Cap and Trade Allocation Schemes: An Earnable Allocation Scheme

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Abstract: Although theory states that the allocation scheme should have minimal impact on the effectiveness of a Cap and Trade policy, in reality, the chosen allocation scheme can have a large impact on the policy. Three common forms of analysis can be done on allocation schemes, efficiency (including over allocation), social welfare, and equity. The most popular form of allocation, free allotment, is plagued with issues in all three aspects. The auction allotment can eliminate some of the issues with social welfare and equity, but only improves efficiency to a certain degree. The last common form is a hybrid model, but it can only leverage the degree to which the various issues arise between the free allocation and auction schemes. Ultimately, no allocation scheme can eliminate the possibility of over allocating permits. We propose a new way for firms to earn the tradable permits by voluntarily reducing emissions during a trial period. The firms will then be rewarded permits based upon how well each did with respect to the others. Ultimately, all firms that choose to partake will have the opportunity to at minimum receive all the necessary permits that is needed. The earnable permit system can eliminate the issues regarding efficiency, social welfare, and equity.

Over the last several years, scientists have improved the quality of research of Global Climate Change. The consensus has been reached that humans do, in fact, play a significant role in the many causes of climate change. It has also been determined that time may still be on our side to combat the many changes that will surely occur if we continue status quo. It has been agreed upon in many circles that in order to prevent the majority of climate change from occurring, we must cap the amount of carbon dioxide-equivalent (CO_2e) in the range of 450-550 parts per million (ppm), with many authorities recommending a goal in the lower portion of that range (Hepburn and Stern 2008; den Elzen 2008). If these limits are met, then it is likely that the world's temperature will increase by less than the 2°C from pre-industrial times, which most

scientists agree will keep the changes moderate enough that the conditions of the Earth will remain relatively intact (den Elzen and Lucas 2008).

This goal is not the responsibility of one or a group of nations, but it can only be achieved if the entire globe enacts tight guidelines on the regulation of CO_2e. Since the Kyoto Protocol was agreed upon in 1997, the majority of the international community has ratified it, with the most notable exception, the United States. Various reasons have been proposed in the past of why the United States has not ratified, but at this point, with mixed results from Copenhagen and a couple more conferences in 2010, the reasons are mute; however, the United States must step up and participate this time around. According to the United Nations Development Programme's Human Development Report 2007/2008, the United States leads all nations in national emissions, as well as per capita emissions (Watkins 2007); however, it has been reported that China might have eclipsed the United States in national emissions since the report (Kanter 2008). Furthermore, the rate at which China and India are growing and the rate at which their national emissions are increasing, they and other developing countries must be part of the global agreement if we are to succeed at averting the major repercussions of climate change (Posner and Sunstein 2009).

Although carbon standards have their issues with incenting companies and being fair, carbon taxes are generally accepted as being fair, efficient, and provide appropriate incentives for companies to actually change the way they do business. Cap and Trade (CAT) policy has also been found to be fair and efficient with arguably sufficient incentives for companies to decrease CO_2e releases. CAT is the idea that companies are granted permits to release a unit of contaminate. The companies are then able to determine if they want to abate the emissions and sell the permits or use the permits to continue to emit at the current level. Companies that have relatively low abatement costs can generally make a profit by selling permits at a higher price than it would cost to abate the unit of contaminate, while companies that have relatively high abatement costs can generally buy the permits at a lower price than they can abate. This provides a market for the contaminate permits, which if done right, can provide a valid price for the contamination.

One of the primary questions that is raised with a CAT policy is the way in which these permits are initially offered. The offering can have dramatic impacts on price, welfare costs, revenues, and many others. The three primary means of offering permits that have been done in the past has been an initial free allocation, an auction, and a varying degree of free permits and auctioned permits, or a hybrid allocation. Section **Error! Reference source not found.** will evaluate these three allocation schemes in more detail.

Once we describe some of the background information for CAT policy, Section **Error! Reference source not found.** will delve into proposing a new type of allocation scheme – one that gives participating parties the ability to voluntarily partake in an initial trial period to have some control in the allocation scheme. Three examples will be provided to describe graphically how the program will work. This new policy will then be evaluated in the same manner as the three previous allocation schemes. Finally, Section **Error! Reference source not found.** will conclude the paper with some exiting remarks.

I. CAT Allocation Schemes

All CAT policies must initially distribute the permits to the participating members. Any allocation scheme can be evaluated on many different levels, but we will look at efficiency, social welfare, and equity in this paper. Efficiency is the idea that resources are allocated correctly by arriving at the correct price and quantity through the market, without any welfare degradation. The social welfare piece will analyze the cost to the firm and the cost to society in the form of environment degradation and financial costs. Finally, equity will be defined as the fairness of the allocation scheme to any given firm in the market.

A. Free Offering

The first type of offering that is popular among CAT policies is the free distribution of all permits. Various ways of distribution exist among different industries or even within a given industry, but the issuing party does not receive any compensation for the distribution. This can be beneficial to society because it could be done in such a way to have minimal impact on the buyers of the products in the given industries. This allows the country to phase in costs that will be incurred by the general population. Political acceptance of this kind of allocation might also accelerate the introduction of a CAT policy.

Hepburn and Stern (2008) have evaluated four different issues that a free allocation scheme can run into. The first issue, especially if historical emissions are a way of determining the allocation among firms or industries, is the incentive to actually increase emissions prior to the launch of the policy in order to obtain more emissions. The next issue comes with the incentive to improve emissions during the program. The firms will see little or no cost to the emissions, so they have little financial incentive to abate missions. The third issue stated is an increase of entry barriers, because incumbent firms might be able to obtain a large quantity of permits. Finally, the lack of money flowing to the government does not allow the government to provide subsidies to the general public to offset the cost of the program (Hepburn and Stern 2008). Furthermore, it has also been shown that the European Emission Trading System (EU ETS) program, which started in 2005, generated windfall profits to some firms because they passed on the price of the permits to their customers even though they did not have to initially pay for the permits upfront (King 2008).

This type of allocation scheme provides very little efficiency in the system. All of the permits are freely distributed, so the market has a smaller amount of time to clear an efficient price and quantity. This can be seen in the EU ETS; Alberola argues that one reason the price of a permit considerably dropped towards the end of the first phase due was due to over-allocation (Alberola and Chevallier 2009), but over-allocation could have been reduced if the permits had not been freely distributed. Furthermore, the welfare of this type of system could be fairly maximal if the firms fairly allocate any increase revenue to abate emissions in the future; however, some firms might take the offering and still raise prices to the general public or have little incentive to actually reduce the degradation to the environment. Lastly, this type of allocation will typically have little equity, because the two best arguments for allocation size is either firm size or current emission levels. Neither one of the strategies will be fair to all firms involved.

B. Auction Offering

The next type of allocation scheme associated with CAT policies is an initial auction of the permits. Auctions will generally equalize the price of the permit by allowing firms to bid on the permit. Also, with an auction, firms do not have the incentive to increase emissions in order to get more permits. An auction will provide revenue for the government to disperse as necessary to accommodate some of the costs that will incur with the auction to either firms or the general public.

An initial auction offering does eliminate many of the issues that are derived from a free offering, but some issues still exist. Even though the market will better price the permit in an auction, if the initial number of permits that were to be sold was too high, the price of the permit could be artificially low. Furthermore, in many cases, all the permits will be distributed even if they were unneeded. Also, by requiring firms to pay for each permit, this will inevitably raise the price that firms must charge their customers, thus increasing the costs to the general public; however, this could be offset if the revenues generated by the auction were properly allocated to offset the increase of prices.

Ultimately, the efficiency of the auction is much higher than the free distribution (Moyes 2008); however, if the initial allotment has been incorrectly measured, then the price of the permit will be artificially low and over-allocation will still exist. If the revenues generated by the auction are correctly allocated to reduce the impact of the increasing prices, then the social welfare of an auction could become neutral. Also, the inherent cost of the permits will entice some firms to reduce emissions and reverse the degradation of the environment. Finally, the auction distribution should be equitable in theory, because the firms will only pay as much as they value the permits (Moyes 2008).

C. Hybrid Offering

The last type of allocation scheme that will be discussed is the Hybrid Offering. This typically involves some ratio of freely distributed permits and auctioned permits. Typically, the ratio of free permits to auctioned permits is relatively high and tends to decrease after time. Since this is truly a balance between a freely distributable system and auction system, then the same advantages and disadvantages will exist in relative proportions depending on the initial ratio.

New Zealand has proposed a new ETS that is currently unmatched in scope to completely internalize the cost of CO_2e and other green house gas (GHG) emissions. It covers the entire spectrum of GHGs and includes all sectors of its economy. The ETS is also including many of the different offsets including forestry agriculture and has provided a means to capture international trade among all facets of the program. Unlike other ETSs in the past, New Zealand's will be a true hybrid system were some of the permits are freely distributed to gain political acceptance, as well as certain sectors requiring to purchase all permits. The freely distributed permits will be phased out over time. Furthermore, the sectors that will be required to purchase all permits will be arguably the dirtiest: liquid fossil fuels, stationary energy, or waste sectors (Moyes 2008).

II. Earned Offering

We have developed a new model that will provide an alternate means of permit allocation for CAT policies. The basic idea is that firms will have the opportunity to earn the amount of permits that they need in order to satisfactorily meet the abatement that has been requested. The government will define a goal for the trial period, and firms, who wish to compete, will try to reach the published goal. After the initial trial period, the firms will be allotted a number of permits that they have earned.

A. Program Description

Prior to the start of the program, the government must clearly define the goal that they would like to see the firms, as an aggregate, hit. This number also corresponds to the number of permits that will be allocated after the trial period ends. The firms must clearly define what their current level of emissions is to begin the trial. This will be the baseline emissions of the program and the reduction goal will be expressed based upon this baseline. Obviously, this gives firms an incentive to cheat and report higher emissions in order to see a larger "drop" in emissions at the end of the program. Although this is out of the scope of this paper, a couple different methods could be used to incent firms to accurately portray their initial emissions[1]. During the trial period, firms are able to choose any means to reduce their emissions. At the end of the trial period, the firms will again report their emissions. Again, firms will have an incentive to report low emission levels, but this can be managed, as just discussed in Footnote **Error! Bookmark not defined.**. After all the reporting has been completed, the results are evaluated to identify how many permits will be allocated to each firm. The process will be described later, but two base cases must be evaluated first.

If no firms choose to voluntarily abate emissions, or if all firms actually come in with higher emissions, due to various factors, then the program will essentially revert to an auction scheme of the permits. This will hurt all firms, because 100% of the permits must be purchased. Furthermore, firms will have a more difficult time reducing emissions, because the government will only allocate the number of permits that was initially declared. In other words, in aggregate, all firms must reduce their emissions by the specified amount, because permits will be allocated up to that amount.

The other base case is if all firms actually meet the goal. This will imply a complete success for the program; the total amount of abatement exceeded the goal. If this is the case, then all firms will be allotted the number of permits that they have shown that is needed. For instance, Firm A and Firm B both emitted 100 units of CO_2e before the trial period and the goal was to reduce emissions by 5%. At the end of the trial period, Firm A reduced emissions by 6% or 6 units and Firm B reduced emissions by 7% or 7 units. The overall program reduced emissions by

[1] The first one is a third party auditing firm that verifies the firms emissions; however, this will be quite costly if all firms were to be audited, so the government must present a credible threat that some of the firms may be audited at the government's discretion. Another is to provide a penalty to firms that are suspected of exaggerating emissions levels. Schakenbach et al. has reported that penalties were effective in the US Acid Rain Program **Invalid source specified.**.

6.5%, and 94 and 93 units would be allocated to Firms A and B, respectively. This will prevent an over-allocation of permits.

Now that the base cases are taken care of, the next stage is to determine to what level of emissions each firm was able to reduce[2]. With these numbers, we can determine each firm's Efficiency during the trial period, the Program Efficiency, each firm's Trial Reduction[3], and the % of Trial Reduction that each firm contributed. With these numbers, we can now determine the Initial Allotment. The Initial Allotment will be calculated whether the firm achieved the stated goal or how much of the trial reductions to which the firm contributed. If the firm achieved the stated goal, then the firm would be allocated 100% of the permits needed – the level at which the firm was emitting after the trial period. If the firm did not achieve the stated reduction goal, then the firm would be allotted a number of permits based upon the percentage of the stated goal that the firm was able to obtain and the level of emissions after the trial period.

After all of the initial allotment has been determined, we must calculate the number of permits that is left. These leftover permits will then be awarded to firms based on a couple of different scenarios, but first, some housekeeping must be done. The first is to determine how many firms achieved the stated goal. If no firms achieved the stated goal, then the remaining permits will be allocated based upon each firm's Trial Reduction. If one or more firms have achieved the goal, then we must sum each firm's Trial Reduction that achieved the goal. After determining the Trial Reductions of the firms that achieved the goal, the remaining permits will be allocated based upon each firm's contribution to the sum just calculated.

Once the Initial Allocation and the Adjusted Allocation has been determined for each firm, all of the permits have been allocated. Here lies the incentive for firms to participate in the program. If a firm is successful in achieving the stated goal of the program, it is, at worst, going to walk away with all of the permits needed to emit at the level of emissions after the trial period, and at best, the firm might walk away with extra permits to sell to offset some of the costs of the trial reduction period of the program. Furthermore, this program can actually accrue higher benefits for the environment and the people within the vicinity of the emissions, because the program has an inherent incentive to reduce emissions, even if other firms choose not to participate. Furthermore, many authors have determined that voluntary emission reductions have benefited firms with respect to the public and even to shareholders (Lyon and Maxwell 2002).

B. Examples

For example, **Error! Reference source not found.** describes the scenario where we have three firms in an industry and no firm hits the stated goal of 98%. Firm A, B, & C have baselines emissions of 500, 1000, and 500, respectively and have emissions of 495, 995, and 499,

[2] If a firm chooses not to participate or if a firm's emissions actually gets worse during the trial period, then the firm's emission level will be the same as the baseline emission level. Inadvertently, the following calculations will provide the firm with zero emission permits, which will require it to purchase all permits or reduce during the first period of the actual program.

[3] This will become clear later, but for example if a firm's baseline emission was 500 and its emission level was 490, then the firm's efficiency would be .98, and the firm's Trial Reduction would be .02. This value is used to eliminate bias towards dirty firms later in the calculations.

respectively, at the end of the trial period. Each firm's efficiency is .99, .995, .998, respectively, while their Trial Reduction is .01, .005, and .002, respectively. The Trial Efficiency of 99.45% was above the stated goal of 98%, which means that a total number of permits to be allocated will be 98% of baseline emissions or 1960 permits.

FIGURE 1-EXAMPLE WHERE NO FIRM HITS TARGET

	Trial Period Measurements					Allotment		
	Baseline Emissions	Trial Emissions	Efficiency	Trial Reduction	% of Trial Reduction	Initial	Adj.	Total
Firm A	500	495	0.99	0.01	0.58824	248	831	1079
Firm B	1000	995	0.995	0.005	0.29412	249	416	665
Firm C	500	499	0.998	0.002	0.11765	50	166	216
TOTALS	2000	1989	0.9945	0.017		547	1413	1960

Notes: For this example, we used the stated goal as 98%, which translates to an expected allocation of 1960 permits.

Since no firm hit the stated objective, then all firms will be initially allocated based upon the percentage of the goal that it was able to obtain, namely 248, 249, and 50, respectively. After the initial allocation, roughly 1413 permits remain. Furthermore, the Adjusted Allotment will be each firm's percentage of Trial Reduction of the remaining units, namely 831, 416, 166, respectively. Firm A will be allocated a total of 1079 units, while B & C will have 665 and 216, respectively.

Looking at the data, this seems intuitive, because Firm A reduced its emissions by 1%, which was the most in our sample; therefore, it received, proportionately, the most permits during the Initial Allocation and during the Adjusted Allocation. Firm B reduced its emissions roughly 50% compared to Firm A, and Firm B received roughly 50% of its emissions during the Initial Allocation. Finally, Firm C reduced its emissions the least amount during the trial period; therefore, it received the least number of permits. Proportionately, it has to buy a higher percentage of the permits in order to emit at the same level. In aggregate, 98% of the baseline emission levels have been provided to the three firms and the industry can trade (i.e. Firm A sell its extra permits to Firms B & C) for a total of 1960 units of emissions, but ultimately, the industry must reduce the total number of emissions another 29 units during the first period of the CAT program.

As another example, **Error! Reference source not found.** shows an industry with five firms and two of the firms have been able to achieve the stated goal of 98%. Firm A and Firm B both achieve the stated goal of 2% reductions with 4% and 2.5%, respectively. All of the other firms only reduced emissions by 1.2%. As stated, Firms A and B will both receive permits equal to their emission levels at the end of the trial period, 480 and 975, respectively, while Firms C, D, and E only receive permits based upon how well they did against the goal.

FIGURE 2-EXAMPLE WHERE MULTIPLE FIRMS HIT TARGET

	Trial Period Measurements					Allotment		
	Baseline Emissions	Trial Emissions	Efficiency	Trial Reduction	% of Trial Reduction	Initial	Adj.	Total
Firm A	500	480	0.96	0.04	0.39604	480	366	846
Firm B	1000	975	0.975	0.025	0.24752	975	228	1203
Firm C	500	494	0.988	0.012	0.11881	296	0	296
Firm D	500	494	0.988	0.012	0.11881	296	0	296
Firm E	500	494	0.988	0.012	0.11881	296	0	296
TOTALS	3000	2937	0.979	0.101		2343	594	2937

Notes: For this example, we used the stated goal as 98%, which translates to an expected allocation of 2940 permits.

Since multiple firms hit the target of 2% reductions, then their % of Trial Reduction will be summed to distribute the remaining units to only Firms A & B. Firm A had a % of Trial Reduction of .39604 and Firm B had a value of .24752, which sums to the .64356 as stated above; therefore, Firm A will receive 61.5% of the remaining units, or 366 units, and Firm B will receive 38.5%, or 228 units. Since Firm A and B have achieved the stated goal, then they will be able to sell the remaining units to the other firms in the market. Finally, this example was selected to depict the prevention of over allocation of permits. The Trial Efficiency is 97.9% or a 2.1% reduction. Since the program achieved its goal, the total number of permits that will be released is 97.9% of the baseline emissions, or 2937 tradable units, instead of 98% of the baseline emissions.

As a final example, **Error! Reference source not found.** shows the distribution if all firms achieve the stated goal of 98% efficiency. The firms have an efficiency of 97%, 97.5%, and 97.6%, respectively, which is below the stated goal of 98% efficiency; therefore, all firms will be allocated enough permits to emit at the level they emitted at the end of the trial period. This total number is considerably lower than 98% of baseline emissions. This will prevent an over allocation of permits.

FIGURE 3-EXAMPLE WHERE ALL FIRMS HIT THE DESIRED TARGET

	Trial Period Measurements					Allotment		
	Baseline Emissions	Trial Emissions	Efficiency	Trial Reduction	% of Trial Reduction	Initial	Adj.	Total
Firm A	500	485	0.97	0.03	0.37975	485	0	485
Firm B	1000	975	0.975	0.025	0.31646	975	0	975
Firm C	500	488	0.976	0.024	0.30380	488	0	488
TOTALS	2000	1948	0.974	0.079		1948	0	1948

Notes: For this example, we used the stated goal as 98%, which translates to an expected allocation of 1960 permits.

C. Evaluation

Overall, the program allows the firms in the industries to self-select whether they want to participate in the trial program. With the given parameters, we feel that it would entice all of the firms in the industry to participate, because if not, any non-participating firm must purchase all permits or reduce emissions during the first phase of the program. If the firm chooses to participate, then they have a chance to receive part of the required permits, all of the required permits, or a surplus of permits. All scenarios are better than the scenario were the firm must purchase all permits.

The efficiency of this allocation scheme should be sufficient in all cases, except for when all firms achieve the reduction goal. In this case, the firms will probably not partake in the trading of permits, because all firms will be allotted the number that they need. With that being said, some firms could decide that they might be able to further reduce emissions at a price lower than what another firm can and trading will commence. Auctions, in theory, have already been shown to be efficient, so if no firms choose to participate in the trial, then all permits will be auctioned. The last scenario where some firms have a surplus and other firms have a deficit, then a market will be established to set the correct price for the carbon unit. Furthermore, we know that the program has not over allocated the permits, so the industry should have an efficient number of permits to trade.

The welfare of the program can be debated over whether or not the auction welfare has been improved. Unless this program reverts into an auction, then no permits will be sold to generate revenue to offset some of the welfare costs to the public. Furthermore, the costs to improve efficiency could be transferred over to society in the form of increased prices. In most cases, many of the externalities of emissions will be reduced with this type of allocation, because firms will have the motivation during the trial period to reduce emissions, which will in turn reverse the destruction of the environment. In the best case scenario, if all firms hit the stated goal, then the total amount of emissions reductions will further negate some of the externalities.

Lastly, it can be argued that the program is completely equitable among the firms, since they are given the choice to participate, the “dirty” firm bias has been calculated out of the model, and firm size bias does not exist in the model. The one remaining disadvantage of the free allocation scheme that has not been addressed yet is the high entry barriers that free allocation might provide to the incumbent firms. This can actually be reduced down to how the program will be transition into future phases. In other words, all allocation schemes can have an inherent factor of grandfathering if a firm tries to enter during a phase, unless some permits have been held back to accommodate this. The model could be modified to accommodate this by either reducing the “Remaining Permits” by some number initially for new entrants or if the trial period is successful in reducing total emissions beyond the goal, then some of difference could be reserved for new entrants.

III. Conclusion

It has been shown that a CAT policy can be efficient and provide the necessary incentive to reduce emissions. How effective a CAT policy is can be affected as early as the allocation of the

permits. Currently, free allocation, auction allocation, or a hybrid model is the main focus points of current literature and policy. In practice, the free allocation scheme has many disadvantages in the form of efficiency and equity, and it has a high potential of over-allocating permits, which further undermine the efficiency of the scheme. Although the auction allocation scheme could improve the efficiency over a free allocation scheme and will most certainly fix the equity problem, it cannot eliminate the over-allocation problem inherent in both of these schemes. Even with the improvements of the auction, the free allocation schemes typically have more political and general populous support. A hybrid model can be used to propose a middle ground for efficiency, equity, and political acceptance. An earned permit allocation has been shown to be efficient, have neutral social welfare, is equitable, and can prevent an over allocation of permits by effectively determining the number of permits that is needed to launch the policy. Furthermore, it provides the firms the ability to voluntarily reduce emissions, which can garner benefits outside the normal analysis.

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