The Initial Allocation of Tradable Emission Permits:

Evening Out the Regional Distribution of Costs Associated with Meeting Canada's Kyoto Protocol Target

By

Vania Karam

2392547

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Supervisor: Professor R. Quentin Grafton

Second Reader: Professor Leslie Shiell

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Section I: Introduction

In 1987, the Brundtland Commission highlighted the problem of environmental degradation and suggested a need to find ways of approaching development without compromising the ability of future generations to meet their own needs, a concept that has since become known as sustainable development. At the United Nations Conference on Environment and Development (UNCED) in 1992, Canada worked with other nations to develop an environmental action plan aimed at improving the environment in keeping with economic objectives that resulted in the United Nations Framework Convention on Climate Change (UNFCC). As part of the ongoing negotiations among the parties to the UNFCC, leading nations signed on to a Protocol in Kyoto, Japan, in 1997 that set binding constraints on the GHG emissions of signatory countries during the first commitment period of 2008 and 2012. Under the Kyoto Protocol, as it has since come to be known, participatory countries agreed to collectively reduce their emissions to five percent below their base levels in 1990 within the first commitment period. Canada committed to reducing its national GHG emissions to six percent below 1990 levels, which, according to Canada's Analysis and Modelling Group[1] (AMG, 1999) would amount to 565 Mt of CO_2 equivalent emissions by 2012.

This paper will attempt to show how an initial allocation of tradable emission permits can be used to even out the regional distribution of costs associated with reducing Canada's

[1] The AMG is a federal/provincial/territorial working group that was put in place to conduct and oversee economic and environmental analysis in the area of climate change. The group provides feedback to the National Air Issues Coordinating Committee on Climate Change (NAICC-CC) so that they can make informed decisions on whether or not Canada should ratify its Kyoto Protocol commitment.

GHG emissions to meet the Kyoto Protocol target. Section I of this paper is the introduction. Section II will provide a regional description of the costs associated with Canada meeting its Kyoto obligation. Section III will entail a theoretical discussion to show the capacity for a system of domestically traded emission permits to separate the issue of 'who pays for abatement' from 'where it occurs', in order to achieve an abatement target at least-cost. Section IV will provide a macroeconomic framework to show the potential for an initial allocation of tradable emission permits to compensate the relevant parties and thus even out the regional distribution of costs associated with meeting Canada's Kyoto Protocol target. Section V will provide the conclusion.

Emissions-intensive industries in Canada are clustered in different provinces, implying that an emissions reduction policy that places the burden of abatement on any one industry will result in an uneven share of negative impacts to gross domestic product (GDP) and employment across regions. The federal government has stated that its primary goal in formulating an emissions reduction strategy will be to ensure that no province is unfairly given a higher burden in terms of emissions reduction. One of the key results of this paper will be to show that the initial allocation of permits can help to compensate parties that are most negatively affected by a national strategy aimed at meeting Canada's Kyoto Protocol target, thus increasing the chance of compliance.

Section II: Regional Distribution of Kyoto Related Costs

In 1998, environment and energy ministers from Canada's federal and provincial governments worked together to form the National Climate Change Secretariat (NCCS) that was charged with developing a national implementation strategy for the reduction of Canada's GHG emissions[2]. The outcome was the formation of sixteen issues tables and working groups that were instructed to consider the regional impacts and cost-effectiveness of proposed measures for meeting Canada's Kyoto Protocol target. One of these groups, termed the Analysis and Modelling Group (AMG), bundled the various measures into five paths and commanded four groups of modelers to simulate the economic impact of these paths under alternative scenarios.

The regional description of costs presented in this paper will take from the results of a model that considers the macroeconomic impacts of GHG reduction options that is commonly referred to as TIM, the Informetrica Model (Cebryk et al., 2000). This modeling work used inputs taken from the Canadian Integrated Modelling System[3] (CIMS model, Energy Research Group, M.K. Jaccard et al., 2000) to determine the national and provincial effects of a national strategy aimed at reducing Canada's GHG emissions. In the literature, a particular combination of policies to meet Canada's Kyoto Protocol target is referred to as a path. Each path is modeled in relation to a particular

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[2] GHG emissions are molecules that are released into the atmosphere that contribute to global warming through the absorption of the thermal radiation that is emitted from earth. Some important GHG emissions come in the form of carbon dioxide, water vapour, methane, nitrous oxide, and chlorofluorocarbons.

[3] The purpose of the CIMS model is to show what the likely response of firms and households will be to policies that affect their technology acquisition and use decisions. The model shows the interaction between industrial, residential, commercial/institutional, and transportation sectors (users of energy), and those sectors that produce and transform energy, such as electricity generation and fossil fuel suppliers, oil refineries and processors of natural gas.

scenario, depending on whether or not Canada acts with the participation of other countries in meeting its Kyoto target and whether or not international mechanisms are permitted.

The United States has renounced its commitment to the Kyoto Protocol. Therefore, the present paper will focus on a scenario in which Canada implements policies to reduce emissions consistent with Kyoto and the U.S. does not, similar to the one called "Canada acts alone" in the literature, where Canada is assumed to be the only country to undertake its Kyoto commitment. The impact case that is presented in this paper uses inputs from CIMS under the Canada acts alone scenario and assumes a national least-cost policy, which is termed Path 2CA[4] (AMG, 2000). Under this Path, an economy-wide emissions reduction target is established and industrial sectors are instructed to meet this target without the use of international mechanisms based on cost-effectiveness, with domestic emissions trading permitted for larger sources. Other paths, in contrast, include Path 0, an aggregation of all the measures, Path 1, based on sectoral targets, Path 3, permit trading for large emitters and sector specific targets, and Path 4, with as broad as practical permit trading.

[4] The defining feature of this path is that some sectors reduce their emissions by more than 6 percent, while others do not, but on the whole the country meets its Kyoto target. The Kyoto Protocol also includes international mechanisms that allow for participatory countries to discharge a portion of their obligations in other countries. Whether or not Canada's trading partners, particularly the U.S., choose to participate in Kyoto can have important impacts on trade and economic activity in Canada. In order to comprehend the implications of these impacts, AMG developed three possible scenarios. One of these scenarios, termed 'Canada Acts Alone', assumes that Canada meets its Kyoto Protocol obligation only by the use of domestic actions and impacts of these actions are unaffected by other countries' emissions reduction efforts. Thus under Path 2CA, Canada meets an economy-wide emissions reduction target and export prices and export demand are assumed to be maintained at the same levels as in the report Canada's Emissions Outlook – an Update (AMG, 1999).

The regional results presented in the analysis of AMG consider the macroeconomic impacts of a national least-cost path for meeting Canada's Kyoto Protocol target. One of the key finding of AMG is that if Canada is to meet its Kyoto obligation, this will likely lead to a long-run reduction in GDP relative to Business-as-Usual[5] (BAU) in the range of 0 to 3 percent[6], depending on the path-scenario combination and the micro-inputs that are used (AMG, 2000). AMG found that over the long-term, total employment is reduced moderately, but unevenly across regions. It is highlighted in their findings that under the Canada Acts Alone Scenario (CA), Ontario accounts for over half of the lasting negative effects for the Canadian economy as a whole. One of the primary conclusions is that Canadian competitiveness will be most negatively affected under the scenario where Canada undertakes domestic abatement action and our major competitors do not, owing to the fact that higher production costs relative to international firms will make our exports less competitive.

Path 2CA is modeled in relation to a number of parameters such as GDP and employment. Regional impacts on these variables under this Path can be found in the macroeconomic modeling of the TIM, Informetrica model (Cebryk et al., 2000). These results are presented by region and province in Table 2.1. To demonstrate the impact on employment, the impacts are transformed into regional shares of Canadian job losses under Path 2CA (using micro-inputs from CIMS) following the policy (effects measured

[5] Business as Usual (BAU) is a modeling scenario conducts forecasts under the assumption that policies do not change from the present. In climate models this means that GHG emissions continue to grow as they have in the past.

[6] A reduction in real GDP of 3 percent in 2010 requires that from the time the policy begins, 2000, to the time it ends, 2010, the economy will grow by 26 percent, instead of the projected rate of growth of the economy under BAU, which is 30 percent (AMG, 1999).

from 2013-2018), relative to the regional share of national employment that existed before the policy (1999). From the results presented in Table 2.1, Ontario, Saskatchewan, and Alberta appear to be the most worse off in terms of GDP impacts. Relative to the share of employment before the policy took effect in the year 2000, Manitoba, Saskatchewan, and Alberta, appear to have the highest employment losses.

Table 2.1: The Regional Impacts of Abatement Efforts on GDP and Employment
(Results are Projected between 2013 and 2018, Path 2CA CIMS)

Nationwide / Provincial	Impact on Real GDP at factor cost, (average %) (a)	Share of Canadian Job Losses, Path 2CA(%) (b)	Share of Employment in Canada (%), 1999 (c)
Canada	-2.0	-	-
Region I: Atlantic	-0.8	-	-
Newfoundland	-0.8	0.7	1.4
P.E.I.	-1.2	0.0	0.4
Nova Scotia	-1.2	2.1	2.8
New Brunswick	-0.2	0.7	2.2
Region II: Central	-2.2	-	-
Quebec	-1.4	23.6	23.1
Ontario	-2.7	39.3	39.1
Region III: Prairies	-2.2	-	-
Manitoba	-1.5	5.7	3.7
Saskatchewan	-2.6	5	3.3
Alberta	-2.3	13.6	10.7
Region IV: B.C. & Territories	-1.0	10	-
B.C.	-1.0	N/A	13.1
Territories	-1.4	N/A	-

Secondary Source: (a), (b) from TIM, the Informetrica Model (Cebryk et.al, 2000), (c) from Statistics Canada (1999), (Assume that policy actions start in 2000)

The results of the CIMS model of the Energy Research Group (M.K. Jaccard et al., 2000) suggest that Path 2 can lead to a cost-effective outcome for the economy as a whole. However, according to the results of TIM, the Informetrica model (Cebryk et al., 2000), the costs associated with a reduction in GDP and employment under Path 2CA are more significant in some provinces than in others. One possible observation that can be derived from these results is that a policy that places a heavy burden of the cost associated with reducing Canada's GHG emissions on emissions-intensive sectors will likely result in an uneven distribution of effects across regions. Thus, a national strategy that is cost-effective but does not consider the regional distribution of Kyoto-related costs will likely result in much reluctance on the part of the provinces to comply with a national emissions reduction policy.

Regional impacts are primarily a reflection of sectoral impacts (AMG, 2000). The contribution to provincial GDP of emissions-intensive industrial sectors is presented in Table 2.2. Sectors that are considered for the provincial totals include the following: electric power generation from coal-fired electric power plants, fuel oil, and natural gas, mining and oil and gas extraction, emissions-intensive manufacturing industries, and pipeline transportation. Sectoral totals indicate that emissions-intensive industries account for a substantial portion of provincial GDP in the Prairies, the Atlantic Region, and the Territories. Thus, given that these industries are clustered in different provinces and electric power generation from emissions-intensive fuel types are widely distributed across the provinces, one might expect that the provincial burden under a GHG abatement policy and types of Kyoto-related costs might be quite differentiated.

Table 2.2: Contribution to Provincial GDP in Emissions-Intensive Industrial Sectors[7] (%), 2000

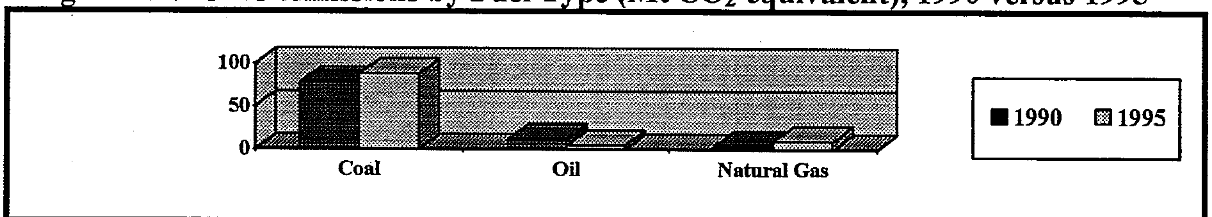
High-Emissions Sectors	Some Industries Within those Sectors	Emissions Intensity (Tonnes of CO_2 equivalent per $1,000 gross output) (1992)	% Of Total Industrial Emissions (1992)	Nfld	PEI	NS	NB	QC	ON	MA	Sask	AB	BC	YK	NWT	NVT
Electric Power Generation *(See Annex 2)*	*(Coal, Oil, Natural Gas)*	19.1[8]	23.36	**0.27**	**1.21**	**2.25**	**2.57**	**0.02**	**0.58**	**0.19**	**1.44**	**1.71**	**0.13**	**0.41**	**1.28**	-
Mining and Oil and Gas Extraction		-	-	**13.66**	**0.14**	**1.48**	**1.83**	**0.74**	**0.68**	**2.00**	14.16	18.60	**2.78**	**6.15**	21.74	23.96
	Petroleum and Natural Gas	3.47	14.89	8.29	0.00	0.47	0.00	0.00	0.01	0.26	8.17	15.29	1.08	1.50	9.41	0.00
	Coal Mining	4.05	1.10	0.00	0.00	0.32	-	0.00	0.00	0.00	-	-	0.58	0.00	0.00	0.00
	Metal Ore (Iron) Mining	2.45	0.44	-	0.00	0.00	-	0.48	0.46	-	-	-	0.59	-	-	22.90
	Support activity mining/oil&gas	-	-	1.80	0.00	0.14	0.23	0.08	0.05	0.16	-	2.95	0.46	-	-	-
Manufacturing (all)		-	-	6.63	9.59	11.48	14.76	23.12	22.36	12.93	7.16	10.17	11.57	0.22	0.23	0.07
	Pulp and Paper	**1.75**	**2.86**	-	0.00	-	**3.68**	**1.57**	0.54	-	-	**0.45**	**1.51**	0.00	0.00	0.00
	Petroleum and Coal Products	**3.21**	**5.19**	-	**0.00**	-	-	-	**0.21**	-	-	-	-	-	0.00	0.00
	Industry Chem. And Products	**Industrial Chem: 3.51 Chem. Products: 2.41**	**3.69 1.60**	**0.04**	**0.01**	**0.08**	**0.21**	**0.60**	**1.04**	-	**0.06**	**1.25**	**0.29**	**0.00**	**0.00**	**0.00**
	Cement and Concrete	**Cement: 10.42 Concrete: 2.97**	**1.62 0.08**	-	-	**0.19**	-	**0.23**	**0.22**	**0.13**	-	**0.25**	-	-	-	**0.00**
	Non-Metallic Mineral	**2.53**	**0.72**	-	-	**0.17**	-	**0.30**	**0.38**	**0.09**	-	**0.14**	-	**0.00**	**0.00**	**0.00**
	Primary Steel /Fabric. Metal	**Primary Steel: 2.94**	**3.36**	-	-	-	-	**3.22**	**2.97**	**1.61**	-	**1.37**	**1.17**	-	**0.00**	**0.00**
Pipeline Transportation		2.8	2.21	**0.00**	**0.00**	-	-	**0.08**	**0.20**	**0.62**	**1.58**	**1.25**	**0.52**	**0.00**	**1.54**	**0.00**
Total Contribution of Emissions-IntensiveIndustrial Sectors to Provincial GDP (sum of bold #'s)				13.97	1.36	4.17	8.29	6.76	6.82	4.64	17.24	25.02	6.4	6.56	24.56	23.96

Secondary Source: GDP-Industry Measures and Analysis Division, Statistics Canada (2001), Emission/Emissions Intensity-TPWG Options Report (2000)

[7] **Emissions-intensive industrial sectors** are ones where one or more of the industries that make up that specific sector have an **emissions-intensity** of tonnes of CO_2 equivalent per $1,000 gross output that is **greater than 1.75** (TPWG Options Report, 1998, *Part III Annexes-Table A.4.1*).
[8] This figure, 19.1, is a national average of different fuel types and therefore cannot be applied directly to any particular province (see Appendix 2).

Electric power generation, primarily from coal-fired electric power plants, but also from fuel oil and natural gas, is the sector that generates the highest share of industrial GHG emissions, and also has the highest emissions-intensity of all sectors. In Figure 2.1, the GHG emissions by fuel type for 1990 and 1995 are shown. As is evident in the figure, emissions from coal-fired electricity generation and natural gas have increased over time, while those from fuel oil have decreased. In terms of reducing GHG emissions, coal is at a definite disadvantage. Clean coal technologies are available, but presently these technologies are quite costly and not well commercialized (NRC, 2000). From 1995 to 1998, the percentage of national capital expenditures on pollution abatement and control equipment by the electric power sector has been moderate in the range of 3 to 5 percent (Environment Account and Statistics Division, Statistics Canada, 1995-1998).

Figure 2.1: GHG Emissions by Fuel Type (Mt CO_2 equivalent), 1990 versus 1995



Source: NCCP Electricity Industry Issues Table Foundation Paper (1997), Canadian. Electricity Assn.

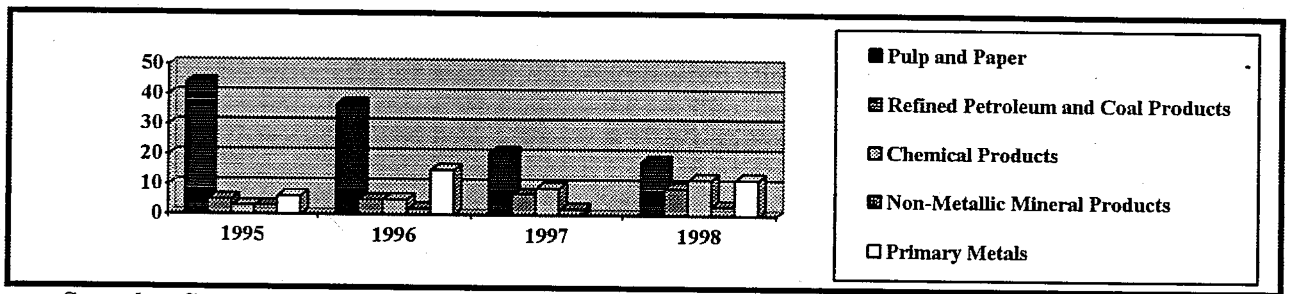
According to Natural Resources Canada (NRC, 2000), total Canadian oil production is forecasted to increase by about 19 percent from 1995 to 2020, with a 23 percent increase in crude oil exports over the same period. Globally, Canada is the 3rd largest producer of natural gas and the 2nd largest natural gas exporter. The NRC estimates that domestic demand for natural gas will increase anywhere from 60 percent to 90 percent from 1997 to 2020, with a forecasted increase in natural gas exports in the range of 40 to 65 percent.

Canada holds approximately 1 percent of the world's coal resources, which are primarily used for generating electricity (thermal coal) and the production of steel (metallurgical or coking coal) (NRC, 2000). In terms of future resources of coal, NRC speculates that Alberta will hold 68 percent of total resources, and British Columbia and Northern Canada will house the rest. According to NRC (2000) estimates, domestic demand for coal is expected to increase by 40 percent from 1995 to 2020, with exports of metallurgical coal staying flat at 1995 levels and exports of thermal coal increasing marginally based on increasing demand from Asia. The supply of electric power generation falls primarily within provincial jurisdiction and in most cases provinces try to meet domestic demand and exports to U.S. regions from internal sources rather than from neighboring provinces. Reducing future GHG emissions from electric power generation in Canada will largely depend on where and how electricity is generated.

The mining and oil and gas sector contributes the most to provincial GDP in Alberta, Saskatchewan, Newfoundland, and the Territories. While the expenditures on abatement and control equipment by the oil and gas industry have decreased from 1995-1998, expenditures by the pipeline transport and oil and gas distribution industry have been steadily increasing (Environment Accounts and Statistics Division, Statistics Canada, 1995-1998). Manufacturing industries that have high emissions-intensities include cement and concrete, industrial chemicals and chemical products, primary steel, non-metallic mineral products, petroleum and coal products, and pulp and paper manufacturing. The percentage of total national capital expenditures on environmental protection is given for some of these industries for the period from 1995-1998 in Figure

2.3. As is evident in the figure, capital expenditures are relatively higher for pulp and paper, however these expenditures have been decreasing since 1996. For other industries, such as refined petroleum and coal, chemical products, and primary metals, expenditures have been increasing from 1995-1998.

Figure 2.2: Percentage of Total Capital Expenditures on Pollution Abatement and Control Equipment[9] in the Manufacturing Sector (%), 1995-1998



Secondary Source: Environment Account and Statistics Division, Statistics Canada (1995-1998), Environmental Protection Expenditures in the Business Sector, (1997-primary metals was unavailable)

Pulp and paper manufacturing contributes the most to provincial GDP in New Brunswick and Quebec. The industrial chemicals manufacturing industry[10] contributes the most to provincial GDP in Alberta and Central Canada. The industry for primary steel[11] and fabricated metal products contributes the most to provincial GDP in Central Canada.

[9] In this context, expenditures on pollution abatement and control equipment include purchases of the following types of capital: pollution abatement and control processes (end-of-pipe), pollution prevention processes, and environmental monitoring.

[10] The fact that the industrial chemicals and synthetic resins industry is concentrated in three provinces, means that an increase in production costs due to a national abatement policy could lead to an uneven distribution of regional effects (MIB, Industry Canada, 2001).

[11] The Canadian steel industry is divided among integrated steel producers that generated 85 percent of the industry's 1997 emissions, and smaller minimills that use electric arc furnaces to melt and refine scrap into liquid steel, without having to smelt scrap by way of coke ovens. Thus, the steel industry will be faced with both direct abatement costs and indirect abatement costs arising from an increase in the price of raw materials due to energy inputs and rising transportation costs (MIB, Industry Canada, 2002).

These results indicate that for the majority of emissions-intensive industries, there are a fair amount of abatement opportunities available. Thus, for these industries, the expected Kyoto-related costs will likely be direct costs associated with real resources being switched from the production of final goods and services to the production of intermediate good abatement, and some indirect costs as a result of higher input prices, altering the output mix such that less manufactured goods are produced in favour of environmental goods. However, for some industries, the Kyoto-related costs will likely be in terms of reduced exports due to declining international competitiveness resulting in displaced workers and stranded capital.

Section III: Separating the Issue of Who Pays For Abatement From Where It Occurs in the Economy

One possibility for addressing provincial inequity problems may be to implement a system of tradable emissions permits that can separate the issue of 'who pays for abatement' from 'where abatement occurs'. Giving firms more flexibility in deciding whether to invest in abatement or purchase additional permits may increase the chance of regional compliance with an emissions reduction policy. Over the short-term, a system of tradable permits may be able to meet an emissions reduction target at a lower cost to all industries as a whole than if each industry were to be constrained by some type of emissions standard.

This section will provide a theoretical discussion to show the capacity for domestically traded permits to separate the issue of which firms pay for abatement from where abatement actually occurs. The first part of this section will discuss the market framework for a system of permits and move into a discussion surrounding emission permits in relation to a firm's marginal cost of abatement. The section will use an example of high-cost versus low-cost firms to show how permit trading can even out the distribution of costs in meeting an economy-wide emissions reduction target.

A tradable permit will act like an economic instrument to put a market price on the additional unit of emissions that a firm releases during production. After permits have been initially allocated, firms that have an excess number of permits will be able to generate revenue by selling off their additional permits to firms that are lacking permits.

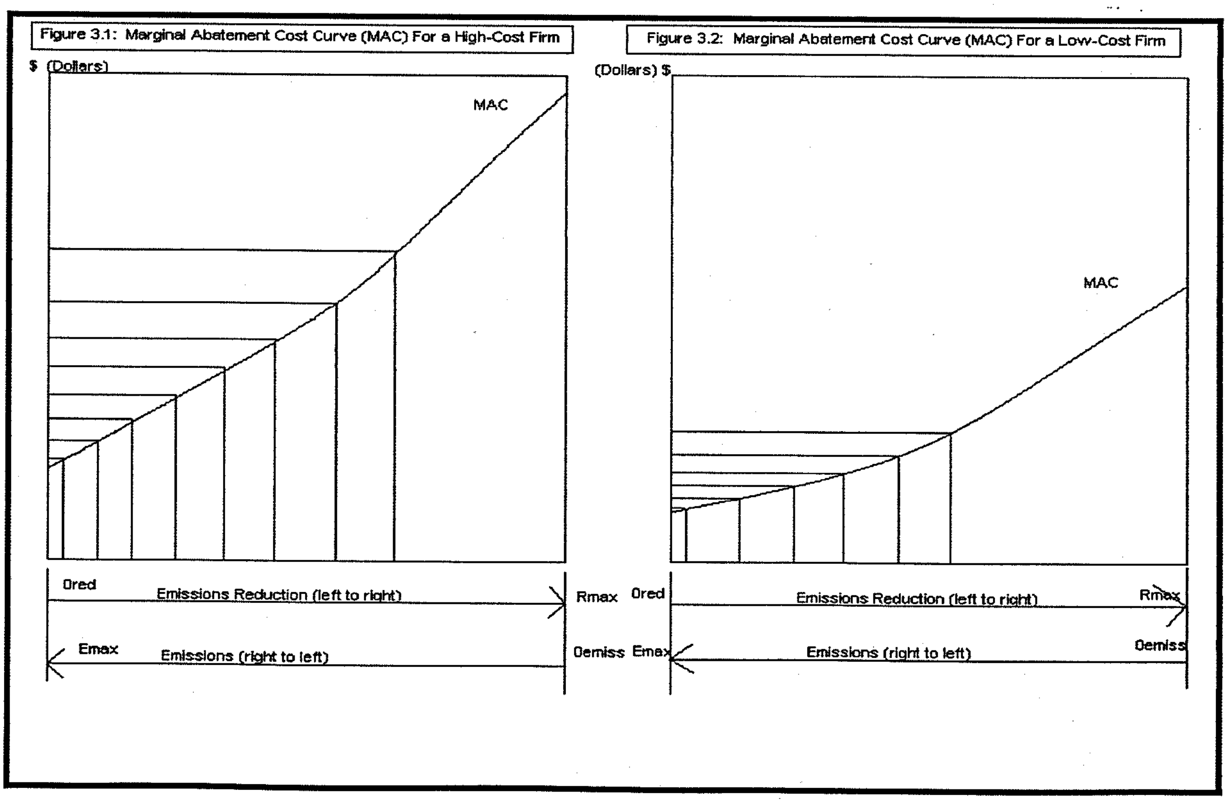
After all trades have occurred, the permit price will be such that it is equal to the marginal cost of abatement for all firms, given that firms are price-takers in the market for permits.

The marginal cost of abatement (MAC) curve is used to show how imposing a tradable permit requirement will affect the emissions and abatement costs for individual firms. Consider two firms that release GHG emissions in their production activities. The MAC curves for these firms will show the relationship between the additional cost of abatement and the level of emissions reduction for those firms. In the example that will follow, it will be assumed that one of these firms must incur a higher marginal cost than the other to achieve a desired level of emissions reduction.

In Figures 3.1 and 3.2, the MAC curve for a high-cost firm is shown on the left and the MAC curve for a low-cost firm is shown on the right. The horizontal axis represents the total amount of emissions reduction. In the other direction on the horizontal axis, from right to left, the total amount of emissions for each firm is given. Note that at any given level of emissions reduction, the marginal cost of abatement for the high-cost firm will be greater than that of the low-cost firm. The upward slope of the MAC curves shows that in order to reduce an additional unit of emissions, an additional cost must be incurred that is getting successively higher as an individual firm chooses to abate more and more emissions.

It is evident from Figures 3.1 and 3.2 that the target amount of emissions reduction can attained at least-cost if the high-cost firm were to emit one more unit of pollution and the low-cost firm were to abate one more unit of pollution. This can be done through a trade in permits resulting in the high-cost firm being able to submit this permit and abate one less unit of pollution, while the low-cost firm would be able to use the revenue it receives from the sale of that permit to abate one more unit of pollution. A system of tradable emissions permits is cost-effective because it minimizes the total cost of achieving a given abatement target. Under a permit system, any emissions source can choose to reduce its emissions below its permit holdings and therefore sell excess permits to firms that have emissions above their permit holdings. Thus, by making emissions permits transferable, sources are able to meet their emissions reduction requirements at a lower cost, even if that means that emissions reduction will be done by another firm where it is cheaper to do so (Tietenberg, 1990).

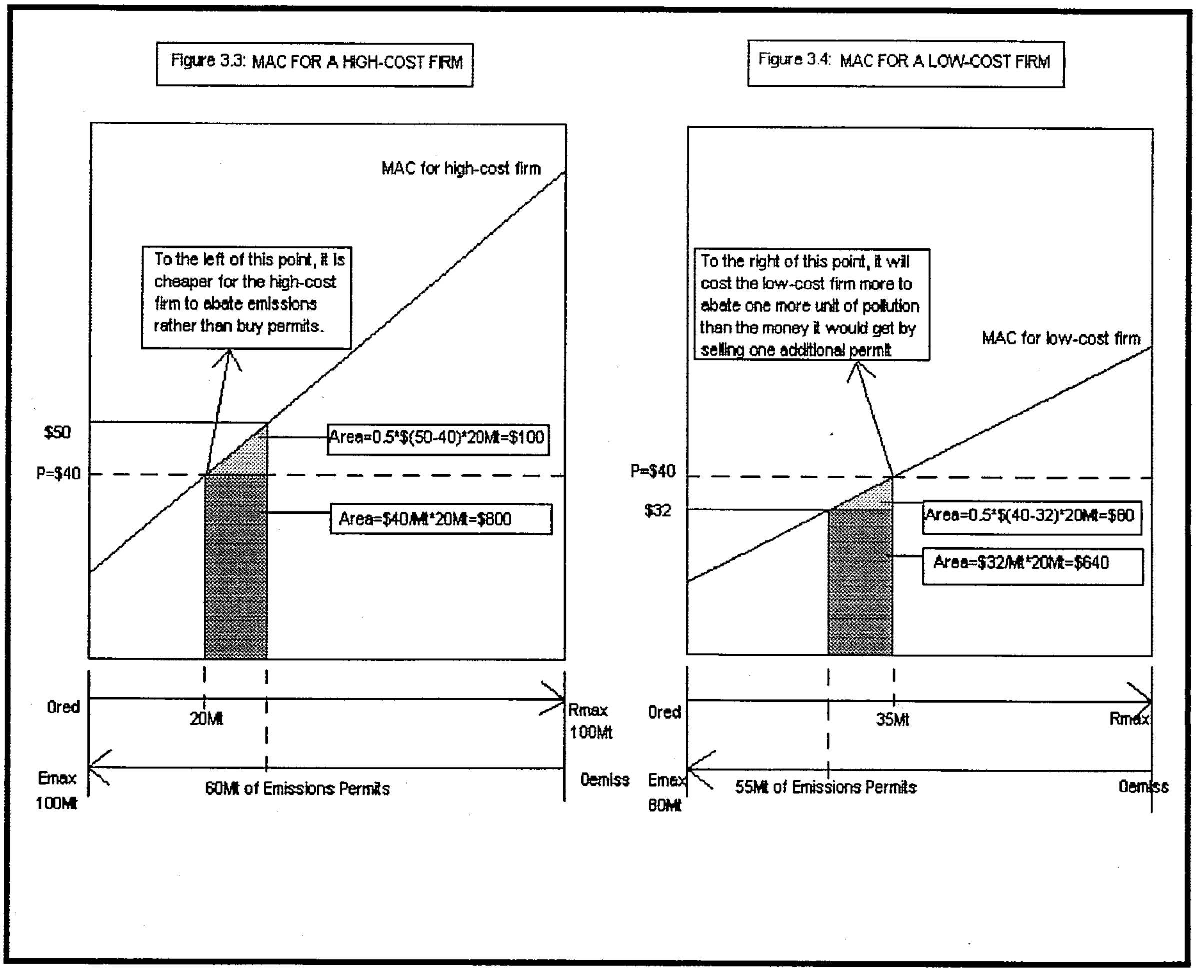
Figures 3.1 and 3.2: MAC for a High-Cost and a Low-Cost Firm



A numerical example is presented in Figures 3.3 and 3.4. If we apply the high-cost and low-cost firm examples to a representation of all firms in a particular industry, we can try and understand how a system of tradable permits can work in the market. Consider the effect of implementing an emissions cap of 115Mt of carbon per year and then allocating permits such that the total amount of permits distributed is equal to this cap. Once all permits have been allocated, the firms will then be allowed to trade their permits if they have excess, or buy permits if the number of permits they have is insufficient for their levels of production.

Take for example that the market price for an emissions permit is $40.00 for one more megaton (Mt) of carbon emissions. The gray shaded areas in Figures 3.3 and 3.4 demonstrate how the issue of which firm pays for abatement can be separated from where abatement occurs. Without the cap on emissions, the high-cost firm will choose to emit 100Mt of carbon emissions per year for their production, while the low-cost firm will choose to emit 80Mt of carbon emissions per year. Suppose that when an emissions cap, as stated above, is implemented using a system of domestically traded permits, the high-cost firm will receive 60Mt worth of carbon emissions permits, while the low-cost firm will receive 55Mt worth of permits. Faced with a price for one more Mt of carbon emission equal to $40.00, the high-cost firm is willing to pay $800 for 20 more emissions permits in the market due to the fact that this firm would have had to pay $900 to abate these 20Mt more emissions, given its steep marginal abatement cost-curve. The low-cost firm is willing to sell these 20 permits to the high-cost firm for $800 due to the fact that it will only cost this firm $720 to abate this much emissions, given its flat marginal abatement cost curve. An outcome where the high-cost firm abates 40Mt of pollution and the low-cost firm abates 25Mt of pollution is not a cost-effective outcome. The low-cost firm would be willing to sell additional permits and use the revenue to invest in abatement up to the point where its MAC is equal to $40, the market price for permits. This is because after this point, it will cost more for the low-cost firm to abate its emissions than it would receive by selling permits in the market.

Figure 3.3 and 3.4: A Trade of Domestic Emissions Permits



Thus, in equilibrium the marginal cost of abatement for both firms will be just equal to the market price for permits, $40. Given that the price for permits in the market is equal to the marginal cost of abatement for both firms, the marginal cost of abatement will be equalized across all emissions sources, and thus the permit system will prove to be nationally cost-effective. The advantage of a system of tradable permits in this context is that every unit of emissions that a firm emits above and beyond their initial allocation of permits will now have a market price that is equal to $40.

Section IV: The Initial Allocation of Tradable Emissions Permits

The initial allocation of tradable emission permits may be used as a policy tool to compensate parties that will be negatively affected under an emissions reduction strategy. Ensuring that no industry or province is unfairly hit with a higher burden in terms of lost GDP or a higher proportion of displaced workers may help to even out the regional distribution of costs to meeting Canada's Kyoto Protocol target. According to TIM, the Informetrica model (Cebryk et al., 2000), in emissions-intensive industries that are clustered in different provinces (as was shown in Section II), these costs are expected to be especially high[12], thus leading to an uneven distribution of regional effects. This section of the paper will provide a macroeconomic framework to show how the initial allocation of permits in a domestic emissions-trading scheme can be used to even out the regional distribution of costs associated with meeting Canada's Kyoto Protocol target.

To determine the initial allocation of permits, this section will set out a simple macroeconomic framework where the costs to a particular region will fall into three broad categories: abatement, reduced output of manufactured goods due to restriction on the pollution input, and reduced output due to a decreasing ability to compete with international competitors in non-participatory countries. Abatement costs occur when real resources are switched from the production of final goods and services to the production of intermediate good abatement. Costs that are in the form of reduced output due to restrictions on the pollution input occur when the output mix is altered so that

[12] According to TIM, under Path 2CA (CIMS), the impact on real GDP in the period 2013-2018 is expected to be –0.9 for wood and paper, -3.3 for energy, -4.1 for chemicals and chemical products, and –6.6 for metallic minerals and products.

more environmental goods are produced and fewer manufactured goods are produced. Costs in the form of reduced output from reduced international competitiveness occur when higher domestic production costs make our exports uncompetitive relative to goods produced in non-participatory countries, resulting in displaced workers and stranded capital.

In this macroeconomic framework, permit payments will represent transfers between buyers and sellers of permits rather than real costs. However, if the buyer and seller are situated in different regions, then the transfer will affect the regional distribution of costs. The model can be considered to be static, meaning that all the effects will occur at one point in time, in 2010. Regions in the model will be denoted by an index i. In total, seven regions will be considered: Atlantic Canada, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, and British Columbia (for some variables, only values for BC plus the Territories are available).

Variables that will be used in this model that can be considered to be exogenous, meaning that their values are determined outside the model, are as follows: N, the total population of all regions combined, N_i, the population of region i, C_i, the final permit holdings of region i, Q_i, the loss of GDP in region i in 2010 due to the least-cost national abatement policy (note that this model is set up so losses have positive signs, thus a negative loss is a gain), q_i, the per capita loss of GDP in region i in 2010 due to the least-cost national abatement policy, and $\overline{q}$, the mean loss per capita. Values for population were derived from Statistics Canada projections for population where both sexes are considered. The final permit holdings of region i, C_i, will just be equal to the final emissions of each region in 2010 as a result of the national least-cost abatement policy. The final permit holdings of region i will be derived from a simple calculation using AMG estimates for projected GHG emissions under the business as usual scenario (BAU) less the regional share of emission reductions to meet Canada's Kyoto Protocol target in 2010 under Path 2CA using CIMS (*Appendix 1*). Values for the loss of GDP in each region are estimated in TIM, the Informetrica Model (Cebryk et al., 2000). The per capita loss of GDP in 2010 is given by dividing the estimated regional loss of GDP by the projected population size in each region in 2010. Values of these variables for each region are given in Table 4.1.

Table 4.1: Values of Select Exogenous Variables for use in this Model

Nation / Region	**Projected Population, 2010 (Both Sexes)** ***(CANSIM)*** **(a = N_i)**	**Final Permit Holdings, 2010 (Mt CO_2 Equivalent)** *(Appendix 1)* **(b = C_i)**	**Loss of GDP, 2010 ($86, millions)** ***(Informetrica, p.218, Table 107)*** **(c = Q_i)**	**Per Capita Loss of GDP, 2010 ($86 millions)** *{(c) / (a)}* **(d = q_i)**
Canada	**32,635.2**	**565.00**	**15,425**	**0.47265 = $\bar{q}$**
Atlantic	2,366.7	40.09	340	0.14
Quebec	7,420.2	75.10	2,274	0.31
Ontario	12,796.6	163.25	8,630	0.67
Manitoba	1,153.2	20.03	293	0.25
Saskatchewan	1,015.3	46.10	576	0.57
Alberta	3,230.2	165.34	2,245	0.70
British Columbia	4,545.5	55.09	1,017	0.22

Source: (a) taken from CANSIM, (b) taken from Appendix 1, (c) taken from TIM,the Informetrica Model (Cebryk et al, 2000.), (d) calculated using (a) and (c)

Exogenous policy variables, that will also be determined outside the model, include C, the total amount of emission permits distributed to all the regions (565 Mt of CO_2 equivalent according to AMG, 1999) and P, the equilibrium price for permits. According to TIM, the Informetrica Model (Cebryk et al., 2000), when a permit system is introduced in 2008, the Canada acts alone (CA) cases assume that payment amounts equivalent to 2 percent of GDP are reached from that point forward. According to Canada's AMG (2000), the CIMS estimate of the economy-wide abatement cost is about \$120 per tonne of CO_2. However, in the report of AMG findings, there is a footnote that states that the CIMS modeling estimated that the strict 'financial cost' estimate of the marginal abatement cost might be about \$80 to \$90 per tonne of CO_2. These prices for permits are quite high relative to literature estimates, thus this model will consider a lower range of possibilities for the permit price as follows: low (\$20 per tonne of CO_2 equivalent), medium (\$50), and high (\$75).

Endogenous variables, which will be determined inside the model, include Y_i, the net loss of region i in 2010, y_i, the per capita net loss of region i in 2010, $\overline{C_i}$, the initial allocation of permits to region i, and $P \times \left(C_i - \overline{C_i}\right)$, the net purchase/sale of permits by/from region i (note: a negative value here implies a 'net sale' of permits).

Definitions that will be considered in the model include the permit balance: $\sum_{i=1}^{I} \overline{C_i} = \sum_{i=1}^{I} C_i = C$, the value of equilibrium in the market for permits: $\sum_{i=1}^{I} P \times \left(C_i - \overline{C_i}\right) = 0$, and the mean loss per capita: $\overline{q} = \sum_{i=1}^{I} \frac{N_i}{N} \times q_i = \frac{1}{N} \times \sum_{i=1}^{I} Q_i$.

Relationships that will be considered in the model include the net loss of region i and the per capita net loss of region i, $Y_i = Q_i + P \times \left(C_i - \overline{C_i}\right)$ and $y_i = q_i + P \times \left(\frac{C_i - \overline{C_i}}{N_i}\right)$ (1), respectively. The policy objective will thus be to choose the initial allocation of permits $\{\overline{C_i}\}$ such that $y_i = \bar{q} \quad \forall i \Rightarrow (1): \bar{q} = q_i + P \times \left(\frac{C_i - \overline{C_i}}{Ni}\right)$, and thus the per capita loss across regions will be equalized. Thus, the initial allocation of permits will be as follows.

$$\overline{C_i} = \frac{N_i}{P} \times \left[q_i - \bar{q} + P \times \left(\frac{C_i}{N_i}\right)\right] = \left(\frac{1}{P}\right)\left(Q_i - \left(N_i \times \bar{q}\right)\right) + C_i = \left(\frac{1}{P}\right)\left(Q_i - \left(\frac{N_i}{N} \times \sum_{i=1}^{I} Q_i\right)\right) + C_i \ \forall i$$

After substituting values for the variables into the above equation (2), the initial allocation of permits to each region under the pre-specified range of permit prices was derived. The results are presented in Table 4.2, along with the resulting purchase/sale of permits by each region, which is the same, regardless of the permit price.

Table 4.2: The Initial Allocation of Permits to Each Region Under A Range of Permit Prices and Each Regions Resulting Purchase/Sale of Permits, The Resulting Net Loss and Per Capita Net Loss of Each Region are also shown

Nation / Province	Initial Allocation of Permits to Region *(Mt CO_2 equivalent)* P=\$20	Initial Allocation of Permits to Region *(Mt CO_2 equivalent)* P=\$50	Initial Allocation of Permits to Region *(Mt CO_2 equivalent)* P=\$75	The Resulting Purchase/Sale of Permits by Region *(Mt CO_2 equivalent)*
Atlantic	1.16	24.52	29.71	778.62
Quebec	13.44	50.44	58.66	1233.15
Ontario	292.33	214.88	197.67	- 2,581.70 (sale)
Manitoba	7.43	14.99	16.67	252.06
Saskatchewan	50.91	48.02	47.38	- 96.12 (sale)
Alberta	201.25	179.70	174.92	- 718.25 (sale)
British Columbia	-1.48	32.46	40.00	1,131.43

The purpose of this section was to show how the initial allocation of permits under a system of domestically traded permits would be able to even out the regional distribution of costs associated with meeting Canada's Kyoto Protocol target. To do the analysis, a range of permit prices were considered ranging from $20 (low), $50 (medium), and up to $75 (high). After plugging in values for all the variables into equation (2) it was found that in all permit price scenarios, Atlantic Canada, Quebec, Manitoba, and British Columbia[13] were allocated permits that were less than their forecasted emissions in 2010, while Ontario, Saskatchewan, and Alberta were given an excess amount of permits to meet their 2010 forecasted emissions. Thus, the results indicate that in equilibrium, Atlantic Canada, Quebec, Manitoba, and, with a permit price of $50 or $75, British Columbia, would be net purchasers of permits, while Ontario, Saskatchewan, and Alberta would be net sellers of permits. According to the calculations, while the gross losses per capita of the regions were widely dispersed, the per capita net loss for each region was equal to the Canadian average under all permit scenarios, $0.47625 ($86 millions).

Following the discussion presented in Section III, regions that have an excess number of permits will sell off those permits to those regions that have an insufficient number of permits to meet their emissions requirements. Thus, the permit regime makes it possible to have inter-regional transfers, through the purchase and sale of permits, so that regional losses are evened out.

[13] With a permit price of $20, the negative permit allocation for British Columbia implied that lump-sum transfers would be required, over and above any allocation of permits, to equalize the net Kyoto-related costs across regions. If such transfers were not available, then British Columbia would have an initial permit allocation of zero. In this case, it will not be possible to completely equalize the regional distribution of costs through the initial allocation of permits; however, the initial distribution of permits can still be used to reduce the variation of costs among regions.

According to data from the Environment Accounts and Statistics Division of Statistics Canada, the percentage of national capital expenditures on pollution abatement and control equipment by region from 1995-1998 are displayed in Table 4.3. The results indicate that although Ontario, Quebec, and British Columbia have the largest capital expenditures on abatement over the years relative to other regions, the values have been either decreasing or increasing only slightly since 1995. On the other hand, Saskatchewan and Alberta have been increasing their abatement expenditures over the same period, with significant expenditures from Alberta. Manitoba appears to have made the least expenditures on abatement and control equipment, and its share of national expenditures has decreased since 1995.

Table 4.3: Percentage Share of National Capital Expenditures on Pollution Abatement and Control Equipment (%), 1995-1998

Region	1995	1996	1997	1998	Observations
Atlantic	10.7	7.1	3.7	4.8	- Decreased from 1995-1998, 1998 value less than one half of what it was in 1995
Quebec	26.4	-	21.7	15.2	- Decreased from 1995-1998, 1998 value under two thirds of what it was in 1995
Ontario	30.1	26.2	37.3	35.7	- 1998 value increased slightly from what it was in 1995.
Manitoba	3.1	1.3	1.9	-	- Decreased from 1995 to 1997, values relatively low compared with other prov.
Saskatchewan	2.5	2.3	4.1	10.7	- Increased a lot from 1995-1998, 1998 value about 4 times higher than in 1995
Alberta	15.8	16.0	13.7	18.5	- Increased slightly from 1995-1998, with a decrease in value in 1997
British Columbia	11.3	18.8	16.4	11.6	- Value is same in 1998 as in 1995, (increased in 1996-1997), relatively high

Secondary Source: Environment Account and Statistics Division, Statistics Canada (1995-1998), Environmental Protection Expenditures in the Business Sector

The results presented in Section II showed that the biggest job losses are expected to be in Manitoba, Saskatchewan, and Alberta, most likely as the result of higher abatement costs making their emissions-intensive industries unable to compete with firms in non-participatory countries[14]. The results of Section II also indicated that Ontario, Saskatchewan, and Alberta would incur the highest GDP losses following the policy during the period 2013-2018. Thus, in order to even out the regional distribution of losses, regions that are expected to have higher-than-average losses of GDP would get an excess amount of permits initially so that they could then sell off those permits and receive revenue from the sale of those permits to offset their losses. Using this model, it was found that with a permit price of $50 and $75, the initial allocation of permits was able to completely equalize the regional distribution of costs through the initial allocation of permits, with Ontario, Saskatchewan, and Alberta receiving an excess number of permits. Thus, in line with the discussion of Section III, a system of tradable permits will separate the issue of 'who pays for abatement' from 'where abatement occurs', thereby evening out the regional distribution of Kyoto-related costs.

[14] Non-signatory countries are countries that did not sign onto the Kyoto Protocol in 1997. *Non-participatory* countries include non-signatory countries plus countries that did sign on but have decided not to ratify their commitment. As of June 2001, the U.S. indicated that it would not be satisfying its Kyoto Protocol obligation and is therefore part of the group of non-participatory countries.

Section V: Conclusion

According to TIM, the Informetrica Model (Cebryk et al., 2000), the dispersion of costs associated with meeting Canada's Kyoto Protocol target are expected vary widely across the provinces. The information provided in Section II showed that the AMG forecast of the long-run reduction in GDP relative to BAU is expected to be in the range of 0 to 3 percent with TIM modeling results as high as a 2.7 percent loss of GDP in Ontario and as low as a 0.8 percent loss in the Atlantic region. The employment losses were also estimated to be quite significant, with the Prairie provinces having the biggest job losses relative to what their share of national employment was before the emissions reduction policy took effect. Section II also examined what the contribution to provincial GDP was for emissions-intensive industries and found that Alberta, Saskatchewan, and the Atlantic region were very much dependent on these industries. Thus, these results are indicative of the importance of devising a method for compensating industries/and or regions that will be most negatively affected under an emissions reduction strategy.

The initial allocation of tradable emission permits may be used as a policy tool to compensate regions that are expected to incur the largest losses in terms of reduced GDP and/or lost employment under a national strategy to meet Canada's Kyoto Protocol target. In this paper, it was assumed that regions were allocated a 'gratis' amount of permits greater than, equal to, or less than their covered emissions in 2010[15]. A second advantage to using a system of tradable emission permits to meet Canada's Kyoto

[15] Another possibility would have been to auction the permits off generating a stream of revenue for the provinces to compensate the relevant parties.

Protocol target, as described in Section III, is that by separating the issue of 'who pays for abatement' from 'where abatement occurs', a system of tradable permits can result in a cost-effective outcome that will ensure maximum abatement at least-cost. One of the primary conclusions of this paper is that a national strategy aimed at meeting Canada's Kyoto Protocol target that is based on cost-effectiveness alone will likely see little compliance due to a large variance in Kyoto-related costs across the provinces.

Section IV presents a simplified macroeconomic framework to show that in cases where regions are facing higher costs in terms of abatement or due to reduced output as a result of higher input costs or reduced international competitiveness, then an initial 'au-gratis' allocation of permits can help to even out the regional distribution of costs to meeting Canada's Kyoto Protocol target. The results of Section IV show that under a range of permit prices ranging from low to high, Ontario, Saskatchewan, and Alberta will receive an excess number of permits and thus be able to sell their permits to regions that have an insufficient number of permits, those being Atlantic Canada, Quebec, Manitoba, and British Columbia. Taking into account the information related to regional share of national capital expenditures on abatement and control equipment that was presented in Section IV, the final permit allocations that resulted from the macroeconomic framework that was set out in this paper appears to succeed in evening out the regional distribution of Kyoto-related costs by separating the issue of which regions pay for abatement from where abatement occurs in the economy.

Appendix 1: Notation, Relationships, Definitions, and the Policy Objective

Notation

Static Model

Effects in year = 2010

Indices

i	=	Index regions *(i=1,...,I)*

Endogenous Variables (determined in the model)

$\overline{C_i}$	=	Initial allocation of permits to region i
$P \times (C_i - \overline{C_i})$	=	Net purchase/sale of permits by/from region i, (Note: A negative value here implies a 'net sale' of permits.)
Y_i	=	Net loss of region i in 2010 due to the national least-cost abatement policy
y_i	=	Per capita net loss of region i in 2010

Exogenous Variables (determined outside the model)

N	=	Forecasted population of all regions in 2010*(Canadian population)*
N_i	=	Forecasted population of region i in 2010 (CANSIM)
C_i	=	Final emissions (permit holdings) of region i in 2010 (Table 1A)
Q_i	=	Loss of GDP in region i in 2010 due to the national least-cost abatement policy *(TIM, the Informetrica model (Cebryk et al.))*
q_i	=	Per capita loss of GDP in region i in 2010 due to the national least-cost abatement policy
$\bar{q}$	=	Mean loss per capita in 2010

Policy Variables

C	=	Total permits (565 Mt CO_2 equivalent)
P	=	Equilibrium price for permits (will be using a range here)

Definitions

Permit Balance:

$$\sum_{i=1}^{I} \overline{C_i} = \sum_{i=1}^{I} C_i = C$$

Equilibrium in the Market for Permits:

$$\sum_{i=1}^{I} P \times (C_i - \overline{C_i}) = 0$$

Mean Loss Per Capita:

$$\bar{q} = \sum_{i=1}^{I} \frac{N_i}{N} \times q_i = \frac{1}{N} \times \sum_{i=1}^{I} Q_i$$

Relationships

Net Loss of Region i: $$Y_i = Q_i + P \times \left(C_i - \overline{C_i}\right)$$

Per Capita Net Loss of Region i: $$y_i = q_i + P \times \left(\frac{C_i - \overline{C_i}}{N_i}\right) \quad (1)$$

Policy Objective

Choose initial allocation of permits $\{\overline{C_i}\}$ s. t. $y_i = \bar{q} \;\; \forall i \Rightarrow (1): \bar{q} = q_i + P \times \left(\frac{C_i - \overline{C_i}}{Ni}\right)$,

thus the per capita loss for each region will be equalized.

Rearranging the expression yields the initial allocation of permits as follows:

$$\overline{C} = \frac{N_i}{P} \times \left[q_i - \bar{q} + P \times \left(\frac{C_i}{N_i}\right)\right] = \left(\frac{1}{P}\right)\left(Q_i - \left(N_i \times \bar{q}\right)\right) + C_i = \left(\frac{1}{P}\right)\left(Q_i - \left(\frac{N_i}{N} \times \sum_{i=1}^{I} Q_i\right)\right) + C_i \;\; \forall i$$

Calculation for the Final Permit Holdings of Each Region

The final permit holdings of region *i* will be derived from a simple calculation as follows: AMG estimates of projected GHG emissions under the business as usual (BAU) scenario for each province in 2010 less the total amount of GHG emissions reduced by Canada under Path2CA in 2010 multiplied by the regional share of reductions in 2010 under Path 2CA with CIMS for each province respectively. The total national reduction in emissions in 2010 under Path 2CA, or the reduction in GHG emissions needed to meet Canada's Kyoto Protocol target, 565 Mt of CO_2 equivalent, is found by AMG to be equal to 199 Mt of CO_2 equivalent emissions. It should be noted that in order to achieve this target, the model used by AMG assumes that Canada commences policy actions for abatement in the year 2000, and achieves a national rate of reduction in GHG emissions of 2 percent annually, meaning that for Canada to achieve its Kyoto Protocol target by the use of domestic actions alone, it would have to achieve a reduction in the total carbon intensity of the economy of 4.3 percent annually (AMG, 1999). The following table will show how the final emissions for each region in 2010 is derived:

Table 1A: Calculation of Final Emissions by Region in 2010 Under Path 2CA using CIMS

Nation / Province	AMG Estimate of Projected Emissions Under BAU in 2010 *(Mt CO_2 equivalent)* (a)	Share of Regional Reductions in 2010 under Path 2CA using CIMS *(%age of the Kyoto Gap)*[16] (b)	(b) Multiplied by national reduction in emissions in 2010, Path 2CA *(Gap=199Mt CO_2 equivalent)* (c)	Total Regional Emissions in 2010 under Path 2CA, using CIMS *(Mt CO_2 equivalent)* (d)
Canada	**764**	-	**199**	**565**
Atlantic	58	9	17.91	40.09
Quebec	95	10	19.9	75.1
Ontario	213	25	49.75	163.25
Manitoba	26	3	5.97	20.03
Saskatchewan	66	10	19.9	46.1
Alberta	233	34	67.66	165.34
British Columbia plus Territories	73 *(Inc. territories)*[17]	9[18]	17.91	55.09

Source: (a) taken from AMG (1999), (b) taken from AMG (2000), (c) and (d) are constructed from (a) and (b)

[16] AMG (2000) "An Assessment of the Economic and Environmental Implications for Canada of the Kyoto Protocol", *Chapter IV, Chart 419,* p. 41.

[17] In AMG (1999) "Canada's Emissions Outlook – An Update", emissions in 2010 under BAU are only given for BC plus the territories; however, for the purpose of this paper, we will consider only BC to give the regional share of reductions in 2010 under Path 2CA, CIMS. This is because in AMG (2000) "An Assessment of the Economic and Environmental Implications for Canada of the Kyoto Protocol", values are only given for BC alone, not for the territories.

[18] In AMG (2000) the share of regional reductions for BC is given as 8%. The total shares of reductions add up to 99% in the AMG paper, thus it is assumed here that the share of regional reductions for BC + the Territories is 9%.

Appendix 2: GDP by Province from Emissions-Intensive Electric Power Generation

Table 2A: Percentage of Provincial Electrical Energy Production[19] By Fuel Type (%), 1997

Fuel Type	Nfld	PEI	NS	NB	QC	ON	MA	Sask	AB	BC	Yukon	NWT
Coal	0.00	0.00	79.89	35.15	0.00	16.49	0.59	68.54	81.42	0.00	0.00	0.00
Oil	6.34	100.00	8.70	25.42	0.06	0.32	0.20	0.55	0.69	0.33	31.12	48.77
Natural Gas	0.00	0.00	0.00	0.00	0.00	7.09	0.03	5.92	12.20	4.29	0.00	15.44
Nuclear	0.00	0.00	0.00	20.64	2.53	47.90	0.00	0.00	0.00	0.00	0.00	0.00
Hydro	93.66	0.00	9.44	13.95	96.72	27.08	99.21	23.67	3.52	92.39	68.88	35.78
Other	0.00	0.00	1.97	4.84	0.68	1.11	0.00	1.31	2.17	2.99	0.00	0.00

Secondary Source: Constructed from the NCCP Electricity Industry Issues Table Foundation Paper (1999)

Table 2B: Contribution to Provincial GDP by Electric Power Generation Separated by Fuel Type (%), 2000

Fuel Type	Nfld	PEI	NS	NB	QC	ON	MA	Sask	AB	BC	Yukon	NWT
All	*4.24*	*1.21*	*2.54*	*4.25*	*3.79*	*2.19*	*3.36*	*1.92*	*1.82*	*1.76*	*1.31*	*1.99*
Coal	0.00	0.00	2.03	1.49	0.00	0.36	0.02	1.32	1.48	0.00	0.00	0.00
Oil	0.27	1.21	0.22	1.08	0.02	0.07	0.07	0.01	0.01	0.06	0.41	0.97
Natural Gas	0.00	0.00	0.00	0.00	0.00	0.15	0.10	0.11	0.22	0.07	0.00	0.31
Nuclear	0.00	0.00	0.00	0.88	0.09	1.05	0.00	0.00	0.00	0.00	0.00	0.00
Hydro	3.97	0.00	0.24	0.59	3.66	0.59	3.33	0.45	0.06	1.63	0.90	0.71
Other[20]	0	0.00	0.05	0.21	0.02	0.02	0.00	0.02	0.04	0.05	0.00	0.00

Secondary Source: Industry Measures and Analysis Division, Statistics Canada (2001)

[19] In Newfoundland, Quebec, Manitoba, and British Columbia, the majority of energy is produced from hydro-electricity generation that givens off zero emissions. In Prince Edward Island, all power is generated from fuel oil that gives off a small share of total emissions from the electric power sector. In the other two Atlantic Provinces, Nova Scotia and New Brunswick, a large share of total energy is produced from coal-fired electricity generation that gives off a large portion of total emissions from this sector. Ontario has a mixture of energy types, with the largest sources from nuclear and hydro (both having zero emissions). Saskatchewan and Alberta generate the majority of their electricity production from coal, and some from other sources such as oil, natural gas, and hydro.

[20] 'Other' refers to energy sources such as wind, wood, biomass, and solar, etc. (NCCP, 1999).

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