Economic Efficiency of Carbon Tax versus Carbon Cap-and-Trade

Muktar Homam
Homam Consulting & Business Solutions Inc.
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EXECUTIVE SUMMARY

Environmental scientists tell us that there is a consensus that human activities resulting in increasing levels of greenhouse gasses (GHG) emissions are contributors to global warming. Although annual anthropogenic carbon dioxide (CO2) emission is reported to represents only a small part of the total carbon in the Earth's carbon cycle, nature cannot absorb and store the CO2 released by the combustion of fossil fuels fast enough.

Economists consider global warming to be a negative externality and thus a market failure. Economic theories suggest implementation of policies that would internalize the cost of this negative externality by imposing a price on the GHG emission through carbon tax or cap-and-trade policies. Those would, subsequently, reduce the level of emission to a socially optimum level. Both have been implemented by some jurisdictions around the world. Although, scientific conclusions and political views on the success and cost of cap-and-trade for reducing GHG emission vary, cap-and-trade policies seem to be favoured by governments possibly due to the political acceptability of it and the fear of using the word "tax." On April 13, 2015 the province of Ontario became the latest jurisdiction to announce the adoption of a CO2 cap-and-trade program.

The success of carbon cap-and-trade heavily depends on international cooperation between all GHG emitters. Establishing an effective and efficient emission cap at international, national and sub-national levels has proven to be a difficult task. In absence of global cooperation on and implementation of cap-and-trade policies, jurisdictions that adopt cap-and-trade programs will suffer from the negative impact of "carbon leakage" and competitive disadvantages. Carbon leakage happens when firms move production to carbon-lax countries and all the products that were once produced domestically are imported. While the consumer surplus is transferred to foreign producers, the inhabitants of a jurisdiction with the cap-and-trade regulation will still suffer from the negative consequences of the increased global CO2 emission. Cap-and-trade has also been found to hinder innovation. The issue of carbon leakage and competitiveness of businesses have been discussed by media and politicians, studied by economists and scientist, and reported in the literature.

What is missing from the discussion on carbon cap-and-trade and, to my knowledge, has not been sufficiently studied or reported in the literature is that the cap-and-trade being a quota system can create monopolies. This happens when firms either by the nature of their product or regulations are protected from external competition. Large firms that acquire and hoard CO2 emission permits when they are given for free or when the prices are low will turn into monopoly power in later years. Good examples of monopoly power that has resulted from quota regulations are dairy and taxicab industries.

This author was drawn to the study of dairy supply management after listening to the political debates on the issue, and has been interested in understanding the carbon pricing because of his work in the energy sector and review of current policy debates in Canadian provinces. Further study of the issues from economics and public policy perspectives enabled the author to connect the similarities between economic implication of the supply management system and the cap-and-trade system. The focus of this

paper, in addition to reviewing the documented inefficiencies of the cap-and-trade policies, is to bring to light the market power and monopolistic economic inefficiency that will result from a cap-and-trade regulation. This paper also discusses the advantages of carbon tax over cap-and-trade regulation for reducing GHG emission negative externality.

Studies have shown that carbon tax with a border adjusted tax can prevent the problems associated with the cap-and-trade regulations and ensure a level playing field for all producers. Canada or the provinces can charge a unit tax on fuels at the point of production or port of entry based on their carbon content. On imported products border adjusted tax can be imposed based on the amount of CO2 emitted during their production. Carbon tax will have to be rebated on all exports.

The carbon tax collected on domestic consumption can be used to invest in CO2 emission reducing technologies, carbon capture and storage, or reforestation; be spent to replace other taxes; or be spent on various social and environmental initiatives.

INTRODUCTION

Environmental scientists tell us that there is a consensus that human activities resulting in increasing levels of GHG emissions are contributors to global warming [1, 2]. Although annual anthropogenic carbon dioxide (CO2) emission is reported to represent only a small fraction of the total carbon in the Earth's carbon cycle, nature cannot absorb and store the CO2 released by the combustion of fossil fuels fast enough. If the rate of release of CO2 was matched by the rate of absorption (by CO2 sinks), then there would not be a great concern about the climate change. Presently, the global combustion of fossil fuels is reported to produce more than 30 gigatonnes of carbon dioxide per year [3]. To reduce CO2 emissions to a socially and environmentally optimum level, there are three approaches to take: emit less CO2, sequester CO2 and reuse CO2 [3].

Economists consider global warming to be a negative externality and thus a market failure since the social and environmental costs of GHG emissions are not fully borne by the emitters. Thus, control of excessive production and release of GHG requires government intervention. Economic theory suggests the implementation of policies that would internalize the cost of this negative externality by imposing a price on GHG emissions – such as a carbon tax. The concept of a tax on a product that causes a negative externality was first introduced by A. Pigou in the 1920s and thus it is known as Pigovian tax.

The other instrument that can be used for limiting a negative externality such as GHG emissions is putting a cap on the quantity of the product that results in the negative externality. This has been implemented in the form of CO2 emission cap-and-trade programs in a number of jurisdictions around the world. After a total cap for a range of years into the future is determined, the government then leaves it to the firms to decide where emissions will come from, using a system of tradable permits or "allowances," typically representing one tonne of emissions [4]. Cap-and-trade policies have been implemented by some jurisdictions around the world to fight GHG emissions. Scientific conclusions and political views on the success and cost of cap-and-trade for reducing GHG emissions vary; however, cap-and-trade policies seem to be favoured by some governments possibly due to the political acceptability of it. It is argued that cap-and-trade policies guarantee reaching quantity targets regardless of cost. On April 13, 2015, the province of Ontario became the latest jurisdiction to announce the adoption of a CO2 cap-and-trade program.

The success of carbon cap-and-trade heavily depends on international cooperation between all GHG emitters. Currently, the level of cooperation, for example commitments to the Kyoto Protocol, among the countries is very low to non-existent. Establishing an effective and efficient emission cap at international, national and sub-national levels is not an easy task and is vulnerable to misuse and corruption [5, 6]. It is argued that carbon trading schemes have tended to reward the heaviest polluters with "windfall profits" when they were granted enough carbon credits to match historic production [7].

Studies have shown that adoption of cap-and-trade programs have resulted in economic inefficiencies. The economicly inefficient aspects of the program that have been widely discussed and covered by the media, political commentators and scientific literature are the "carbon leakage" and competitive disadvantages. If a jurisdiction implements a cap-and-trade program while its trading partners do not implement any carbon pricing policies, the jurisdiction will suffer.

Carbon leakage happens when firms move production to carbon-lax jurisdictions and all the products that once were produced domestically are imported. As a result, while consumers' surplus of the inhabitants of the jurisdiction with the cap-and-trade regulation will be transferred to producers in jurisdictions that do not have carbon pricing systems, they will suffers the negative consequences of the increased CO2 emission coming from outside its borders, even if it is released half a globe away. This happens because the mixing and dispersion of CO2 in the air happens relatively rapidly, resulting in a nearly uniform CO2 concentration in the atmosphere around the world irrespective of the point of emission [3]. One tonne of a GHG emitted anywhere in the wold has the same climate change consequences for everyone on the globe [8]. Cap-and-trade has also been found to hinder innovation [5, 9].

What is missing from the public discussion and scientific literature on the cap-and-trade is that the cap-and-trade system, being a quota system, can enable large firms to become market powers and act as monopolists. This will create an economic inefficiency similar to the supply management (quota) system that is in effect for farm products and the taxicab industry. By design, cap-and-trade regulations convert emission permits into assets or properties. Large firms will be able to receive for free, buy and then hoard large quantities of these assets and then manipulate both the emission market and their product market.

Supply management in Canada is a system of controlled markets that applies to dairy, poultry and eggs. In Canada it is reported to have been implemented in the 1970s with the aim of ensuring a fair return for farmers and price stability for processors and consumers [10, 11]. However, the supply management system has created an economic challenge to free markets and international trade. It has also created an entry barrier to new and young farmers. The existing farmers or corporations that hold quotas under the supply management system exert almost a monopoly power, resulting in various types of economic inefficiencies. The Canadian federal and provincial governments now have a challenge and seem to be unable to address this issue in a manner that is satisfactory to all stakeholders. Another industry where the quota system is resulting in economic inefficiencies is the taxi industry. The price of a taxi medallion – plate - has increased from mere $100s in the later part of 1900s to $100,000s and $1,000,000s in the past ten years. The government regulated quota systems have allowed the taxi plate owners to extract profit at the expense of taxi drivers and consumers.

A more efficient policy instrument than cap-and-trade is carbon tax. Carbon tax combined with a border adjusted tax can prevent the problems associated with a quota system and ensure a level playing field for all producers. The existing producers and new entrants will face the same tax system, and economic rent payment to foreign producers could be eliminated. Canada or the provinces can charge domestic producers a unit tax for their products based on the level of GHG emitted for producing them. For imported products, Canada can impose a unit carbon tax based on CO2 emission of the country of origin, unless individual producers from the exporting countries demonstrate that they have CO2 emissions per unit of the product that is no more than those produced in Canadian provinces, in which case the carbon tax on their product can be adjusted accordingly. A unit carbon tax should be imposed on all fuels at the point of production or at the port of entry based on their carbon content. The taxes collected on all exported fuel and products will have to be rebated at the border.

The carbon tax collected can be used to invest in CO_2 emission reducing technologies, carbon capture and storage or reforestation; replace other taxes; or be spent on various social and environmental initiatives. For example, in the province of British Columbia the revenue generated from carbon tax is returned to British Columbians through reductions in other taxes.

The objective of this paper is to review and highlight the unintended economic implication of carbon cap-and-trade system, especially the market power problems that are currently missing in the GHG emissions discussion and studies. The paper does not provide any argument for or against carbon reduction interventions. It is assumed that Canadian provinces have decided to implement a carbon emission reduction measure. This paper will argue whether cap-and-trade similar to what Quebec implemented in 2013 and Ontario announced in April of 2015 is the right tool, or if the government should adopt a carbon tax system, similar to what British Columbia has implemented since 2008. Alberta's system is a hybrid system and is different from the other three provinces. However, because of its low CO_2 pricing - $15 per tonne of CO_2 emission until now - it has functioned as a carbon tax system [12]. On June 25, 2015, however, Alberta announced that by 2017 it will increase the carbon price to $30 per tonne of CO_2 emitted [13].

A brief history of efforts related to awareness, reduction and prevention of GHG emissions and climate change are presented. The economics of emission reduction instruments are discussed along with a review of literature on the theory and practices of emission reduction strategies and options. The paper makes a conclusion as to what a preferred market instrument for reducing the GHG negative externality is.

BACKGROUND

Greenhouse Gasses Emission

It is reported that in 1938 an English engineer, Guy Stewart Callendar, concluded that over the previous hundred years the concentration of carbon dioxide had increased by about 10%. This rise was thought to be from human activities and industries, and had resulted in global warming. By the 1950s the belief that global warming was truly possible was reportedly solidified with more research results by the US scientific community. With observations of increased levels of CO_2 in the 1960s, CO_2 was found to be an important player in global warming. It was reportedly demonstrated that doubling the CO_2 concentration in the atmosphere would result in 3-4°C rise in temperature. The level of CO_2 is also considered to be a regulator of water vapour and ultimately governing the planet's long-term equilibrium temperature [14].

It was reportedly confirmed that within a few years of their release any addition of CO_2 was well mixed throughout the atmosphere, from pole to pole and from the surface into the highest stratosphere [3, 15]. It was also confirmed, based on the observed isotope of carbon, that the increase in CO2 was mainly from human use of fossil fuel and not from volcanos [14].

Those who argued against the suggestion that CO2 was responsible for climate change believed that the Earth automatically regulated itself where the oceans that have fifty times more dissolved CO2 than atmosphere would absorb any excess gasses that came into the atmosphere. It was also argued that if the oceans failed to stabilize the system, organic matter would absorb the balance of excess CO2. It is believed that whatever gasses humanity added to the atmosphere, one way or another, they would be absorbed — if not at once, then within a century or so — and the equilibrium would automatically restore itself [14].

However, data collected in the past 60 years shows that the level of CO2 in the atmosphere has increased. Figure 1 shows the changes in the level of atmospheric CO2 from 1960 to 2015. The environmental experts, observing the evidence, have concluded that the world is facing a serious problem. There are calls on governments to act and put in place policies that would restrict GHG emissions.

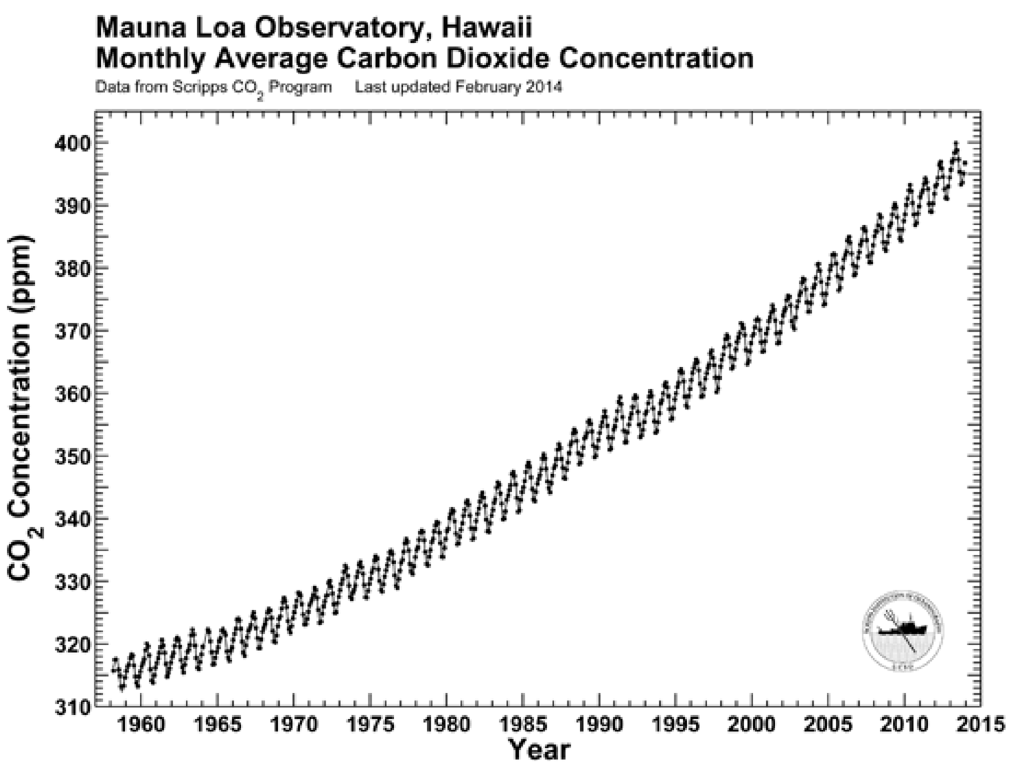

Figure 1: CO2 concentration records from Mauna Loa Observatory, Hawaii

The calls resulted in the formation of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and the Kyoto Protocol. The UNFCCC is an international treaty established to cooperatively tackle climate change issues. The ultimate objective of the UNFCCC is to stabilize atmospheric GHG concentrations at a level that would prevent dangerous interference with the climate system. Canada ratified the UNFCCC in December 1992, and the Convention came into force in March 1994 [16]. However, in 2012 Canada withdrew from the accord.

The Kyoto Protocol was agreed on in 1997 and entered into effect in 2005. At its heart lies an international cap-and-trade system. Countries classified as “developed” under the UNFCCC were given emission reduction targets with reference to their 1990 emissions. Kyoto Protocol furthermore lets countries with emissions below their targets to sell surplus allowances to countries that struggle to reach their targets [4].

Article 3, paragraph 1 of the Kyoto Protocol states that thirty-seven developed nations, individually or jointly, ensure that their overall emissions of GHG are limited and reduced over a five-year period (2008 – 2012) by at least 5 percent below the 1990 levels. Paragraph 3 of the same article states that the net changes in GHG emissions induced by humans and removals by sinks such as forestry activities, since 1990, can be used to meet the commitments to the respective parties. Article 10(c) of the Kyoto Protocol expects the developed nations to share, support, promote and finance technologies related to climate change reduction with developing countries [17].

Negative Externalities

According to Weimer and Vining (2011) a negative externality is any negative valued impact from any action, whether from production or consumption, that affects someone who was not a party to the transaction [18]. Air and water pollution generated by firms in their production activities are cited as common examples of negative externality [19].

Figure 2 illustrates the negative externality created in the production of electricity. S1 represents the marginal cost faced by the electricity producers that takes into account its internal costs such as fuel, labour, operation and maintenance. The producer produces Q_{Market} quantity of electricity where the demand curve and marginal private supply curve are at equilibrium. At this level, however, the private producer does not take into account the negative impact of the production and burning of fuel on society; society pays a higher cost represented by the marginal social cost, S_2. This could be in the form of health care costs, air cleaning cots, loss of property value, etc.

For the production to be socially efficient, at the actual output level the social marginal benefits and social marginal costs should be equal. This occurs at quantity $Q_{Efficient}$, where the demand curve intersects with the marginal social cost curve, S_2. However, without a government intervention, the firm produces Q_{Market} which is higher than $Q_{Efficient}$. The quantities produced above $Q_{Efficient}$ costs the society more than the benefit the society receives. This overproduction results in a deadweight loss equal to the area of the shaded triangle. This is economically inefficient.

Since markets left on their own produce an inefficient quantity of electricity, an intervention by the government is required. Two types of intervention are recommended by economists. The first one is imposition of a tax on each unit of electricity produced by an amount where the marginal cost of the production equals the social cost, thus internalizing the cost of the externality. The second one is imposition of quantity regulation where if all inputs to production including fuel stays the same, the quantity of electricity be capped at $Q_{Efficient}$.

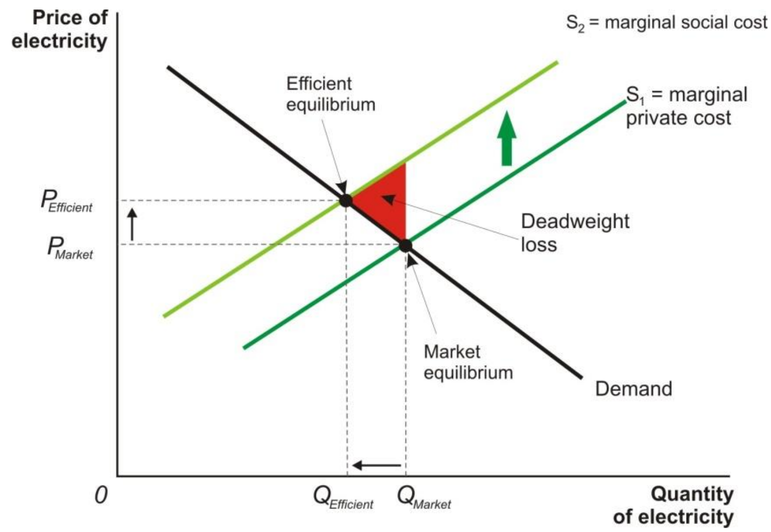

Figure 2: Overproduction with a negative externality **[20]**

Carbon Tax

A carbon tax is a tax that is intended to provide monetary incentives to CO2 emitters to reduce the quantity of emission to a socially efficient level. As shown in Figure 3, the tax will internalize the cost of the negative externality. It was first introduced by A.C. Pigou and is, therefore, known as Pigovian tax [21]. The major advantage of a tax is argued to be that it allows firms and consumers the choice of deciding how much to produce to limit their tax payments. It is also argued that as long as each firm sees the same tax, the industry as a whole would reduce the quantity of the externality to the socially efficient level. After tax, since consumers will have to pay the price $P_{Efficient}$, the quantity of demand drops to $Q_{Efficient}$. On the supply side, since the producers will only receive the price P, they will not produce any units beyond $Q_{Efficient}$. As a result, the market will produce an efficient quantity of electricity.

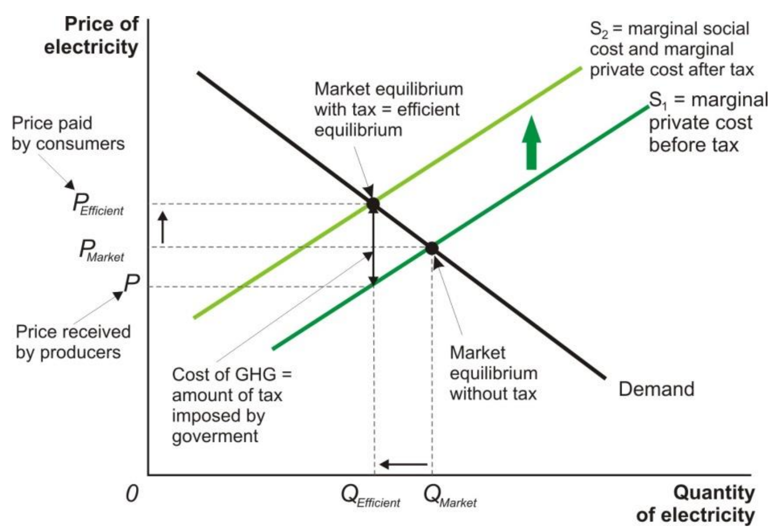

Figure 3: Imposing a Pigovian tax on quantity of electricity to socially efficient level **[20]**

The imposition of an externality-correcting tax is sometimes difficult, because, in addition to political resistance, a major problem facing governments is cited to be the difficulty in defining the exact cost and benefit schedules and curves that can be used to determine the optimum tax. Nonetheless, it is argued that it is possible to approximate the rate of tax by trial and error after observing how firms respond, or use the cost of emission mitigation measures such as carbon capture and storage to determine the rate of tax per unit of emission [21]. Pizer (1999) argued that economic theory as well as numerical simulations had indicated that the tax approach for GHG control was preferable, generating five times the net expected benefit compared to even the most prudent cap-and-trade instrument [22, 21].

Carbon Quantity Regulation (Cap-and-Trade)

Quantity regulation can be used to limit, as shown in Figure 3, the production of electricity to $Q_{Efficient}$, and consequently cap the quantity of the GHG associated with the target power plant and its fuel. At $Q_{Efficient}$ the social costs and social benefits of electricity production are equal.

Weimer and Vining (2011) wrote that although quantity regulation is less flexible and generally less efficient than market incentives, it usually provides greater certainty of outcome. Therefore, it is stated that quantity regulation may be desirable in situations where the cost of error is great [18].

Tradable emission permits or cap-and-trade system is a form of quantity regulation that is combined with market-like mechanisms such as taxes. The objective of the cap-and-trade policies is to create a system of property rights for pollution and allow the property owners to trade them. Before trading begins, a total quantity of allowable CO2 emission (the “cap”) must be established. The concept of cap-and-trade is attributed to Ronald Coase, who in 1960 had argued that one way to solve the negative externality problems in an economically efficient manner was to recognize resources such as clean air and water as a form of property, assign the property rights to private actors and allow them traded their properties in a market [18]. In this theory final allocation of permits was considered to be independent of the initial allocation, and it was assumed that transaction costs would be zero. Although this does not hold true in the real-world problem, cap-and-trade systems have been implement in various jurisdictions [18]. Hahn and Stavins (2010) wrote that there were six conditions under which the cap-and-trade system ran into problems. These conditions were said to be: transaction costs, market power, uncertainty, conditional allowance allocations, non-cost-minimizing behaviour by firms, and differential regulatory treatment of firms [23].

The two common options used for allocation of emission permits include auctions by the government and free allocation based on the existing level of emission of the firms, called grandfathering. Auctioning and sale of permits by the government generates revenue. Grandfathering, the politically feasible and most common method, of emission permit allocation gives assets in the form of tradable property rights to emitters. Firms may sell unused permits to others who need them, or they may save (“bank”) them for future years, in anticipation of potentially higher demands, fuel price fluctuations or other changes to the firm’s circumstances [4]. The industries with political power are said to push for grandfathering of permits [19].

The quantity regulation in the form of cap-and-trade for GHG emission reduction has a number of problems and results in economic inefficiencies. The highly discussed problems are those associated with "carbon leakage" and losses for domestic industries to foreign competition. The results of various studies on these problems are available in the literature. A few examples will be provided and discussed in the Literature Review section. One issue that is not being discussed in the public domain - in the context of GHG emission cap-and-trade - is the market failure that has been experienced in the case of farm product quota and taxicab quotas. In these two industries the quota holders have turned into monopolists and can use the quotas to create a barrier to entry to competition. This is what Hahn and Stavins (2010) have called market power condition that result in failure of cap-and-trade assumed efficiency [23]. The following subsection provides some background information on farm quotas (supply management in Canada) and taxicab quotas.

Dairy Farming Industry

Accordance to the Dairy Farmers of Canada (DFC), Canada's supply management system enables Canadian dairy farmers to act collectively to negotiate prices and adjust milk production (manage supply) to meet consumer demand [11]. The supply management is basically a system of controlling the market for dairy, poultry (chicken and turkey) and eggs (both table eggs and hatching eggs), which has evolved over time. The Canadian Dairy Commission was created 1966 and in the 1970s dairy became the first commodity in Canada for which a national supply management program started operation [10, 24].

The following discussion uses the dairy supply management to provide an example of inefficiencies that result from a quota system. The supply of milk and butterfat is managed (controlled) by imposing quota limits on production. The prices paid to dairy producers by the Milk Marketing Boards are said to cover producers' production costs; it is not based on supply and demand equilibrium of market. To maintain the high prices, the government, in addition to the quota system, has applied import tariffs to all products that are covered by the Supply Management system [10]. Tariffs range from about 160% to 300%, as a result of which imports are virtually blocked and domestic industry is completely protected [10].

Recent studies and experience with the supply management has shown that it has created a major economic distortion that negatively affects the consumers, new farmers and those farmers that are not covered by the Supply Management System. In 1971, when the system was established, it is reported that quotas were allocated for free to producers based on their existing level of production at that time [10, 25, 26]. The quotas are transferable and have greatly appreciated from their time of initial introduction. For example, dairy quota prices in Canada reportedly hit $40,000 for the equivalent of one cow's annual production [25]. A dairy quota in 2012 was reported to be worth about $28,000 per cow, excluding the cost of the actual cow. Thus, a new farmer who plans to have 100 dairy cows will need to have about $2.8 million just for the quota, more than what is needed for all other capital investment in the farm. It is reported that the cost of quota, therefore, represents about 60% of the value of dairy farm [25]. This has created a barrier to entry for new farmers and an opportunity for economic rent seeking by quota holders. This along with the import tariff has provided the quota holders and the milk marketing boards a monopoly power over dairy products [10, 25]. Quota is not traded between provinces. The price of milk quota has reportedly doubled in the last 10 years.

It is argued that the marketing boards for farm products each has become a cartel, as a result of which everyone suffers [10]. Canadians pay twice the amount for a litre of milk than Americans, while the Canadian farmers are prevented from taking advantage of the opportunities and efficiencies that a truly free market affords [10]. To keep the prices high, the marketing boards dump into manure lagoons thousands of litres of extra milk instead of selling them in the market [27, 28, 29]. This is economically inefficient.

Because of the economic inefficiencies created by the quota systems, there are calls for their elimination. Recent estimates put the total national value of Canadian dairy quota in the $25-billion range. This combined with the egg, poultry and turkey quotas would add up to about $35 billion [26]. Eliminating the quota system will have a catastrophic impact on the financial condition of quota holding farmers. Buying all quotas off the farmers and then eliminating them will be an enormous burden on the government.

Some governments are hesitant to act on it; others have eliminated their quota system. For example, Australia reportedly managed the elimination of the quota system by offering dairy farmers transition payments over eight years, financed by a temporary milk tax, which is argued to be still less than what consumers were paying under the quota system. Consumers are said to be now enjoying lower prices, and Australia is able to supply its dairy products globally. New Zealand's dairy industry is reported to have become that country's largest export earner after the elimination of the quota system [10].

Taxicab Industry

Supply management-induced economic inefficiencies have manifested themselves in the case of the city taxi industry too. A limited number of taxi medallion, plate, holders are seeking economic rent at the expense of taxi drivers, commuters and citizens.

A historical study of taxi quota by Davis (1998) puts the origin of the taxi quota system to taxi wars of 1925 to 1950 where a large number of taxis were operating in major North American cities. Davis wrote that the push for taxi quota came from old taxi companies that had heavily invested in the industry, did not want to lower their prices and wanted to reduce competition from independent taxi operators. Thus, it is argued that the group with the most to gain from strict regulation, and hence its primary advocate, were the large and established taxi companies [30]. Because of their money and influence at the municipal levels, these large companies reportedly won the taxi war. Now the taxi industry is argued to be keeping their monopoly through lobbying the government [30].

The medallions in New York, for example, were sold for $10 each in 1930s. They are reported to have been worth about $500 each in 1980s and about $1,000,000 each in 2013 [31]. A licence to operate a cab in Boston costs over $700,000, in Vancouver it costs over $800,000 [32]. In Toronto the cost of a standard medallion was reported to have been $70,000 in 1980s and $250,000 in 2010 [33]. It reached a peak of $360,000 in 2012; however, the values are falling due to some changes in the city by-laws and the rise of ride-sharing businesses [34]. A medallion is rented for about $1800 a month in Toronto in 2015.

The significant gain in prices is argued to be coming from a tightly restricted supply of medallions paired with a large number of people – mostly immigrants – willing to do the difficult work of driving a taxi [31]. The main beneficiaries of the taxi quota system are said to be those who obtained the quotas at a nominal price in the early stages of the system [35]. They are either collecting economic rent through renting their medallions or have made hundreds to thousands of times gain on their initial investment. These gains are made possible by inefficient government economic policies at the expense of consumers. The other beneficiary of taxi quota is the financial industry who collects interest from those who want to get into the taxi industry but need to borrow large amounts of money to get over the entry barrier created by the quota system [35].

Then, there are those who pay for these economic inefficiencies. The first group of people who suffer are non-owner taxi drivers whose margins are significantly cut by the quota rent seekers, and the demand for their service is reduced because of high fare rates [31]. A study by the City of Toronto concluded that the high plate rent seeking and plate sale value at times hampered some participants' ability to earn a fair wage [36]. The drivers have reportedly become the "sharecroppers" who carry most of the risk that is pushed away from the large companies that own the medallion [31]. The current rise of ride-share services and unlicensed taxis has put a strain on taxi drivers who have to pay a fixed monthly rent or interest on the taxi medallion but cannot compete on price. The other sufferers are the rest of the society who directly or indirectly pay for the high taxi fares [32].

Some cities have realized the economic inefficiencies created by the taxi quota system and have either gotten rid of them or put in place measures to minimize their impact. It is reported that a number of U.S. cities (among them Kansas City, Milwaukee, Phoenix, Raleigh, and San Diego) as well as some countries (including Ireland, New Zealand and Sweden) have eliminated supply management in the taxi sector [35].

The City of Toronto has "tried" to correct the enlargement of taxi quota assets by stopping the issuance of standard taxi plates. Since 1999, the city only issues "ambassador" plates which can only be used by a taxi owner. According to the City of Toronto, ambassador licence holders cannot lease, transfer, or sell their ambassador taxicab or give up possession, custody or control of such taxicab or allow any other person to manage or operate their ambassador taxicab [33, 36]. The City of Toronto considers the ambassador and owner-operated models as more economically efficient as the fare revenue has to cover only their own operating costs [36].

The objective of the dairy and taxicab quota systems are different than those of CO_2 emission cap-and-trade regulations. In supply management quantities are capped to keep the prices high; while in the CO_2 cap-and-trade system the quantities are capped because that is the ultimate objective. No attention is paid to the costs and price of CO_2 cap compliance. The supply management systems have proven to be inefficient because they have created market power and prevented competition. The CO_2 cap-and-trade regulations seem to have the potential to suffer from similar market power and even more economic inefficiencies.

LITERATURE REVIEW

There are two widely held views among economists and academics studying how to limit climate change. One view favours command-and-control cap-and-trade policies, whereas the other view favours a carbon tax. A considerable amount of research has been conducted on the pros and cons of CO2 emission cap-and-trade versus carbon tax in the context of reducing GHG emission and global warming. This section presents the findings from a selected group of studies on the subject.

Recent Experiences

Newel et al. (2013) conducted a "Lessons Learned" review of the carbon markets 15 years (1997 – 2012) after the Kyoto Protocol [8]. Newel et al. found that the dream of a global solution for control of GHG emissions was far away. The existing systems that had reportedly emerged until 2012 included:

1. European Union Emission Trading System set up in 2005,
2. The Clean Development Mechanism[1], set up in 2009 as part of the Kyoto Protocol,
3. Regional Greenhouse Gasses Initiative (RGGI), in seven northeastern US states, started in 2005,
4. The New Zealand Emissions Trading Scheme started in 2008, and
5. Voluntary markets.

Newel et al. tracked the changes in the price of CO2 emission permits in the above markets as shown in Figure 4.

According to Newel et al. the main lessons from the carbon markets until then were the following:

- Based on the research from ETS, the long-term investments in new technologies have been limited.
- The free allowance allocation has had both distributional and efficiency consequences that have allowed economic rent seeking by large power firms.
- There have been environmental and economic impacts due to carbon leakage where firms move production to carbon emission-lax jurisdictions. A survey from EU showed that 55 percent of metal manufacturing and 44 percent of pulp and paper and cement manufacturing firms have either moved or are considering moving out of EU zone.[2]

[1] The Clean Development Mechanism (CDM) was reportedly set up as part of the Kyoto Protocol. It is a market for certified emission reductions undertaken by developing countries that can be used for compliance in other programs. It is not a cap-and-trade program, but is a system that uses emission reduction efforts in developing countries into credits that can be used to offset emissions in the other parts of the world. It was reportedly created to provide additional flexibility for industrialized countries to meet their specified targets. The EU ETS is reported to have been the main purchaser of CDM credits. New Zealand, Australia and Japan are also reported to have purchased millions of CDM credits to reach their emission reduction targets [8].

[2] It is worth noting that most, over 90%, of the emission allowances in the EU were given for free; even then, the energy intensive industries were leaving the jurisdictions with cap-and-trade programs.

- Policies exhibiting stable prices and less-certain emissions, as typically associated with a carbon tax, had higher than expected net benefits than policies where emissions are fixed and prices fluctuate.

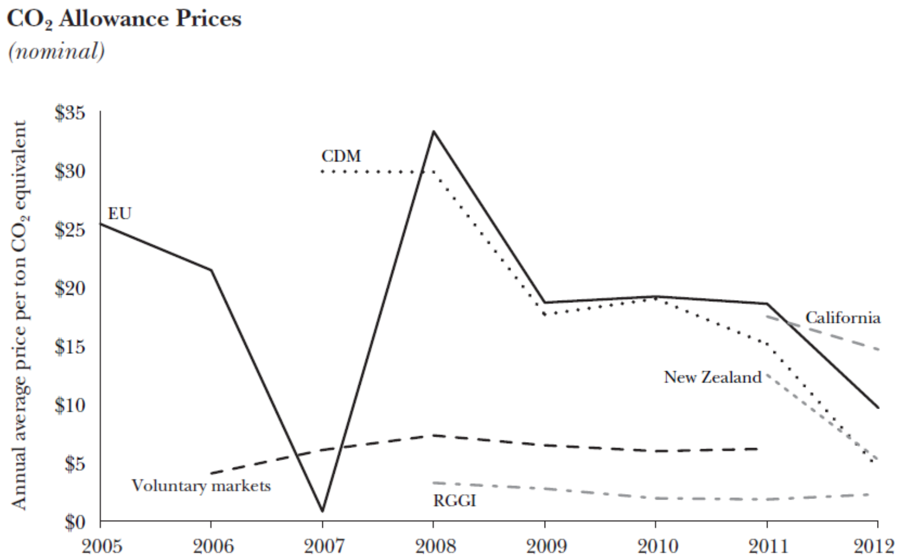

Figure 4: Annual average prices of CO2 equivalent emission permits in various emission markets **[8]**

Ellerman et al. (2014) conducted an analysis of performance of the European Union's (EU) Emission Trading System (ETS) from 2005 to 2012, from its inception to the end of its second phase [37]. The ETS was considered to be the largest cap-and-trade program in existence. As of 2013, it was reported that EU ETS covered about 13,500 stationary installations in the electric utility and major industrial sectors and some 2000 airline accounts in the twenty-eight member EU, Norway, Iceland and Liechtenstein. It was reported that about two billion tonnes of CO2 and some other GHG were included in the system, making up about 4% of global GHG emissions.

The system of emission quota allocation was such that each nation was allocated an emission permit based on their historic emission. Then, each nation would allocate the allowance within its borders. The national allocation plan had reportedly been criticized because of "windfall profits" from free allocation and the competitive impact of different allocations to like facilities in various member states in what was intended to be a single market. It was reported that in accordance with the directive by the European Parliament, 95% of allowance in the first phase and 90% of allowance in the second phase was allocated to the emitting firms freely. It was reportedly found that because of other policy measures and a decline in economic activities, the actual emission levels stayed well below the cap. This resulted in the price of emissions per tonne of CO2 dropping from €15 in 2006 to virtually zero by the end of phase one in 2007, back to about €30 before the economic crisis of 2008, €10 after the crisis and was reported to be about €3.65 in 2013 [37].

Tvinnereim (2014) looked at the empirical record of cap-and-trade since the beginning of 1995, and found that carbon cap targets were always easier and cheaper to reach than expected. However, one reason he cited was that the targets were “generous” [4]. Since the emissions were or easily had fallen below the cap, the prices of emission permits were lower than originally predicted. The presence of lower prices was considered to be a challenge to the continued existence of the cap-and-trade policy instrument [4].

Tvinnereim reported that the gap between annual caps under EU ETS and annual emissions in the covered jurisdiction had widened by about one-half of one percentage point per year. The EU ETS covers CO2 and nitrous oxide (N2O) emissions in sectors such as electricity, metals, cement, refineries, paper, and glass [4].

Tvinnereim provided the following as the reasons for cap-and-trade regulations in the EU not being binding [4]:

- The EU introduced a cap-and-trade system to help reach the collective European Kyoto target for 2008-12, after efforts to introduce an EU-wide carbon tax had failed.
- The initial three-year phase (2005-07) was designed as a test run, and permits issued for this period were not transferable to future periods. In the first phase, member states were in charge of the initial distribution of permits to industry. As the first batch of verified emission data was published in April 2006, showing much lower emissions than permitted under the aggregate cap, allowance prices crashed.
- The cap was subsequently lowered for the second (2008-12) phase, in line with the EU’s collective Kyoto commitment. The tighter cap contributed to EU installations emitting more than the annual cap in 2008, forcing them to borrow from their 2009 allowance or to use external offset credits to remain in compliance. However, amid the global economic downturn, emissions in 2009 fell below the cap, where they have stayed. The market is likely to stay over-supplied for years to come.

Tvinnereim also studied the Regional Greenhouse Gasses Initiative (RGGI) cap-and-trade system that went into effect in nine US state in 2009 and concluded that all major cap-and-trade programs showed that emissions were consistently below the cap. The main reasons were listed to be, again, caps were set too high, economic activities and output declined due to recession, the price of low carbon content fuel dropped, innovations in technology played a role in abatement in early years, and other, complementary, policies were a major factor in emission reduction.

In conclusion Tvinnereim wrote that the empirical record had shown that cap-and-trade did not yield any “fixed” emission levels and that existing caps were based on political feasibility rather than global temperature stabilization scenarios [4].

Carbon Tax versus Cap-and-Trade

Ekins and Barker (2001) conducted a study to compare the efficiency and economic impact of carbon tax and cap-and-trade instruments [19]. They found that in unequivocal terms researchers had concluded that revenue-raising instruments such as carbon taxes and auctioned emission permits, with revenue recycling that reduced other taxes, would reduce emissions at lower cost than both regulations and grandfathering emission permits [19].

They wrote that carbon tax had all the hallmarks of "good taxation," the benefits of which were listed as follows [19]:

- It tackles a problem of negative externality by incorporating the social cost of global warming in the cost of CO_2 emission.
- Its revenues are expected to increase with income.
- It should be simple and low cost to administer through the use of many existing tax structures or excise duties.
- It is expected to stimulate energy saving, innovation and investment in clean technology, and possibly economic growth.
- Any regressive side effects on low-income groups can be remedied using a small fraction of the expected revenues for equalization.

They wrote that the revenue from carbon tax could be used in a number of ways including [19]:

- To achieve further environmental benefits (for example, by subsidizing energy efficiency measures, or low-carbon technologies),
- To achieve distributional objectives, either in response to the distributional impact of the carbon tax, or more generally,
- To reduce government borrowing or debt, thereby reducing the level of taxation that will be required in the future, and
- To reduce other inefficiencies in the economy, by distortionary taxes.

Ekins and Barker reported that European countries that had introduced carbon taxes, had also introduced rebates or special tax reduction to address the concern about industrial competitiveness. Taxes depending on the type of fuel ranged from €20 to €80/tonne of CO_2 [19]. Ekins and Barker argued that the reason several jurisdictions had implemented cap-and-trade and not carbon tax was because they deemed the implementation of a tax be politically problematic.

Hovi and Holtsmark (2006) in their paper on feasibility of enforcement and effect of non-compliance associated with the carbon tax and cap-and-trade argued that the cap-and-trade approach under Kyoto Protocol suffered from a number of weaknesses. They argued that one alternative to Kyoto's quantitative approach was a regime based on an internationally harmonized carbon tax. Referring to published reports and analyses, Hovi and Holtsmark argued that Kyoto Protocol would do little to alleviate the problem it was designed to solve. It was reported that the countries for which Kyoto provided binding constraints were responsible for just 19% of global emission, and these countries were required to reduce their emissions by only a little over 5%. It was concluded that, in addition to being difficult to enforce, compared to the business-as-usual scenario, the Kyoto Protocol would reduce global emissions by only 0.9% [6]

Hovi and Holtsmark suggested that under an internationally harmonized carbon tax regime countries would agree to penalize emissions domestically via an internationally agreed-upon harmonized tax on carbon emission, where no emission targets, no emission trading, and no base period emission levels would be involved. To counter the competitive advantage of the countries that remained outside this tax regime, a border adjusted tax could be put in placed on trade between parties and non-parties of the harmonized carbon tax. Another advantage of the carbon tax was argued to be that the business would have a certain cost to plan for and deal with as opposed to cap-and-trade where the prices would not be constant [6].

Hovi and Holtsmark listed the following additional arguments that made a harmonized carbon tax preferable to cap-and-trade [6]:

- Carbon tax can be used to reduce the inefficiencies and deadweight loss that are created by income and consumption taxes.
- Carbon taxes are transparent and known, whereas the compliance and effectiveness of emission allowance is hard to confirm.
- Tax based emission reduction policies are less susceptible to corruption than the quota based regulations.
- Emission permits create a potential for making a profit for those who control the permits. Thus, giving dictators and corrupt administrators the ability to sell permits and pocket the money.
- The emission permit-based regulation provides the opportunity for creating artificial scarcities and monopolies.
- With carbon tax there is no problems of defining the baseline emission level or emission year and arguing over the level of emission credit each nation is entitled to.
- A carbon tax system, because of the government revenue, may make it difficult for subsequent administrators to cancel the emission reduction commitments.

Based on their study, Hovi and Holtsmark conclude that an international climate agreement based on uniform carbon tax is likely to be superior to a cap-and-trade policy in terms of efficiency and compliance perspectives.

Parry and Pizer (2007) conducted an assessment to compare and contrast cap-and-trade versus carbon tax [38]. They questioned whether cap-and-trade was the best regulatory model, and compared the advantages and disadvantages of the two systems. They argued that a carbon tax imposed “upstream” in the fossil fuel supply chain minimized the number of entities subject to the tax and therefore had administrative advantages. They also wrote that there was typically greater efficiency – lower cost per tonne – associated with upstream programs because they can encompass virtually all emission sources with minimal administrative burden.

They listed the following as the potential advantages of a carbon tax [38]:

- A carbon tax provides price certainty which would allow businesses and others to plan and estimate the return on their investment in carbon-saving capital or R&D, both of which may have a high up-front cost.

- It will allow seasonable and annual emission variation due to changes in prevailing economic conditions; otherwise the cost of abatement could range from zero to extremely high, as was observed in the case of EU ETS. The flexibility can be achieved without significant regulatory and administrative costs of an emission banking system.
- Carbon tax system will raise government revenues which can be used to reduce other taxes nation-wide and be invested in R&D. In the case of cap-and-trade, most of the revenues from the free allocation of permits go to the businesses.
- Carbon tax eliminates the administrative costs of establishing a new institution for an emission credit trading system or issuance of permits.
- From a cost-effectiveness standpoint, carbon tax is considered to be superior to performance standards such as fuel economy of vehicles or energy efficiency of the household appliances. Performance standards do not impose an economy wide carbon price and therefore fail to efficiently distribute the burden of emission reductions across different firms, households, and mitigation options.

Parry and Pizer also list the disadvantages of carbon tax as follows [38]:

- There is always a political resistance to carbon tax, thus, it may prove politically infeasible to introduce.
- There is a possibility that the revenues generated from carbon tax are wasted instead of being spent on social interest or replacing other taxes.
- The policy makers may choose to compensate some industries that are considered most affected by tax, the legislative process of compensating some industries could be complicated.
- The most widely argued disadvantage of carbon tax is that it does not achieve a certain level of emission reduction because the emission varies from year-to-year. Having a certain level of emission reduction will be considered very important when CO2 concentrations are very high.

Innovation

Scotchmer (2011) studied the expansion of innovation under carbon tax and cap-and-trade. Scotchmer found that under tax regulation, an innovator could always profit from diffusing the clean technology to all producers. This was found not to be the case under a carbon cap-and-trade. It was stated that because in the latter case innovation diffusion resulted in energy supply expansion and reduction in the price of energy, the producers under cap-and-trade regulation then would have lower willingness to pay for further emission reducing technology licences. If there were no expansion in energy production, it was argued, then there would be excessive supply of emission permits and consequently lower prices. In either case the source funding for innovation dwindled [9].

According to Scotchmer another outcome under cap-and-trade could be that the proprietor of innovation might want to prevent the fall in prices by licensing only some of the energy producers, which could lead to productive inefficiency. With tax regulation, it was argued, innovation that resulted in reduced emission would not affect the price of energy, permits or the corresponding tax before and after the innovation [9].

Scotchmer argued however that cap-and-trade and carbon taxes were not equivalent for innovation. Scotchmer stated that if demand for emission permits was such that a small drop in emission level resulted in a large drop in prices, i.e., in the inelastic range, then innovation under cap-and-trade would not diffuse because the innovators could not collect sufficient royalty for their innovation when the prices of emission credits were very low. The opposite was said to be true when the demand was in the elastic range of the demand curve. The conclusion of the study was that from an innovation perspective the cap-and-trade and tax would not have the same effects.

Mason (2009) studied the effect of carbon tax and cap-and-trade on emission reduction and innovation. Mason found that moderate taxes could have substantial effects on emission reduction where cap-and-trade, after the fact, could be found to be overkill [5]. A significant problem with cap-and-trade in the years prior to their study was found to have been that the prices were more volatile than originally envisioned [5]. Because of this emission credit price volatility, firms' incentives to invest significantly in newer, cleaner technologies for the long-term were said to be undermined [5]. European Union ETS experience was considered to be a good example of price volatility, where in span of three years prices dropped from about \$20 to almost zero and back to about \$35.

Mason writes that the European experience was important because the primary purpose of a cap-and-trade-based carbon market was to provide long-term incentives for firms to invest in clean-air technologies. Because such technologies were said to be extremely costly to build, private investment in capital intensive technologies only made sense if the long-term benefits of the investment were clear. With carbon permit prices fluctuating wildly, long-term signals regarding the benefits of investment in clean-air technology were said to be very uncertain. Therefore, according to Mason, it was not apparent that a cap-and-trade system resulting in a market for carbon permits was helpful for investment in technologies that would reduce carbon emissions [5].

Mason also questioned the intentions and motivations of those who were pushing for the cap-and-trade regulation and stated,

> *Both Wall Street investment firms and environmentalists have similar goals – to restrict the number of carbon permits …. Environmentalists' motivations are obvious. What is less apparent in the emotion of the environmental debate is the fact that financial firms that make markets for tradeable pollution permits will be able to make higher commissions the scarcer the permits are. Any alliance between environmentalists and Wall Street presents a particularly intractable problem as far as public choice theory is concerned. Public choice theory is a phenomenon where well-coordinated groups manipulate government programs meant to provide for the common good.*
>
> *The empirical evidence indicates that these public choice concerns are well-founded. Indeed, two companies infamously associated with corporate malfeasance and financial manipulation, Enron and AIG, both lobbied for cap-and-trade programs so that they could reap profits by making markets for permits.*

Border Adjusted Tax

Elliot et al. (2013) studied the impact of carbon pricing, border adjusted tax and carbon leakage. They referred to the United Nations Framework Convention on Climate Change (UNFCCC) of 1992 and the Kyoto Protocol of 1997 that envisions a process whereby developed nations would commit to reducing their emission to GHG before developing nations took similar steps. The Kyoto Protocol currently only binds thirty-seven nations to meet set emission targets. No fast-growing developing nation faces emission limitations [39].

Elliot et al. wrote that there were two central concerns with respect to the Kyoto Protocol. The first was whether carbon controls that exempt developing nations could sufficiently reduce global emissions. Even if the developed world were to cut its emissions drastically, it was argued that atmospheric carbon dioxide would not be stabilized by this action alone. The developing world was expected to be a major source of emissions in the future [39].

The second concern that Elliot et al. listed was that if only developed nations imposed carbon controls, emissions in the developing world might go up, offsetting reductions, through carbon leakage. Carbon leakage was thought to arise for two reasons. First, if only a subset of nations imposed controls on emissions of CO2, energy-intensive production might flee to regions without controls. Second, if nations with carbon controls used fewer fossil fuels, the price of fossil fuels might go down, resulting in more use in other regions [39].

Elliot et al. concluded that carbon leakage had the potential to defeat the purpose of having carbon controls, because it would inefficiently shift the location of production and energy use, and would create domestic political challenges [39]. They simulated the effects of border adjusted tax, taxes on the emissions from the production of an imported good, and rebates of domestic carbon taxes on the export of goods. From the results of their simulation, they found that border adjusted tax reduced leakage substantially [39].

Eyland and Zaccour (2014) studied the impact of international cooperation on the effectiveness of climate change policies using analytical models. They wrote that a challenge for a country contemplating to introduce an environmental regulation that imposed a price on emission was how to keep its local firms competitive. They wrote that in the abstyence of an international environmental agreement on climate change, a country might be reluctant to unilaterally implement environmental regulations. That was because environmental policies would increase production costs and might force companies to move production to countries that had lax environmental regulations. Consequently, the emission from the production going abroad would cancel out the reduction in carbon emissions in the abating country because of the less environmentally friendly technologies being used in the lax country [40].

To avoid this problem while still taking care of the environment, they proposed that a country might impose a carbon tariff that adjusted for the differences between its own carbon tax and the other country's tax. One of their main findings based on an economic duopoly model was that a border adjusted tax might be a way around the lack of actions and cooperation on an international environmental agreement [40].

Eyland and Zaccour found that the border adjusted tax almost completely mimicked a situation where two countries cooperatively set their carbon taxes. Thus, border adjusted tax was argued to be able to address the goal of obtaining a cooperative-type outcome in the absence of cooperation [40].

Monjon and Quirion (2010) looked into a design for border adjusted tax for the European Union Emission Trading System (ETS). They argued that the European Union, that had implemented a cap-and-trade system, should define product specific borr adjusted tax for goods that were at risk of carbon leakage. The carbon content of each product was suggested to be computed based on the average emissions that was released by producing each specific product in the 10 percent of least carbon-intensive European plants [41].

Maruyama (2011), former General Counsel of the Office of the US Trade Representative (2007 – 2009), wrote that one way of dealing with the international trade problems that arose from cap-and-trade and carbon leakage was to implement a carbon or energy tax that was imposed on imports and rebated on exports to ensure a level playing field. According to Maruyama, such a system could be implemented under the World Trade Organization's (WTO's) existing border adjusted tax rules even in the absence of a multilateral climate agreement [42].

Maruyama argued that if something serious needed to be done about climate change, it made far more sense from a trade policy and WTO standpoint to enact a straightforward carbon tax with border adjusted tax for imports and exports to ensure a level playing field. Maruyama called the cap-and-trade practices of the US a fiasco and suggested that a carbon tax would be a better interim approach pending an international climate change agreement, since unlike cap-and-trade-based import restrictions; it could be implemented under existing General Agreement on Tariffs and Trade (GATT) and WTO rules without the need for a new multilateral consensus [42].

Maruyama interpreted that WTO permitted a carbon or energy tax to be structured as a tax on energy products (oil, natural gas, coal, etc.), a specific tax on specific products (such as steel) based on their levels of energy consumption or carbon emission, or a broad-based tax based on energy usage or carbon emission that applied to all products. Maruyama wrote that from a legal perspective, a carbon or energy tax would offer a straightforward solution to WTO Members who were committed to adopting climate change controls even in the absence of a global agreement, but nevertheless feared the employment and industrial competitiveness consequences of higher energy prices [42].

Schott (2013) studied the energy link between the US, Canada and Mexico and evaluated the carbon pricing options for Canada [12]. He wrote that the United States was sitting on a major oil shale reserve and was becoming slowly self-sufficient, and the only country that the US was still increasing energy imports from was Canada. However, Canada was said to be the only G8 country without a national energy strategy, giving a lot of discretion to the provinces on both energy policy and climate initiative [12].

According to Schott, Canadian business leaders and energy-rich provinces were starting to realize that one could not be a major player on international energy market without a coordinated and consistent strategy concerning energy trade and harmonization on environmental policy. The Canadian Council of Chief Executives was reported to have called for "a clear, national consistent carbon price across the economy" [12].

Schott wrote that without a proper carbon pricing, inefficient energy choices and investments were made. Schott argued that an integrated energy market in North America required either the linking of environmental policy and regulation, or cross-border adjustments. In the US there reported to be arguments for both cap-and-trade and carbon tax policies. Schott wrote that if Canada did not implement GHG emission reduction policies similar to the US, in accordance to American Clean Energy and Security Act of 2009, Canada would very likely face border adjusted tax for trade with the US [12]. It was argued that it was, therefore, in the interest of Canadian provinces such as Alberta and Saskatchewan to link their emission-reduction programs directly with energy-receiving jurisdiction rather than face border adjusted tax [12].

Schott wrote that the federal government was, however, the only authority that could level the competitive playing field both internationally and between provinces. He stated that only the federal government had the authority to impose import duties or export rebates and to ensure that interprovincial trade was governed by a standard and reasonable carbon price.

DISCUSSION

There is a consensus that today CO2 gas is released to the atmosphere at a rate that is higher than what the natural carbon dioxide sinks, mainly the plants and the sea, can absorb. The environmental scientists suggest that we should emit less, sequester or reuse CO2 [3]. If we can capture and sequester the CO2 emissions at the same rate as they are released into the atmosphere, then we should be fine [3]. However, currently that is not the case. The high rate of emission has resulted in an increased level of CO2 concentration in the atmosphere (from 310 ppm in 1960 to 400 ppm in 2015) as reported by Mauna Loa Observatory in Hawaii [43]. This elevated concentration of CO2 is argued to have and will result in climate change. As a consequence, it is feared that societies, nations and all living beings will be negatively affected by the climate change and the related extreme weather patterns [14].

Economists consider global warming to be a negative externality that results from the increasing CO2 emissions, thus a market failure. To reduce the level of CO2 emissions to a socially optimum level government interventions are required. Economists suggest the use of market instruments such as carbon cap-and-trade or carbon tax to reduce negative externalities.

Carbon cap-and-trade is a regulatory instrument for emission reduction. It is the foundation of the Kyoto Protocol and has been implemented by some jurisdictions and rejected by others. An attraction of the cap-and-trade program is its political feasibility. According to Endre (2014), the EU introduced a cap-and-trade system after efforts to introduce an EU-wide carbon tax had failed [4]. As it was observed from the literature review, however, carbon cap-and-trade regulation has a number of problems and has proven to result in economic inefficiencies. That is probably one of the main reasons why the Kyoto Protocol will never be implemented as it was initially envisioned [4, 39, 42].

Although some argue that cap-and-trade will result in known levels of reduction in the amount of carbon dioxide emission, empirical results from Europe and the United States have shown that this is not necessarily the case. In both Europe and the US, because of overestimation of the baseline emissions of the target gasses, the cap-and-trade system has not had any effects to-date, since they were first legislated in each jurisdiction [4, 8]. The tradable permits program initiated by the EU has been subject to administrative problems and disappointing results [4, 7].

Two major problems with cap-and-trade that are widely talked about in the literature, media and political discussions are carbon leakage and industrial competitiveness. Carbon leakage occurs when the emission reduction in one jurisdiction is offset by increased emission in another jurisdiction. An industrial competitiveness problem arises when the cost of production of firms in a jurisdiction with cap-and-trade policy gets much higher than its competitors in other jurisdictions.

The Kyoto Protocol exempts developing nations from the carbon cap-and-trade requirements [17, 39]. This seems fair since the developing and underdeveloped countries will need to consume considerable amount of energy and fuel to get the standard of living and infrastructure within their borders to those of the developed nations. However, if a developing nation uses the carbon emission cap exemption to produce products at a lower cost for export to a developed country like Canada, for example, where the production costs will be higher because of the carbon cap-and-trade, this will negatively affect Canadian industries that are exposed to international competition [6, 12, 19]. Some companies will be forced to shut down, while others may move production to carbon cap exempt jurisdictions.

One side-effect of carbon cap-and-trade that is not being talked about in the context of CO2 quantity regulations but has proven to be a problem in the case of dairy industry or taxi industry is the economic rent (profit) seeking by the permit (quota) holders to the extent that it is creating a barrier to entry and giving the quota holders monopoly power [30, 31]. In both the dairy industry and the taxicab industry, because of the high accumulated value of the permits, the governments are now unable to eliminate them. If Canadian provinces proceed with their own GHG quota (cap-and-trade) systems, soon they will replace a negative externality market failure with a monopoly market failure. A large firm with allocated permits can use its power in the permit market to gain an advantage in its product market by manipulate the price of emissions permits to drive up the production costs for its competitors and new entrants [23]. The monopoly power and the associated inefficiencies will very likely develop in industries that are energy intensive but are immune from international competition either because of regulations or the nature of the industry. For example, take the food industry. If one large bread making firm using natural gas for energy freely acquires, buys and hoards emission permits, soon this firm will have a market power that will enable it to set prices, while no competition will develop because others will not have the emission permits to even turn the oven on. The presence of a firm with market power in the emission allowance market under a cap-and-trade regime could prevent the final allocation of permits from being efficiently distributed [23].

The Organization of Economic Co-operation and Development (OECD) during the summit of June 6, 2011 recognized that the potential for market monopoly as a result of cap-and-trade program existed. OECD stated that large emitters might exercise market power, such as monopoly, to manipulate the permit prices to their own advantage; and firms might try to abuse permit trading systems to create distortions in the market for their product and impede competitors. OECD stated that large emitters could raise their rivals' cost of production either by buying all the permits in the market or by pushing up the permit price [44].

An analytical study of the effect of initial allocation of sulfur oxides (SOx) permits in Los Angeles region on economic efficiency was reported to show that how the property rights were distributed to emitters affected the function and efficiencies of the market [45].

It is apparent that the province of Ontario, based on the recent announcement on Ontario's environmental policy, will use cap-and-trade. It is an emission regulation instrument that has proven to be economically inefficient. The only justification for it seems to be political feasibility and appeasement of some sectors of the economy irrespective of its environmental, technological or economic impacts. The discussion below analyzes Ontario's announcement in light of the findings presented in the literature review section of this paper.

On April 13, 2015 the government of Ontario announced [46], "Ontario is joining other jurisdictions, including Quebec and California, by imposing a hard ceiling on the pollution allowed in each sector of the economy." It is not clear and there is no detail on how this will be implemented on each sector of the economy. While it may be easy to regulate and monitor the emission levels at large and fixed factories and plants; it is not known as to how Ontario will implement the cap-and-trade on the trucking industry, airline industry, food processing, restaurants, and construction industry, to name a few. Ontario's Climate Change Discussion Paper 2015 [47] that was released in advance of and in preparation for this announcement stated, "Together, building and transportation are currently the most significant contributors to Ontario's emissions." How will the cap-and-trade regulation implemented in Ontario reduce emission by these "most significant contributors?"

The announcement continued, "[Cap and trade] effectively reduces the amount of GHG pollution in our atmosphere by setting a limit on emissions, rewarding innovative companies, providing certainty for industries and creating more opportunities for investment in Ontario." Unfortunately, the empirical results from Europe and other jurisdictions suggest that none of these objectives were attainable under cap-and-trade. Under cap-and-trade, the price of CO_2 emission permit per tonne of CO_2 in Europe changed from $20 in 2006 to almost zero in 2007 and $35 in 2008. The over 80% drop in one year and the 1200% increase in the other do not provide certainty for industries. Therefore, no firm will take a risk to invest if they can't calculate the economic cost and benefit of their investment. Also, analytical and empirical results available in the literature have demonstrated that innovation suffers under cap-and-trade [5, 14].

It was stated, "Ontario intends to join the cap-and-trade system under the Western Climate Initiative. Under the cap-and-trade system, businesses will have their own GHG quota and will then be able to sell it if they don't need it because of their own efficiency." First from a regulation perspective, how can Ontario and its partners ensures that every business is complying with their cap and that they are trading a genuine surplus? How would the governments prevent the carbon leakage, both due to companies moving production to carbon-lax jurisdiction and importing from the carbon-lax jurisdictions [3, 40]. It is known that the CO2 disperses very fast globally, and the CO2 that was not emitted in Ontario but was emitted in a carbon-lax jurisdiction will be dispersed in the atmosphere and impact Ontarians in a way that would be no different than if the CO2 was emitted in Ontario? One thing that is certain is that the production cost of Ontario firms will be higher than their competitors in other provinces or overseas [12, 42].

It was stated, "The government will reinvest the money raised through cap-and-trade in a transparent way back into projects that reduce GHG pollution and help business remain competitive." There won't be much revenue to the government of Ontario from the cap-and-trade program. Once the government issues permits, most of which will very likely be for free as it was done in the case of dairy quota in Canada and the ETS in Europe to current emitters on a grandfathering basis [44], there will be no revenues coming to the government. Even in the case of auctioning some of the permits, government's revenue will be small and limited because at the early stages no firm will pay a high price for an asset whose future value is unknown and extremely volatile [37].

The announcement stated, "Good environmental policy is good economic policy." Unfortunately, there is a risk that Ontario will end up with an economic policy that will have little environmental impact. After about 17 years of cap-and-trade policy, Europe's carbon reduction cap is still not binding. The EU economic policy does not seem to have had a positive environmental impact, at least not for the past 17 years, while it has forced many industries to move production to carbon-lax jurisdictions [8]. Although, the level of information and knowledge on the quantities of emission are much better now than it was in the 1990s, the statement made by Ontario will very likely not stand the test of time.

The announcement stated, "Fighting climate change while keeping industries competitive and strong is part of the government's economic plan for Ontario." Assuming that the carbon cap will be binding and it will result in higher carbon emission permit prices, it will give companies one more push to move production outside Ontario and very likely outside Canada, unless there are changes to tax and rebate regulations on imports and exports [12].

In 2012 the Canadian Council of Chief Executives called on the governments and asked for a clear, nationally consistent carbon price across the economy. They suggested that the price should start at relatively low levels so as to give time for adjustment and to avoid unnecessary impacts on competitiveness. It was suggested that the revenue raised should be used to fund reductions in other taxes, assist vulnerable consumers, to support the competitiveness of Canadian industry, devote a portion to the development of new technologies and eliminate undue cost burden on any particular region or sector. They argued that transparent costs to Canadians are essential to stimulate smart consumer energy choices [48].

To prevent cap-and-trade induced carbon leakage and competitiveness problems as well as the monopoly power problem, it is much more efficient and economical to use carbon tax imposed on domestic consumption and border adjusted tax imposed on imports and exports, and stay away from carbon cap-and-trade regulation, as the tool for dealing with CO2 emission negative externality [4, 42, 38].

Carbon tax, a behavioural changing and revenue generating instrument, can be used by governments to induce a reduction in CO2 emission. The revenues from carbon tax can be used to fund emission mitigating measures, to spend on social programs and environmental protection, or to replace other taxes.

On June 8, 2015 the leaders of G7 nations declared that they will jointly mobilize US $100 billion a year by 2020 from a wide variety of sources, both public and private for carbon emission mitigation actions. They also declared that they would apply effective policies and actions throughout the global economy, including carbon market-based and regulatory instruments, to promote low-carbon growth [49].

Since the main objective of the policy is to reduce CO2 emission, the US $100 billion funding should and very likely will come from the negative-externality-correcting carbon tax. Obviously, issuing emission permits that has been practiced in the case of carbon cap-and-trade cannot generate much revenue. Most importantly, the emission mitigation funding should not come from the inefficiency-inducing income, corporate and general consumption taxes. Based the CO2 emission data provided by the World Bank, at a rate of $30/tonne of CO2 emission that British Columbia has imposed, the G7 nations could collect about $270 billion in carbon taxes a year (Appendix A). This will not only cover the US $100 billion funding commitment but it will also provide a surplus for other social and environmental initiatives.

Nationally, a carbon tax can be collected at the point of production or at the port of entry of all fuels. If we use the $30 per tonne of CO2 emission tax for making estimates, the carbon tax on each tonne of coal (lignite) would be about $42, resulting in an increase of about 2.9 cents per kWh of coal-produced electricity (Appendix B). The carbon tax on a litre of gasoline, on a litre of diesel and on one cubic metre of natural gas would be about $0.07, $0.08 and $0.06, respectively. The cost of electricity produced from diesel and natural gas would increase by about 2.3 and 1.7 cents per kWh, respectively. Currently, as of May 2015, the average rate of electricity charged to residential consumers in Ontario, for example, is about 10.3 cents per kWh. This rate is an increase of 5 cents per kWh from 5.3 per kWh in July 2007. This is an increase of about 93% (Figure 5 & Appendix D). This increase is due to wind and solar power generation subsidy and closure of 7,000 MW of coal power generating capacity (equivalent of 10 CANDU 6 nuclear power plants) between 2005 and 2014. Had Ontario decided to implement a carbon tax, the marginal increase in the rate of electricity, for residential consumers, due to carbon tax today would be about 30%. Comparing this to the 32 cents per kWh, or marginal increase of about 320%, for cost of electricity paid to solar power producers in Ontario [50], carbon tax is not too bad at all. It is a good tax that will evenly distribute the burden of GHG emissions reduction to all emitters and consumers, and can be used to implement CO2 emission mitigating measures that will make even the burning of coal environmentally acceptable and economically competitive. Figure 5 shows the percent increase in the rate of electricity for the residential costumer's in Ontario along with the percent change in consumer price index (CPI) and real gross domestic product (GDP) of Ontario between 2007 and 2014. The current increase in the rate of electricity for residential consumers has outpaced the inflation and GDP by several factors.

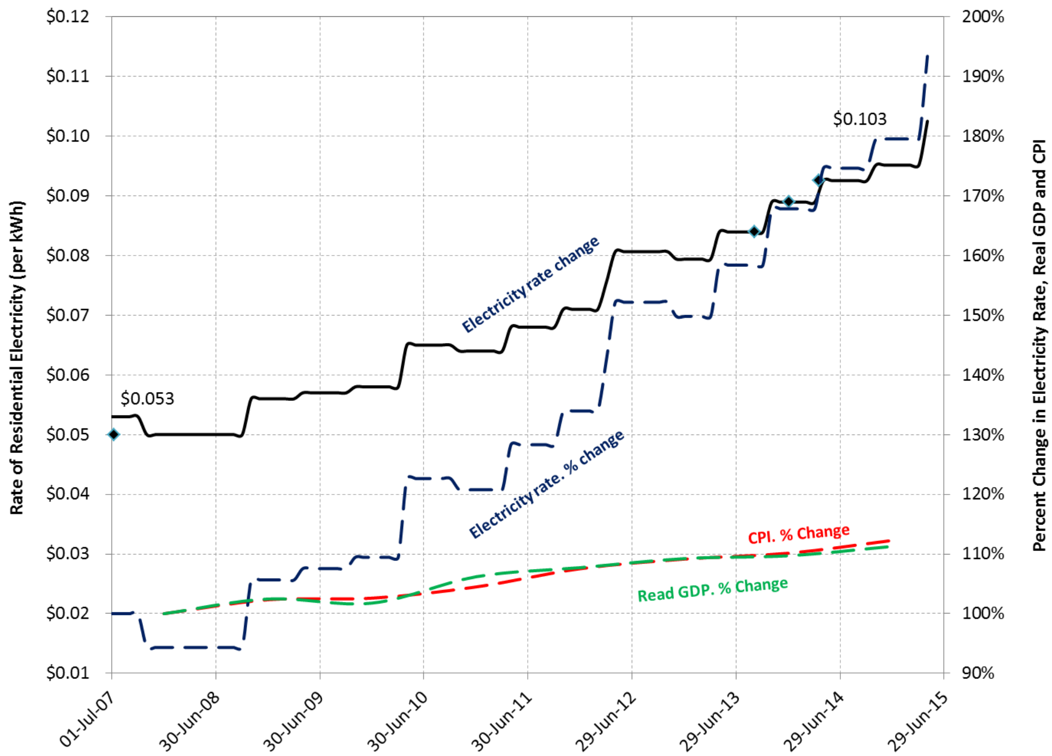

Figure 5: Rate of electricity for residential consumers, CPI and real GDP of Ontario – 2007 base

Carbon capture and sequestration (CCS), a CO_2 emission mitigating measure, can be done through the use of technology or by increasing the size of forests at the global level. Environmental scientists tell us that CO_2 disperses in the atmosphere very fast and the effect of emission in Canada will affect the lives in Australia. One tonne of a GHG emitted anywhere in the world has reportedly the same climate change consequence for everyone on the globe [8]. By the same token, a carbon sink in Australia can be used to absorb an equivalent amount of CO_2 that is emitted in Canada to get a global zero net CO_2 emission. Carbon taxes collected on CO_2 emission in Canada can be used to pay for creating CO_2 sinks even in Australia, for example.

The cost of technology-based CCS, in accordance to a statement that is attributed to the Julio Friedman of the US Energy Department, is reported to be between $70 and $90 per tonne [51]. Although, the costs for a full scale CCS plant that has been built in Saskatchewan, after some cost recovery from the sale of CO_2, could be much lower. The new federal regulation governing the performance standards of new coal power plants that took effect on July 1, 2015 in Canada, requires that the level of emission from a new coal-fired power plant does not exceed that of a high efficiency natural gas-fired power plant – about 420 tonne of CO_2/GWh. The emission from coal-fired power plants on average is about 780 tonne of CO_2/GWh. Carbon tax collected from existing coal-fired power plants can be used to implement CCS anywhere in the country or in the world, and reduce the net impact of coal burning to the same or even lower than a high efficiency natural gas-fired power plant.

The simplicity and efficiency of carbon taxes is argued to make it more immune from manipulation and corruption [5]. Joseph (2009) wrote, "A carbon tax confers far greater economic efficiency than an ill-defined, unstable, and environmentalist –and Wall Street-driven cap-and-trade market design." [5].

Ideally, to ensure a level playing field for Canadian firms, Canada's federal government should implement a system of national carbon tax collected at the point of production of all carbon dioxide emitting fuels along with a fuel import tax. Otherwise, since Canadian provinces do not have jurisdiction over border tax, Ottawa should allow the provinces to impose their own border adjustment taxes. Carbon tax can and should be applied to all products that cross borders based on their carbon consumption. This will be very similar to the excise taxes that apply to goods that people buy and claim tax rebates for at ports of departure and pay taxes on at ports of entry [42]. Implementation of a carbon tax and its associated border adjustment tax will greatly reduce regulation costs and provide a fair treatment to all industries [22].

The import tax revenues can be used by the importing country to invest in research and development, to create carbon sinks or, as stipulated under Article 10(c) of the Kyoto Protocol, to assist underdeveloped and developing countries for the purpose of supporting and promoting technologies related to the GHG emission abatement.

According to Warren Maruyama, the former General Counsel of the Office of the US Trade Representative, a carbon tax that is imposed on imports and rebated on exports to ensure a level playing field could be implemented under the World Trade Organization's existing border adjusted tax rules even in the absence of a multilateral climate agreement [42].

A carbon tax will fairly distribute the burden of GHG emission reduction on all consumers and producers and prevent the formation of monopolies in the market place.

CONCLUSIONS

Environmental scientists tell us that there is a consensus that human activities resulting in increasing levels of GHG emissions are contributors to global warming. Economists consider global warming to be a negative externality and thus a market failure, which requires government intervention. The intervention options include implementation of CO2 cap-and-trade regulation or carbon tax.

CO2 cap-and-trade, however, in absence of international cooperation between all GHG emitters results in carbon leakage and puts domestic industries in competitive disadvantage. Cap-and-trade has also been found to hinder innovation. Missing from the public discussions and scientific studies is the fact that CO2 cap-and-trade, being a quota system, can also create monopolies. Large firms that acquire and hoard CO2 emission permits when they are given for free or when the prices are low will turn into monopoly power in the emission market and in the product market in later years, as observed in dairy and taxicab industries.

To prevent the above cited problems, studies have shown that carbon tax with a border adjusted tax is a better policy instrument to reduce the impact of GHG emission negative externality. A Carbon tax ensures a level playing field for all producers and consumers, and a border adjusted tax will ensure a level playing field for the domestic and foreign producers and suppliers. Furthermore, major efficiency gains of carbon taxes include [21]:

- Lower cost – the same outcome can be achieved at a lower cost than the alternatives,
- Less administration complexity – economic incentives require a minimum level of administrative intervention, and
- Lower transaction costs – economic incentives avoid many of the hidden costs of bureaucratic regulation, such as negotiation and lobbying.

The carbon tax collected on domestic consumption can be used to invest in CO2 emission reducing technologies, carbon capture and storage, or reforestation; be spent to replace other taxes, or be spent on various social and environmental initiatives.

According to the World Bank fifteen countries are implementing or have passed legislation for implementation of a direct carbon tax [52].

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Appendix A

Average CO2 emission of G7 counties for 2010 – 2014 and estimated carbon tax revenue based on a carbon tax of $30 per MT of CO2.

Country	MT of CO2 ('000)	Carbon Tax Revenue (B$)
Canada	499,000	$ 14.97
France	361,273	$ 10.84
Germany	745,384	$ 22.36
Italy	406,307	$ 12.19
Japan	1,170,715	$ 35.12
UK	493,505	$ 14.81
United States	5,433,057	$ 162.99
Total		**$ 273.28**

Source for the CO2 emission quantities: the World Bank [53]

Appendix B

CO2 emission, carbon tax per unit of physical quantity, and carbon tax per kWh of electricity produced from each type of fuel

Carbon Dioxide (CO2) Factors:	Kilograms CO2[1]	Per Unit of Volume or Mass	CO2 Tax ($) Per Unit of Volume or Mass	MT of CO2/MBTU[1]	MT of CO2/MWh	Carbon tax (cents)/kWh
Diesel Fuel	2.68	Litre	$ 0.08	0.073	0.757	2.27
Gasoline	2.35	Litre	$ 0.07	0.071	0.737	2.21
Natural Gas	1.92	cubic metre	$ 0.06	0.053	0.549	1.65
Coals by type						
Coal (All types)	2,315.75	MT	$ 69.47	0.095	0.957	2.87
Anthractie	2,842.50	MT	$ 85.28	0.104	1.041	3.12
Bituminous	2,465.65	MT	$ 73.97	0.093	0.936	2.81
Subbituminous	1,857.95	MT	$ 55.74	0.097	0.975	2.93
Lignite	1,395.80	MT	$ 41.87	0.098	0.981	2.94
Coke	3,119.84	MT	$ 93.60	0.114	1.145	3.44

[1.] Source: U.S. Energy Information Administration estimates.
http://www.eia.gov/environment/emissions/co2_vol_mass.cfm
Carbon tax assumed at $30/Metric Tonne (MT)

Gallon =	3.785	Litre
1 cft =	0.0283	cum
1 short ton =	0.907	MT
1 kWh heat	3,412	Btu heat
1 kWh Electricity 10,089	Btu heat @ 34% efficiency	

Assume 34% thermal coefficient for coal
Assume 33% for natural gas and diesel

Appendix C

The current Feed-in Tariff (FIT) prices for each renewable fuel/technology in Ontario

Renewable Fuel	Project Size Tranche*	Price (¢/kwh)
Solar (PV) (Rooftop)	≤ 10 kW	38.4
	>10 ≤ 100 kW	34.3
	> 100 kW ≤ 500 kW	31.6
Solar (PV) (Non-Rooftop)	≤ 10 kW	28.9
	> 10 kW ≤ 500 kW	27.5
On-Shore Wind	≤ 500 kW	12.8
Waterpower	≤ 500 kW	24.6
Renewable Biomass	≤ 500 kW	17.5
On-Farm Biogas	≤ 100 kW	26.3
	> 100 kW ≤ 250 kW	20.4
Biogas	≤ 500 kW	16.8
Landfill Gas	≤ 500 kW	17.1

* The FIT Program is available to Small FIT projects; that is, projects generally ≤ 500kW [50].

Source: Independent Electricity System Operator of Ontario (http://fit.powerauthority.on.ca/fit-program/fit-program-pricing/fit-price-schedule)

Appendix D

Rate of electricity for residential consumers in Ontario between 2007 and 2015, along with the consumer price index (CPI) and real gross domestic product (GDP):

Effective April of 2012, three different rates were in effect depending on the consumption time in the day. For the averages given in the table below, it is assumed that the usage ratios for a typical household between peak, mid-peak and off-peak were 20%, 15% and 65% of the total daily consumption, respectively.

Increases in rate of electricity for Ontario residential consumers

Date	Average Rate (kWh)	Percent Change
01-Jul-07	$ 0.053	100%
01-Oct-07	$ 0.053	100%
01-Nov-07	$ 0.050	94%
01-Oct-08	$ 0.050	94%
01-Nov-08	$ 0.056	106%
01-Apr-09	$ 0.056	106%
01-May-09	$ 0.057	108%
01-Oct-09	$ 0.057	108%
01-Nov-09	$ 0.058	109%
01-Apr-10	$ 0.058	109%
01-May-10	$ 0.065	123%
01-Oct-10	$ 0.065	123%
01-Nov-10	$ 0.064	121%
01-Apr-11	$ 0.064	121%
01-May-11	$ 0.068	128%
01-Oct-11	$ 0.068	128%
01-Nov-11	$ 0.071	134%
01-Mar-12	$ 0.071	134%
01-Apr-12	$ 0.076	143%
01-May-12	$ 0.081	152%
01-Nov-12	$ 0.081	152%
01-Dec-12	$ 0.079	150%
01-Apr-13	$ 0.079	150%
01-May-13	$ 0.084	158%
01-Oct-13	$ 0.084	158%
01-Nov-13	$ 0.089	168%
01-Apr-14	$ 0.089	168%
01-May-14	$ 0.093	175%
01-Oct-14	$ 0.093	175%
01-Nov-14	$ 0.095	180%
01-Apr-15	$ 0.095	180%
01-May-15	$ 0.103	193%

<u>Ontario's CPI and Real GDP chained to 2007</u>

Year	2007	2008	2009	2010	2011	2012	2013	2014
All-items, CPI	111.5	114.1	114.4	116.5	119.9	121.7	122.8	125.2
CPI increase relative to 2007	100%	102%	103%	104%	108%	109%	110%	112%
Real GDP (chained $2007), billion	$567,302	$581,285	$577,399	$602,429	$611,097	$619,700	$622,385	$631,280
Real GDP increase relative to 2007	100%	102%	102%	106%	108%	109%	110%	111%

Sources: Statistics Canada (Table 384-0038) and Ontario Ministry of Finance
http://www.fin.gov.on.ca/en/economy/ecaccts/ecat10.html