first-best” scenario in which the economy is free from any distortions and the policy covers all emissions in the economy, (2) a scenario in which the climate policy only covers a single country or region and other countries neglect to implement climate policies of similar stringency, (3) a scenario in which the policy only covers some sources of emissions in the region and leaves others uncovered, and (4) a scenario in which there are pre-existing, distortionary taxes in the economy. We conclude that although the cap and trade system is more efficient in the first-best scenario, the tradable performance standard policy may offer some advantages in the other scenarios. Finally, we summarize the literature relevant to the impacts of alternative policy designs on firm-level incentives for technical change. Here our conclusions are more reserved, since neither the theoretical nor the empirical evidence comes out clearly in favour of a particular policy.

Certainty of Achieving Emission Reductions

A conventional cap and trade system regulates the absolute level of emissions. In such a system, the regulator chooses a desired level of emissions Z, and issues that amount of permits to emitters, who are required to hold a permit for each unit of emissions released. Cost effectiveness is achieved because emitters can trade permits with one another, which, in the absence of transaction costs, should result in the emission reduction target being reached at the
lowest possible cost (Montgomery 1972). When the target is reached, the following identity holds:

\[ Z = Q \cdot e \]  

(1)

where \( Q \) is the output of the regulated sectors of the economy, measured in dollars or in some physical unit, and where \( e \) is the emissions intensity of the regulated sector(s), measured in units of emissions per unit of economic or physical output. Because firms are required to hold a permit to release emissions, the regulator knows with certainty the amount of emissions that will be released in the future: it will exactly equal the amount of permits issued.

In contrast, in a performance standard, the regulator sets a level of emission intensity, \( e \). Individual firms with an emissions intensity greater than \( e \) are required to acquire permits from firms with an emissions intensity less than \( e \), such that the overall emissions intensity of the regulated sectors of the economy reaches \( e \). In this case, the absolute level of emissions, \( Z \), is not set directly by the policy but is the product of the regulated emissions intensity, \( e \), and the unregulated economic output, \( Q \). In theory, if the regulator can perfectly predict the future growth rate of each sector of the economy, including any impact of the policy on economic output, it can set \( e \) in the performance standard system to produce the same overall emission reductions that would be generated by a cap and trade system.

As noted, the Canadian government’s proposed industrial emissions policy specified a reduction in GHG intensity for large industrial emitters of 18 percent by 2010 from 2006 levels. A recent forecast suggests that economic growth in these sectors will average 2.3 percent annually during this period (Natural Resources Canada 2006). If this forecast turns out to be correct, the intensity target is equivalent to an absolute reduction of 10.2 percent from 2006 levels.\(^2\) If the future were known with certainty, the two policies—a mandate that absolute emissions in these sectors decrease by 10.2 percent and a mandate that emissions intensity in these sectors decreases by 18 percent—would produce the same reduction in overall emissions.

However, given uncertainty of economic growth, a performance standard system results in a policy outcome where emissions in the future are uncertain. If growth turned out to be 3 percent annually, emissions reductions under the performance standard system would only be 7.7 percent rather than 10.2 percent. Lack of certainty over future emissions has been a key source of criticism for Canada’s currently proposed intensity-based policy (Bramley 2007).

In this regard, the absolute versus intensity debate parallels the cap and trade versus carbon tax debate. A carbon tax guarantees a given future price for carbon emissions (the level of the tax), but not the resulting amount of abatement by firms, which depends on how firms react to the tax. In contrast, a cap and trade system guarantees an amount of abatement (the amount of permits issued by the regulator) but not the resulting price of emission permits. A performance standard system is similar to a tax in that the quantity of emissions reductions is uncertain, but is like cap and trade in that the price of emissions permits is also uncertain (but, as discussed below, the uncertainty in both variables can be less than for a tax or cap and trade system).

Weitzman (1974) analyzed the desirability of price and quantity certainty and showed that the latter is preferred in cases where the marginal benefits of emissions abatement increase more quickly than the marginal costs. For climate change, Pizer (1998) concludes that the opposite is true: deviations from the optimal quantity of emissions reductions are likely to have a much bigger impact on the marginal cost of control than on the marginal environmental benefits of abatement. As a result, a price instrument like a carbon tax is usually considered preferable to a quantity instrument like a cap and trade system for controlling GHG emissions (Pizer 1998). However, the presence of environmental thresholds—where marginal damages change quickly with small changes in emissions—could reverse this conclusion.
Recently, Newell and Pizer (2008) and Sue-Wing, Ellerman, and Song (2009) have extended Weitzman’s analysis to compare a cap and trade system to an emissions performance standard. Their research suggests that, in the face of uncertainty, an intensity-based approach can maintain the abatement cost closer to the level intended by the regulator than a cap and trade system, provided emissions and economic output are strongly correlated and the variance in emissions is high relative to the variance in output. When these conditions hold, uncertainty in economic output is propagated through to uncertainty in emissions (because of the strong correlation between these variables). The stringency of a cap and trade system will therefore deviate from the policy-maker’s intended stringency, potentially imposing higher than planned costs (if economic growth is more robust than expected) or lower than planned emission reductions (if economic growth falters). In contrast, an intensity-based regulation adjusts the emission target in response to changes in output and thus maintains the policy stringency closer to the range originally anticipated by regulators.

For these conclusions to hold, however, there must, as stated, be a relatively strong correlation between economic output and emissions. Bruneau and Renzetti (2009) show that emission intensity in the industrial sector in Canada has changed only slightly since 1990, so that changes in economic output are likely to translate to changes in emissions. Provided that such a relationship continues to hold in the future (in the scenario where no policy is implemented), it is likely that a performance standard system in Canada would result in less permit price variability than a cap and trade system. A similar conclusion was reached by Sue-Wing, Ellerman, and Song (2009). Although the performance standard system does not offer the perfect price certainty of a carbon tax, it offers less price uncertainty than a cap and trade system. Likewise, although the performance standard system does not offer the perfect quantity certainty of a cap and trade system, it offers more certainty over the level of emission reductions than a carbon tax. In this dimension, it shares characteristics with other mechanisms that are often considered in conjunction with cap and trade systems, which increase price certainty at the expense of quantity certainty: for example, price ceilings (safety valves) and price floors to constrain the permit price to within a desirable range.

### Static Efficiency

The design of environmental policy not only affects the certainty of achieving a given level of emissions reduction but also directly changes the incentives faced by regulated firms. This can have important consequences for the overall efficiency of the policy and for the prices of all goods affected by the regulation.

This can be demonstrated in a simple partial equilibrium model, which considers a representative firm in a competitive market. In this section, for clarity of exposition we assume that the firm is in a closed economy (with no trade to or from outside countries); in the following sections we relax this and other assumptions. Profit for the representative firm, in the absence of any emission control policy, is given by

$$\pi = \{P \cdot q\} - \{(c + a(\eta)) \cdot q\}$$

(2)

where $P$ is the price at which the firm sells its output, $q$ is the quantity of output produced by the firm, $c$ is the firm’s unit cost of production, $a(\cdot)$ is the cost associated with abatement of emissions, and $\eta$ is a variable that ranges from 0 to 1 that represents reduction in emission intensity achieved by the firm (as a result of a policy), where 0 signifies that no abatement is undertaken by the firm, and 1 signifies that the firm has eliminated all its emissions. The firm’s overall unit cost of production is given by $c + a(\eta)$. As specified, the cost does not vary with the scale of the firm. We assume that $a(\eta)$ is increasing in $\eta$ (such that $a'(\eta) > 0$) and that there is no abatement cost if there is no emission abatement (such that $a(0) = 0$). The first term on the right-hand side of (2) is the revenue from sales of the firm’s...
output, and the second term is the cost of producing that output.

In the absence of any emissions policy, the firm will pursue no abatement (\( \eta = 0 \)). In a competitive market, the price at which the firm sells its output will be equal to the marginal cost of production, \( P = c \).

Now consider what happens when the firm faces an emission tax, \( \tau \), designed to reflect the social cost of emissions. The firm must pay for any emissions it produces, so the profit function becomes

\[
\pi = \{ P \cdot q \} - \{(c + a(\eta)) \cdot q\} - \{(1 - \eta) \cdot e_0 \cdot \tau \cdot q\} \tag{3}
\]

where \( e_0 \) is the emissions intensity of the firm in the absence of any abatement effort. The final term on the right-hand side represents the firm’s payments of emission tax on its residual emissions (those it did not reduce when the tax was applied). The firm chooses \( \eta \) to maximize its profits. In doing so, it sets its marginal cost of abatement equal to the permit price:

\[
a'(\eta) / e_0 = \tau \cdot \text{ At equilibrium the firm’s cost of production has risen to } c + a(\eta) + (1 - \eta) \cdot e_0 \cdot \tau.
\]

The emission tax has increased costs in two ways: first, by inducing emission abatement, which is costly, and second, by forcing firms to pay a tax for any residual emissions. Given perfect competition, the increased cost of production is translated fully through to the consumer price of the good. The increased price of the good results in reduced consumer demand, assuming a consumer demand function that is not perfectly inelastic. (Remembering that this is a closed economy, a rising cost of production in a given sector will lead to rising prices for goods that do not have perfect substitutes).

Now consider what happens when, instead of imposing a tax, the regulator uses a cap and trade system to cap emissions at a socially desirable level. We assume that permits are allocated to firms in lump sum, as opposed to in an auction (an auction would be analytically equivalent to the tax case above), and we use \( L \) to represent the number of permits that are allocated to the representative firm. We assume that \( L \) is set by the regulator to reflect historic emissions; this is known as grandfathering of emission permits.\(^3\) In this case, the profit function for the representative firm is

\[
\pi = \{ P \cdot q \} - \{(c + a(\eta)) \cdot q\} - \{(1 - \eta) \cdot e_0 \cdot q - L \cdot \tau \} \tag{4}
\]

where we treat \( \tau \) as the equilibrium permit price. The firm again chooses \( \eta \) to maximize profits, with the same result as above:

\[
a'(\eta) / e_0 = \tau \cdot \text{ As a result, the quantity and price of that output is exactly the same as in the emission tax scenario. Grandfathering of emission permits does not affect these variables because it does not affect the marginal price of producing output; instead, it is a one-time transfer that results in a profit to the firm’s shareholders relative to the tax case.} \tag{7}
\]

Finally, we turn to the performance standard system. We assume that the regulator sets an emission intensity target given by \( b \), where \( b \) is the rate of reduction in emission intensity required (\( b=0.18 \) for 2010 in Canada’s proposed system). Firms that fail to reduce emission sufficiently are required to purchase emission permits to make up the shortfall, while firms that reduce their emission intensity by more than the target requires create permits that can be sold to others.

Profit for the representative firm is now given by

\[
\pi = \{ P \cdot q \} - \{(c + a(\eta)) \cdot q\} - \{(b - \eta) \cdot e_0 \cdot q \cdot \tau \} \tag{5}
\]

The last term in this equation represents the firm’s net purchases of emission permits from other firms. The first order condition for (5) suggests that the firm still sets its marginal cost of abatement to the tradable permit price:

\[
a'(\eta) / e_0 = \tau \cdot \text{ However, the firm’s unit cost of production is now}
\]
\[ c + a(\eta) + \tau \cdot e_0 \cdot (b - \eta), \]

which is lower than both the cap and trade system with grandfathering and the carbon tax by the amount \( \tau \cdot e_0 \cdot (1 - b) \). The performance standard system has therefore given firms the same marginal signal to reduce emission intensity as the cap and trade system, but has not resulted in marginal production costs increasing by the same magnitude.

In effect, relative to the cap and trade system with grandfathered permits or the emission tax policy, the emissions performance standard acts like a subsidy to output of \( \tau \cdot e_0 \cdot (1 - b) \) per unit of production (Newell 2007). To be clear, the performance standard system does not result in a net subsidy to firms, just an implicit subsidy relative to the cap and trade system or the emissions tax. Cost of production under the emissions performance standard will, on average, still increase relative to the no-policy case because of abatement expenditures. An alternative way to think about the tradable emissions performance standard is that it applies a price signal to stimulate firms to reduce emissions at the margin, like a carbon tax or cap and trade system, but does not force firms to pay that price for all the units of emissions they emit.

We can compare the cap and trade system with the tradable emission performance standard by assuming that the regulator has perfect information about future output and therefore can set the emissions performance standard to match the intensity that results from the cap and trade system: \( b = \eta_{ets} \) (the subscript ets refers to the cap and trade system, while the subscript tps refers to the tradable performance standard). In equilibrium in our simple closed economy, the representative firm must comply with the standard, such that \( \eta_{tps} = b \). As a result, the permit price in both systems is equal, \( \tau_{tps} = \tau_{ets} \). The cost of production in the cap and trade system is \( c + a(\eta) + (1 - \eta) \cdot e_0 \cdot \tau \), while in the emissions performance standard it is \( c + a(\eta) \). Because the cost of production is lower under the performance standard, the demand and therefore the equilibrium supply of output is higher, \( q_{tps} > q_{ets} \). And since the emissions intensity is the same in both systems, the total amount of emissions under the performance standard is higher than under the cap and trade system, \( \eta_{tps} > \eta_{ets} \). Conversely, to achieve the same overall emissions reductions in the performance standard system compared to the cap and trade system, the emission intensity must fall further, and the permit prices must reach higher levels (Helfand 1991; Fischer 2001; Goulder et al. 1999).

In the simple model here, where there is perfect competition, no other taxes in the economy, and no trade with other regions, and where the regulation covers all emissions in the closed economy, several analysts have demonstrated that both an emission tax and a cap and trade system are economically efficient policies for reducing emissions (Baumol and Oates 1988). The tradable performance standard, which stimulates more output and emissions than the efficient level, is therefore less efficient than these alternatives (Fischer 2001; Holland 2009). When these idealized conditions hold, there is no economic justification for a regulator to choose an emissions performance standard to reduce emissions.9

In practice, most of these conditions do not hold. The regulator may not be willing to regulate emissions from all of the economy for political or administrative reasons. Canada’s government can only regulate emissions from Canadian companies, not companies situated abroad. And, so far, federal regulators in Canada have been more focused on regulating GHG emissions from heavy manufacturing and extractive industries (sometimes termed “large final emitters”) than from other sectors of the economy. Finally, the economy is already significantly distorted from the first-best case by numerous taxes, suggesting that a second-best analysis is more appropriate for evaluating alternative policies. These cases deviate from the simple model that was described above, and conclusions from that analysis may not apply directly to these more complicated scenarios. We address each of these cases in turn.

Unilaterally Applied Carbon Policy. We start by considering impacts of the cap and trade system
when the economy is open to trade and variation exists in the GHG regulations of different countries. In this situation Canadian firms would be regulated by the Canadian climate change policy, but firms in other regions may be regulated by other systems or may be unregulated altogether. Emerging economies, which are increasingly important in international trade, are unlikely to subject their firms to climate policies with the same stringency as those of wealthy countries over the next decade.

To the extent that more aggressive emission abatement increases the cost of producing goods, persistent differences in policy stringency between countries could have important implications for the international competitiveness of firms in the regulated country (Baron and ECON-Energy 1997; Hourcade et al. 2007). In particular, increases in production costs could lead corporations eventually to shift production of carbon-intensive goods away from more stringently regulated countries, leading to loss of employment and economic output in these sectors. Fears of this type of competitiveness impact undermine the support for abatement policy in developed countries. Such concerns have been at the forefront of national debates about Canadian climate policy.

A variety of policies have been proposed to deal with this potential problem, ranging from border tax adjustments to sectoral exemptions. However, all of these policies face considerable hurdles related to compatibility with trade law, efficiency, and political acceptability. As an alternative, a tradable emissions performance standard provides an implicit subsidy to output relative to a cap and trade system, and so does not increase production costs by as much as a cap and trade system. In so doing, it helps to maintain the competitiveness of certain firms in the regulated country relative to external competitors (Bernard, Fischer, and Fox 2007; Holland 2009). For a country like Canada, which depends on energy-intensive primary exports for a significant share of economic activity, the emissions performance standard might be particularly attractive for this reason. Additionally, unlike border tax adjustments, a performance standard system would be unlikely to conflict with international trade law or induce retaliatory trade actions.

**Imperfect Coverage of Emissions.** The proposed federal GHG policy as of 2009 focused emissions pricing on large industrial emitters, which represent 10 to 15 percent of Canada’s economic output and about half of its emissions. The remainder of the economy would not be exposed to a carbon price under the proposed policy. Such a policy contravenes standard economic theory, which suggests that all sources of emissions should be charged the same carbon price since the environmental damage associated with carbon emissions is independent of where these emissions originate, and without a common emissions charge, some low-cost reductions might not be pursued.

Expanding the scope of the regulatory policy so that all emissions are covered would produce greater emissions reduction at the same cost. However, there may be political or administrative reasons that inhibit expansion of the regulatory scheme to cover all emissions in the economy. In particular, limiting the policy to large industrial emitters helps to avoid the politically problematic issue of increases in household energy prices. The history of federal climate policy proposals in Canada, which have all limited emissions pricing to large industrial emitters, suggests that such political acceptability concerns have (historically, at least) been at play in this country. Similar obstacles seem to have been operating in Europe, which has confined its emission trading system to large industry.

A failure of government to price emissions at the same level throughout the economy could actually cause emissions to increase in sectors with low or non-existent emissions pricing. This is because the higher production costs of firms facing emissions charges and abatement costs will be passed on to consumers, inducing substitution toward goods and services that are not facing these charges. If
emissions are released during production of these products, this could counteract the original intent of the climate policy. For example, Canada’s federal proposal for industrial emissions pricing includes emissions from electricity generating facilities but not emissions from residential consumption of fuels like natural gas and home heating oil. However, these fuels are potential substitutes for electricity in space and water heating, the key household energy end uses. Increases in the price of electricity resulting from the industrial emissions pricing policy will likely cause some substitution from electricity toward these fuels that increases residential emissions, counteracting some of the impact of the emissions pricing policy.

Such induced substitution is obviously undesirable from an efficiency perspective, since it distorts choices made by firms and individuals without achieving reductions in emissions (Hoel 1996). In this case, a performance standard system, which minimizes production cost increases in covered sectors, may be less problematic than an absolute cap and trade system, since it will cause less substitution from goods produced by sectors subject to the pricing policy to goods produced by sectors not subject to it (Bernard, Fischer, and Fox 2007). The actual difference between the two systems depends on the elasticity of substitution in consumption between products of covered and uncovered sectors, as well as the degree to which Canadian firms can pass on production cost increases to consumers (in markets like crude oil, where the price is determined internationally rather than nationally, firms would not be able to pass along cost increases to consumers and would instead lose market share or profitability).

Pre-existing Taxes. Although most analysis of environmental policy takes place under the assumption that there are no pre-existing taxes in the economy, research suggests that conclusions from such analyses can be dramatically altered when proper account is taken of pre-existing taxes (Bovenberg and Goulder 1997; Goulder et al. 1999).

When an emissions pricing policy is implemented in a closed economy, it will raise the price of goods, as described earlier. Since consumers purchase goods and services using their income, and since the emissions pricing policy raises prices of consumer goods relative to consumer income, the policy shares some characteristics with a tax on income (Bovenberg and De Mooij 1994). Essentially, the emissions pricing policy has reduced the return to income in much the same way as an income tax reduces the return to income. Both the income tax and the emissions pricing policy can therefore be expected to distort the labour market by reducing the incentive to work relative to a world of zero income taxes.

If the emissions pricing policy is implemented on top of other income taxes, it reduces real consumer income in the same way as an increase in the income tax rate does, and so amplifies the market distortion caused by the pre-existing income tax, since the marginal deadweight loss induced by labour taxation is increasing in the tax rate. This interaction between the emissions pricing policy and pre-existing taxes raises the cost of the policy above what it would have been in the absence of pre-existing taxes (Goulder et al. 1999).

Some of this tax interaction effect can be eliminated if the environmental policy also raises revenues that are used to cut the rates of pre-existing taxes. For example, revenues from British Columbia’s recently implemented carbon tax are returned to the economy as cuts to corporate and labour income taxes (British Columbia 2008). By reducing income and corporate taxes from their previous levels, the emissions pricing policy can reduce economic losses from application of the carbon price.

As Goulder et al. (1999) show, the recycling of emissions pricing revenues can have important implications for the overall cost of the policy. Since different policy instruments impose different costs and distribute revenue differently, it is important to consider them in light of pre-existing taxes.
In this regard, an absolute cap and trade system and an emissions performance standard differ in two significant ways. First, a performance standard system raises no revenue that government can use to cut other taxes. In contrast, a cap and trade system can be designed to raise substantial revenue for government by auctioning some or all permits to emitters, which could then be used to reduce other taxes. If, however, political constraints prevent auctioning of permits in favour of grandfathering, then the cap and trade system would not generate economic benefits from efficiency-focused revenue recycling. Second, as described above, the emissions performance standard should cause smaller price increases than the absolute cap and trade with grandfathering. As a result, the performance standard should result in a smaller interaction with pre-existing taxes than the cap and trade policy.

**Technical Change**

The previous analysis focused on static efficiency concerns when the level of technology was exogenous. However, the impact of a policy on the pace and direction of technological change can play a significant role in shaping the economic impact and effectiveness of a policy over a longer time horizon (Kneese and Schultz 1978).

We develop a simple theoretical model to illustrate how different policy instruments affect incentives to firms to develop new technologies. Like other papers in this field, we analyze the change in firms’ profits as a result of an innovation that reduces abatement costs to $k$ times the original amount (an innovation will therefore be represented by $0 \leq k < 1$) (Milliman and Prince 1989; Montero 2002). Using Montero’s notation, we assume that policy A provides a greater incentive to innovate than policy B if $(|\partial \pi / \partial k|)^A > (|\partial \pi / \partial k|)^B$. In other words, if the same innovation increases profits more under policy A than under policy B, policy A is more likely to stimulate more innovation. This static framework is useful for highlighting the impacts of a policy on innovation in a transparent fashion, but we warn the reader that the results may be altered in a more complex dynamic model of innovation.

We first consider a cap and trade system with grandfathered permits. Using the notation developed above, profit for the firm with the technological innovation is given by

$$\pi = \{P \cdot q - \{c + k \cdot a(\eta) \cdot q\} - \{[(1 - \eta) \cdot e_0 \cdot q - L \cdot r] \} \}$$

By reducing abatement costs, the innovation clearly increases firm profits. Similar to above, the first order conditions are $k^a (\eta_{ets}) / e_0 = \tau$ and $P = c + k \cdot a(\eta_{ets}) + \tau \cdot e_0 \cdot (1 - \eta_{ets})$. Taking the total derivative, and using the envelope theorem, we get

$$\frac{d\pi}{dk} = -q_{ets} \cdot a(\eta_{ets})$$

This indicates that as $k$ gets lower as a result of innovation, profits increase proportionately to the total cost of abatement.

Now we consider the incentive to innovate under a performance standard. To keep the two instruments comparable, we again assume that the regulator maintains the same emission intensity in the performance standard as in the cap and trade system, $\eta_{ets} = \eta_{ets}$. Profit is then given by

$$\pi = \{P \cdot q_{ps} - \{c + k \cdot a(\eta_{ets}) \cdot q_{ps}\}$$

The first order condition relating price to marginal cost is: $P = c + k \cdot a(\eta_{ets})$. As we showed above, because the marginal cost is lower, we would expect consumer demand and therefore output to be higher, $q_{tps} > q_{ets}$ (provided consumer demand is not perfectly inelastic).

The total derivative of equation (8) is

$$\frac{d\pi}{dk} = -q_{ett} \cdot a(\eta_{ets})$$

Since $q_{tps} > q_{ets}$, we have $(|\partial \pi / \partial k|)^{TPS} > (|\partial \pi / \partial k|)^{ETS}$ when the performance standard is set to mimic the emission intensity under a cap and trade system. In other words, the incentive for innovation under the performance standard will be greater than
Intensity-Based Climate Change Policies in Canada

under the cap and trade system. The intuition is straightforward: because output is higher under the performance standard, the total amount of abatement is larger, and so innovations that reduce abatement costs are valued more highly.\(^1\)

While this simple model suggests that incentives for innovation may be higher under a performance standard than under a cap and trade system, we emphasize that this conclusion is tentative. In particular, our model considers only the innovation phase and does not consider how diffusion of the technology affects firm incentives to innovate, nor how a dynamic regulator (who responds to the innovation by altering the abatement policy) may affect such incentives. These issues are dealt with by Milliman and Prince (1989). Further, our model does not consider the possibility that competition in the output or permit market is imperfect, which introduces substantial complexity to the analysis (Montero 2002). Nor does it consider the case where innovation is costly and may not be perfectly appropriated by the innovating firm. These complexities are addressed by Fischer, Parry, and Pizer (2003). In these more complicated analyses, it is not possible to draw strong conclusions on the superiority of alternative policy instruments for promoting innovation. In fact, although there is fairly widespread acknowledgement of the importance of induced technical change in evaluating alternative policy instruments, the theory is still somewhat unclear on which policy designs lead to superior innovation incentives, especially as simplifying assumptions are relaxed. Additionally, little empirical testing has been conducted to evaluate these alternative theories of innovation incentives.

MODELLING ANALYSIS

Policy-makers designing climate policy need to trade off among potentially competing objectives. A critical trade-off is between the environmental effectiveness of policies and their effect on economic output. As the previous discussion highlighted, the choice between an absolute cap and trade system and an emissions performance standard involves both of these objectives.

While the previous discussion outlined in theoretical terms some of the key distinctions between the policies, it is critical to know how these effects interact with one another, as well as the overall effects of the alternative policy approaches. To this end, this section presents an evaluation of the absolute cap and trade system and the emissions performance standard using a quantitative model of the Canadian economy.

The model is a single-region dynamic computable general equilibrium model, similar to the type used for tax policy analysis (Baylor and Beauséjour 2004) and for many studies of environmental policy (McKitrick 1997; Paltsev et al. 2007). The model contains a detailed representation of the transactions in the Canadian economy, including transactions amongst firms, between firms and consumers, and between Canada and other countries. Like most models of this type, it operates under the assumption that Canada is a small open economy with negligible effect on world prices. Additionally, it includes a relatively detailed accounting for pre-existing taxes in the economy, as well a representation of government spending and transfers. The model is calibrated to Statistics Canada’s System of National Accounts, and energy consumption data are included from Statistics Canada’s Report on Energy Supply and Demand (RESD). (A more detailed description of the model is included in the Appendix available in the CPP online archive at http://economics.ca/cpp/.)

Two important limitations of the model are worth mentioning explicitly. First, the model treats technology as exogenous and so does not account for the possibility of policy-induced technological innovation, as described in the earlier discussion. This is a drawback shared with most models of this type.\(^1\) Including endogenous technological change in the model would likely reduce our estimates of the economic impact of climate change policy. Second, the model treats population as exogenous. One way
to meet an emission target would be to change immigration policy—a possibility we do not explore.

We use the model to compare an absolute cap and trade system and an emissions performance standard covering GHG emissions from Canada’s large industrial emitters. For the cap and trade system, we model two variants: one in which government auctions permits and uses all revenues to lower the pre-existing labour income tax (this is analytically equivalent to a carbon tax with revenue recycling), and another in which government allocates permits free to firms based on their initial level of emissions (grandfathering). To account for the complicating factors described in the previous section, the model accounts for international trade between Canada and other countries (and assumes that Canada implements a climate policy unilaterally), accounts for the fact that consumers may substitute from products of sectors facing emissions pricing to products of sectors without emissions pricing, and includes a detailed accounting of pre-existing taxes in the economy.

To make the policies directly comparable, the model is run such that each of the policies reduces emissions from the large industrial emitters by the same amount. The quantity of emissions reduction is based on the Canadian government’s 2008 Turning the Corner policy proposal, which specified that existing large industrial emitters would be required by 2020 to reduce emission intensity by 38 percent below 2006 levels (Government of Canada 2008). Given projected growth in output from these sectors, this works out to about a 15 to 20 percent (absolute) reduction in emissions from 2006 levels (for these sectors only). This target is used as a constraint for the large industrial emitters in the simulations that follow.15

Table 1 shows the model projections for the overall impact of the three policies. As suggested by the

### Table 1
Overall Impacts of the Cap and Trade and Performance Standard Systems

<table>
<thead>
<tr>
<th>Real CO2 price ($/t CO2), 2020</th>
<th>Welfare (equivalent variation)</th>
<th>Real 2020 GDP loss from changes in:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cap and Trade – Grandfathering</td>
<td>Performance Standard</td>
</tr>
<tr>
<td>$64</td>
<td>$117</td>
<td>$65</td>
</tr>
<tr>
<td>−0.24%</td>
<td>−0.18%</td>
<td>−0.11%</td>
</tr>
<tr>
<td>Real 2020 GDP loss from changes in:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td>−0.27%</td>
<td>−0.11%</td>
</tr>
<tr>
<td>Investment</td>
<td>−0.35%</td>
<td>0.03%</td>
</tr>
<tr>
<td>Government</td>
<td>−0.07%</td>
<td>0.01%</td>
</tr>
<tr>
<td>Net exports</td>
<td>0.03%</td>
<td>0.01%</td>
</tr>
<tr>
<td>Total</td>
<td>−0.66%</td>
<td>−0.06%</td>
</tr>
</tbody>
</table>

Change in 2020 emissions in Mt CO₂ (relative to 2006):

| LFE                        | 170                           | 170 | 170 |
| Others                     | 3                             | 0   | 2   |
| Total                      | 173                           | 170 | 172 |

After-tax wage rate, 2020

<table>
<thead>
<tr>
<th>Cap and Trade – Grandfathering</th>
<th>Performance Standard</th>
<th>Cap and Trade – Labour Tax</th>
</tr>
</thead>
<tbody>
<tr>
<td>−0.82%</td>
<td>0.11%</td>
<td>−0.02%</td>
</tr>
<tr>
<td>Labour supply, 2020</td>
<td>−0.27%</td>
<td>0.11%</td>
</tr>
<tr>
<td>Real exports, 2020</td>
<td>−0.03%</td>
<td>−1.00%</td>
</tr>
<tr>
<td>Real imports, 2020</td>
<td>−0.32%</td>
<td>−1.13%</td>
</tr>
<tr>
<td>Price of foreign exchange, 2020</td>
<td>1.01%</td>
<td>0.15%</td>
</tr>
</tbody>
</table>

Source: Authors’ calculations based on computable general equilibrium model described in text.
earlier theoretical analysis, the equilibrium permit price needed to reach the same level of emissions reduction under the emissions performance standard is significantly higher than under the absolute cap and trade system. This increased permit price reflects the additional distortion caused by the implicit output subsidy present in the intensity-based allocation scheme. In the model results presented here, the equilibrium permit price in the emissions performance standard is roughly double the price in the cap and trade system, suggesting that the choice of allocation method can have a dramatic impact on emission price. This is consistent with results from Dissou (2005) and Fischer and Fox (2008). Likewise, it is close to results from Dissou (2006), who evaluated a similar cap and trade system with output-based allocation of emission permits.

All three policies reduce emissions from the large industrial emitters by the same amount (by design). Impacts on the non-covered sectors are similar between policies. Overall, the policy allows for significant growth in emissions by 2020, since about half of the economy is not covered by a carbon policy.

The impact on overall economic output is dependent on the policy design. Table 1 shows that the absolute cap and trade system is projected to result in a reduction in GDP from projected levels of about 0.7 percent by 2020 if the revenues are recycled in lump sum to households, and of about 0.4 percent when the revenues are used to cut the existing labour income tax. In contrast, the emissions performance standard is projected to reduce GDP by less than 0.1 percent from projected levels by 2020. Figure 1 shows the transitional impacts of the policy on economic output; the impacts of the policy in 2020 are quite similar to the long-run impacts of the policy on economic output. It is useful to translate these impacts into growth

**Figure 1**
Economic Output under Cap and Trade and Performance Standard Systems

<table>
<thead>
<tr>
<th>Year</th>
<th>Performance Standard</th>
<th>Cap and Trade – Labour Tax</th>
<th>Cap and Trade – Grandfathering</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>-0.2</td>
<td>-0.3</td>
<td>-0.4</td>
</tr>
<tr>
<td>2010</td>
<td>-0.1</td>
<td>-0.2</td>
<td>-0.3</td>
</tr>
<tr>
<td>2015</td>
<td>-0.1</td>
<td>-0.1</td>
<td>-0.2</td>
</tr>
<tr>
<td>2020</td>
<td>0</td>
<td>-0.1</td>
<td>-0.1</td>
</tr>
<tr>
<td>2025</td>
<td>0</td>
<td>-0.1</td>
<td>-0.1</td>
</tr>
<tr>
<td>2030</td>
<td>0</td>
<td>-0.1</td>
<td>-0.1</td>
</tr>
<tr>
<td>2035</td>
<td>0</td>
<td>-0.1</td>
<td>-0.1</td>
</tr>
</tbody>
</table>

Source: Authors’ calculations based on computable general equilibrium model described in text.
rate impacts, since that is usually how economic output is reported. Under the cap and trade system, the economic growth rate would be reduced by less than 0.1 percentage points over the 2010-20 period, while under the performance standard system, the economic growth rate would be relatively unaffected.

As shown in Table 1, the cap and trade system with grandfathered permits results in a reduction in the real wage rate, reflecting increases in the prices of consumer goods under the carbon policy. This results in a reduction in labour force participation. In this policy, allocation of permits in lump sum results in an increase in non-labour income for consumers. Since leisure is a normal good in the model, this increases the demand for leisure and so decreases labour supply. The overall reduction in labour supply is about 0.8 percent. In contrast, the other policies do not feature large increases in non-labour income for consumers, and wage rates do not drop as much, so labour force participation remains much higher than when permits are allocated through grandfathering.

Finally, Table 1 also shows the impact of the policy on household welfare. This measure shows the change in the lifetime income of the representative consumer that would, in the eyes of the consumer, exactly equal the negative impact of the policy (equivalent variation). The model suggests that the absolute cap and trade system is projected to reduce consumer welfare by about 0.25 percent. For a household with an after-tax income of $60,000 (roughly the Canadian median in 2007), this works out to about $120 annually. This in contrast, the emissions performance standard and the cap and trade system with labour tax recycling are projected to reduce welfare by a lower amount.

Although we do not present results here, we have conducted a wide range of sensitivity analyses on model parameters, including on Armington (trade) elasticities, on production and consumption elasticities, and on assumptions related to factor mobility. Although the results are sensitive to changes in parameter values, the ranking of policies remains invariant to changes in parameter values, and the overall economic impacts of the policy remain the same order of magnitude. These results are available upon request from the authors.

The results in Table 1 suggest that the emissions performance standard, by providing an implicit output subsidy to emitters, can help to mitigate some of the overall economic consequences of climate policy, under certain real-world constraints facing countries seeking to implement immediate emissions pricing policies. In addition to these overall economic impacts, Figure 2 shows that the policy can have important impacts on the international competitiveness of firms in regulated sectors. The figure shows the impact on output from each sector as a result of change in net exports. This is a good measure of the competitiveness of a policy, because it accounts for any changes in market share of a sector in both domestic and international markets (Jaffe et al. 1995). The left-hand side of the figure shows impacts on the large industrial emitters. Under the absolute cap and trade system, international competitiveness of several of these sectors is expected to deteriorate as a result of extra costs imposed by the requirement to purchase emission permits. Under the emissions performance standard, however, the price of outputs does not rise by as much, which somewhat mitigates the competitiveness impacts associated with the policy. In fact, several large industrial sectors, in particular those that have access to low-cost emission reduction opportunities and those that use a significant amount of inputs whose price falls in general equilibrium, are projected to increase in international competitiveness as a result of the emissions performance standard system.

In the figure, the oil and gas and the mining sectors stand out: both of these sectors are projected to experience boosts in net exports as a result of climate policy. This somewhat counterintuitive result occurs because domestic demand for fossil fuels, which are the product of these sectors, falls significantly. This reduces the domestic price of
fossil fuels, which reduces imports. Meanwhile, the international price of fuels remains stable by assumption, so domestic producers shift production from domestic markets to export markets. The combination of reductions in imports and increases in exports causes significant increases in net exports. It should be cautioned, however, that the overall level of output from these sectors drops as a result of declining domestic demand; the figure just shows changes in net exports (see note 18).

At the beginning of this paper, we discussed the differences between a cap and trade system, an emission tax, and a performance standard in the presence of uncertainty about costs and benefits of emission mitigation. Here we use the quantitative model to illustrate our arguments in the presence of a specific type of uncertainty: future growth rates.

Consider a regulator with imperfect knowledge of future economic growth rates, who chooses a policy today to regulate emissions through to 2020. The regulator can set a fixed emission tax, use a cap and trade system to cap the overall level of emissions, or use a performance standard to regulate emission intensity. If there is no uncertainty about future growth
rates, the regulator can set each policy to produce the same level of emissions. However, if growth rates are different than predicted by the regulator, future emissions will depend on the specific policy instrument chosen by the regulator. Likewise, the emission price will also depend on the interaction between the policy instrument and the uncertain growth rate.

To generate results, we simulate uncertainty in future economic growth by altering the exogenous rate of Harrod-neutral (labour augmenting) technological change in the model. In the base case, annual technological improvement is set to 1.25 percent, and all policies are set by the regulator to produce the same level of emissions in 2020 given this anticipated growth rate. We hold all policies fixed at this level, and then test for differences in outcomes when the growth rate deviates from the forecast level; we test a HIGH and LOW case where technological change improves labor efficiency by 1.75 percent and 0.6 percent annually, respectively.

We illustrate results in Table 2, where the left panel shows changes in total emissions from regulated industries (large final emitters) compared to the base case, and the right panel shows changes in the emission price compared to the base case, when economic growth is either higher or lower than expected. Under the cap and trade system, the regulator fixes the level of emissions, and so this does not change with economic growth. However, because of the fixed level of emissions, a higher growth rate means that the cap on emissions becomes more binding, and the price of emission permits increases. This is illustrated in the right panel, where a high growth rate leads to emission prices 24 percent higher than originally anticipated by the regulator. Likewise, a low growth rate means that the cap becomes less binding, meaning that emission prices fall relative to expectations—by 30 percent in the scenario examined here. In contrast, a tax fixes the emission price, so this is unchanged no matter the rate of economic growth. But with a fixed tax rate, higher growth means higher emissions. This is illustrated in the left panel, where a high growth rate leads to 5 percent more emissions than anticipated by the regulator and a low growth rate leads to 8 percent less emissions than anticipated. Under a performance standard, neither the emission price nor the level of emissions is fixed; instead the policy fixes emission intensity.

Provided economic growth does not impact emission intensity or the abatement curve, we would expect no change in the stringency of the policy under economic growth. However, in the model, new plants are treated as flexible, whereas old plants are treated as fixed (they are unable to alter inputs in response to changes in relative prices). As a result,

<table>
<thead>
<tr>
<th>Performance standard</th>
<th>HIGH</th>
<th>LOW</th>
<th>HIGH</th>
<th>LOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cap and trade</td>
<td>–</td>
<td>–</td>
<td>+24%</td>
<td>–30%</td>
</tr>
<tr>
<td>Emission tax</td>
<td>+5%</td>
<td>–8%</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

Source: Authors’ calculations based on computable general equilibrium model described in text.
more growth means a lower emission intensity abatement curve (since flexible new plants make up a higher proportion of the total capital stock), and thus a lower emission price needed to reach a given level of emission intensity. The table shows that the emission price is 6 percent lower than expected with a high growth rate. With a lower emission price as well as a higher overall growth rate, overall emissions grow by 7 percent—even higher than under the emission tax. Likewise, if the growth rate is lower than expected, the emission price under the performance standard is higher, and the level of emissions is 10 percent lower than expected.

CONCLUSION

The choice of emissions pricing policy to reduce GHG emissions—emissions tax, cap and trade system, or tradable emissions performance standard—can affect the policy’s economic impacts. This paper has explored these alternative policies first using a simple analytical approach and then using a computable general equilibrium model applied to Canada. We find that although an emissions tax or an absolute cap and trade system is the optimal policy in a first-best economy, where all sources of emissions are regulated, and where there are no pre-existing tax distortions, emissions performance standards may offer some advantages in a second-best economy. In particular, because they do not raise the cost of production in key emissions-intensive sectors by as much as the other policies, emissions performance standards are likely to have less impacts on the international competitiveness of carbon-intensive industrial sectors in a world where the emission pricing policies of other countries are less aggressive or non-existent. Given Canada’s trade-dependent economy, this could be an important feature of a greenhouse gas mitigation policy.

Of course, the potential economic benefits of the emissions performance standard approach are associated with trade-offs. Unlike an absolute cap and trade system, an emissions performance standard does not offer certainty over future emissions levels. Also, the emissions performance standard may be difficult to integrate with the emissions pricing policies of other countries, should most of these opt for some type of absolute cap and trade system, as appears to be occurring. While permits could (in theory) be tradable between countries with cap and trade systems and emissions performance standards, the differing incentives offered by a performance standard may mean that countries with cap and trade systems may be reluctant to allow such permit exchanges. Perhaps most importantly, the use of an emissions performance standard on its own raises no revenue for government to apply in lowering other taxes, funding technology development and deployment, or addressing equity issues imposed by adoption of climate policy. If, however, the policy included an emissions price ceiling (safety valve), this could provide some revenue, as would be the case with the proposed Canadian emissions performance standard. Finally, the performance standard system may be less transparent than the absolute cap and trade system, since it may not be readily apparent to the public whether a particular intensity requirement requires significant effort on the part of emitters or whether it would be reached even without a policy.

NOTES

1 An offset is an equivalent emission reduction by a non-regulated entity that is paid for by a regulated firm and would count toward its emission reduction requirement.

2 $Z = Qe = (1-0.18)(1+0.023) = 0.898 = 1 - 0.102$.

3 A proof of this proposition is given in Newell and Pizer (2008) and Sue-Wing, Ellerman, and Song (2009).

4 Similar models are presented in Fischer (2001), Boulder et al. (1999), Helfand (1991), and Holland (2009).

5 Throughout the paper we assume that grandfathered permits are allocated in perpetuity to existing firms, and that the allocation is not contingent on firm operation. This is similar to the allocation scheme in the US sulphur dioxide market (Schmalensee et al. 1998).
ways for allocating permits in a cap and trade system, for example, based on updating rules, would generate different incentives at the firm level.

In a regulated market, like the electricity market throughout much of Canada, the firm sells output at the average cost of production rather than the marginal cost of production. In this special case the firm would pass lump sum profits from grandfathered permits along to consumers in the form of lower prices.

Sijm, Neuhoff, and Chen (2006) provide empirical evidence for this phenomenon based on lump sum allocations to electricity generators in the first phase of the European Union Emission Trading Scheme.

In reality there are many firms, some of which purchase permits and some of which sell permits. In this model we are concerned with the “representative” firm, which is intended to represent the regulated portion of the market as a whole. Since there are no net permit purchases from outside the regulated portion of the market, the firm must exactly comply with the regulation, so \( n_{eq} = b \).

This conclusion relates to the static efficiency of the policies. In a later section of this paper we discuss the dynamic efficiency.

Specifically, all three federal policy proposals since 2002 have proposed an emissions pricing policy limited in scope to large final emitters.

In an open economy the policy would also raise the price of goods, except those for which international production is a perfect substitute for domestic production (crude oil is a good example of the latter).

In practice, governments may combine the performance standard with an agreement to sell an unlimited number of permits at a given price (a “safety valve”), which would raise some revenues for government.

If, instead of matching the intensity under the performance standard to the intensity under the cap and trade scheme, the regulator chose to match the emissions under the two policies, the incentive for innovation under the performance standard would still be higher. In this case, output is again higher under the performance standard system (because of the “dilution effect” identified by Heffland), and abatement is also greater. Since abatement is greater, innovations that reduce abatement cost are more highly valued (Bruneau 2004).

Some energy-focused CGE models do model the process of technological change explicitly, but mostly these are very aggregated and not appropriate for answering the policy questions examined here (e.g., Bosetti et al. 2006).

To maintain focus on comparing the tradable performance standard policy with the cap and trade policy, other details of the Turning the Corner proposal are not modelled. In particular, policies aimed at other sectors are not modelled, and some of the compliance mechanisms for large industrial emitters are not included. For example, while the Turning the Corner proposal allows large industrial emitters to meet emission obligations by purchasing technology fund credits and international and domestic offset credits, in addition to inter-firm trading and in-house reductions, the modelling described here includes only the last two compliance options. Thus the results should not be taken as an accurate simulation of the total federal government policy but rather as indicative of the likely effects of the emissions performance standard component of that policy relative to alternatives.

There are slight differences in emissions from non-covered sectors between the policies. These differences reflect the combination of two effects: first, a substitution effect, described earlier in the paper, encourages consumers to shift consumption toward covered sectors under the performance standard relative to the cap and trade system, because prices do not rise as much under the performance standard. This reduces emissions from non-covered sectors in the performance standard. Second, an income effect is present, since under the performance standard national income is higher than under the cap and trade system, increasing consumption of all goods. This increases emissions from non-covered sectors under the performance standard.

In the dynamic framework adopted here, the relevant measure is lifetime income. However, we present numerical results in terms of annual income because these are more familiar. Like most models used to conduct this type of analysis, the one employed here does not consider the environmental benefits associated with reduction of greenhouse gas emissions. The welfare measure reported here therefore only considers the economic costs of abatement, not the environmental benefits of abatement.

The figure does not show the total change in sector output, just the change in sector output resulting from changes in net exports. Demand for a sector’s products
can change for three reasons in the model: (i) because total domestic demand changes, (ii) because the sector becomes less competitive in international markets, and (iii) because domestic consumers substitute imported goods for domestically produced goods. Since (i) can be an intended result of the policy (for example, the policy is designed to reduce domestic demand for fossil fuels), the figure only shows impacts of (ii) and (iii) on sector output.

19 We assume that the regulator holds each policy fixed regardless of the rate of economic growth. While this is useful for illustrative purposes, it is possible that the regulator would change the stringency of each policy in response to the growth rate.

20 In the theory section described above, we did not differentiate between “new” and “old” plants, and so reached somewhat different conclusions than in this quantitative analysis.

REFERENCES


