Coalition Strategies and Reduction of GHG Emissions

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Abstract

The Flexible Mechanisms articulated in the Kyoto Protocol provide a robust framework for emission reduction issue in a manner that is not just economically efficient, but is also pro-growth for trade. In the presence of liquid or illiquid markets, to attain higher value from the emission trading, we have shown that coalition strategies provide a pertinent alternative to production optimization measures which may not be feasible at times. The whole game is analyzed taking a resource based view of the strategic factor markets. We have also illustrated the measures needed to provide stability to the coalitions and hence the coalition strategies.

Introduction

With the enactment of the Kyoto Protocol and its implementation, the energy trading map is destined to change. The new addition is carbon credits. The success of such international climate change agreement would depend on abatement targets and the incentives for countries to participate. Equally important would be modus of operandi for implementing the emission caps on the businesses as this will bring out the actual transformation desired to make a significant reduction in green house gases (GHG).

Trading makes stern targets more economical. Further on appropriate agreements could be made to usher in the developing countries by first, allowing them to capture the rents from permit sales and then making them a partner in emission reduction.

The present paper formulates a framework and sketches out how coalitions are formed between the businesses or entities to attain set emission targets. A lot of work is being done to examine self-enforcing environment agreements using game theoretic concepts, whose members are often referred to as coalitions. Our work shares many features with these literatures, but differs in important respects. We are not limited to modeling international environmental policies as games in emissions. Rather we focus on the possibility that the entities agree on a system of emissions trading, as in the Kyoto Protocol. The key strategic variable (factor, as we would call them) for members of such a trading coalition is the initial endowment with tradable emission rights (or permits).

Also, it is commonly assumed that coalition members behave cooperatively, maximizing their joint payoff. In the case of heterogeneous countries, this involves agreement on a particular sharing rule such as the core, Nash equilibrium or Shapley value (e.g. Roth 1978). On the other hand, countries act selfishly in that they leave (or do not join) a cooperating coalition if this increases their payoff. Stability of a coalition depends on the prospects to reduce interest conflicts with regards to a minimum agreement. A bargaining situation contains opportunities to collaborate for mutual benefits. As demonstrated by a real negotiation processes, a full agreement of all players is unlikely. Rather, some players may act independently or unilaterally to maximize their own welfare and self-interests, while other players create small and stable coalitions. The decision to join a coalition or initiate a partial coalition depends on the difference in net benefits of a cooperative and a non-cooperative strategy. The combination of both these strategies is well elucidated by Brandenburger and Stuart (1995), Lippman and Rumelt, (2003).

SECTION I

Kyoto Protocol and Flexible Mechanism

The Kyoto Protocol was officially launched at the Third Conference of the Parties to the UN Framework Convention on Climate Change (UNFCC) held in Kyoto in December 1997. The aim of this agreement is to reduce the greenhouse gases (GHG). Among the main outcomes of this agreement is the commitment by all Annex I (updated list now called Annex B) countries to lower their emissions of six GHG namely, CO_2, CH_4, N_2O, HFCs, PFCs and SF_6, by at least five percent below the 1990 levels, with a target date between 2008 and 2012. Reduction commitments within the Annex B Group of industrialized countries are not uniform.

Our purpose is not to analyze the Kyoto Protocol, or the Flexible Mechanism[1], but rather to suggest various strategies to control GHG emissions as the Kyoto Protocol comes into force[2]. Traditionally, environmental protection does not list out as a priority for businesses. High levels of environmental protection very often go against the interests of organizations motivated by profits. They may see this as softening of the competitive edge. In wake of these implementation difficulties at the ground level, Kyoto Protocol, provides three flexible market oriented mechanisms for reduction of emissions or Kyoto Mechanism.

International Emission Trading (IET): As stipulated in Article 17 of the Kyoto Protocol, Annex B countries are allowed to transfer/trade their emission allowances,

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[1] Also called Kyoto Mechanism, it provides for market based approach for implementing the GHG emission cap.

[2] Refer Malvik and Westskog (2001) for a discussion on Kyoto Protocol and related policy issues.

called "assigned amount units" (AAUs)[3], among themselves. This means that the Annex B countries will have the option of buying or selling some portion of their emission allowances.

Joint Implementation (JI): It provides Annex B Parties or their authorized agents to transfer marketable emission reduction units (ERUs)[4] tied to a specified project with another Annex B country as they participate in cooperative GHG abatement activities. Companies or other entities in countries with emission targets can transfer and/or acquire ERUs by investing in projects that reduce GHG emissions or impound carbon in other countries that have binding commitments.

Clean Development Mechanism (CDM): The CDM is established by Article 12 of the Kyoto Protocol**.** It is a market-based instrument which helps non-Annex B parties to host projects that help in cost-effective reductions in GHG emissions as well as contribute to their sustainable development goal or economic growth. The Annex B parties can use these certified emission reductions to meet part of their commitment. The CDM is meant to benefit both industrial and developing countries (Annex B and non-Annex B). The CDM provides developing countries with opportunities to become active participants in international efforts to curb GHG emissions.

SECTION II

Framework for Analyzing the Coalition Strategies

Here we argue how a coalition can possibly form and why would it sustain. The background to analyzing the framework and reasoning the possibility of a gain and

[3] The total amount of GHG emissions that each developed country has agreed not to exceed in the first commitment period (2008-2012).

[4] A unit of trade representing a specified amount of GHG emissions reductions achieved through a joint implementation project.

avoiding losses could be done by considering that all the coalition members are trading in a strategic factor market. A basic framework for a strategic factor market is given by Barney (1986). Simply stating, it is a market where the resources necessary for implementing a strategy could be acquired. Hence a market where a coalition or even a single player[5] could implement its strategy for abatement of GHG emissions could also be called a strategy factor market. The underlying assumption to strategic factor markets as given by Barney (1986) is that all strategies that require the acquisition of resources for implementation have strategic factor markets associated with them. An Annex B party intending to reduce GHG emission in a low cost fashion, but cannot optimize its existing production processes, could do so using the JI mechanism, i.e. tie up with a low emission producer to carry on its production or transfer emission credits from this project to make up for the requirements for the emission cap. Hence such a producer is looking at a strategic factor market where resources[6] to implement its strategies are available from other players.

Further on we take a resource based view in the strategic factor market. Here all tradable resources are pooled into the market for trading and no resources are 'firm specific'. But a firm (also a player in the market) can come to the market with a bundle of resources. To state it in a more simple term, everything tradable is up for grabs and what needs to be resolved is the division of the whole pie, which is the total value of the trade, among all the players in the market, associated with the trade.

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[5] We use players interchangeably with parties who have an emission target to meet or the parties who help in reduction of emission targets. They could be from an Annex B country or a non-Annex B country depending on the implementation mechanism. Hybrid strategies using various mechanisms are also possible.

[6] It could be intellectual property, partnering firm or a carbon sink. These are in line with mechanisms suggested in Kyoto Protocol, namely JI, IET and CDM respectively.

In neoclassical case, where we can deal with firms as a bundle resources as we are doing here, pricing of resources in the market are axiomatized by the assumption of:

1. Non co-specialization of resources in the market
2. Near perfect price elasticity of demand and supply, or that there are large numbers of buyers and sellers for each product or input.

The market for GHG emission trading, which we are dealing here are to begin with nascent. So the second condition for pricing in the neoclassical case is not satisfied. Again, with the formation of established markets, and with the setting up of global carbon credit[7] exchanges, the liquidity in the market will increase. In such situations, coalition formation is feasible (shown in section III and more general in section IV) only when the cooperating parties have complementary additions to the resource pool whose combined value is higher compared with if the same resource is held or acquired individually. This co-specialization again does not satisfy the first condition for neoclassical pricing mechanism. As shown by Roth (1978), Cooperative Game Theory (CGT) answers many questions which neoclassical economics cannot. Lippman and Rumelt (2003) write "CGT provides a valuable alternative perspective. In particular, CGT separates the issues of opportunity cost, value, and the distribution of rents. It replaces the conceptual looseness surrounding the economic profit concept with a formal system in which surplus is known, but its division is subject to negotiation".

[7] One carbon credit is equivalent to one ton of CO_2 emission. Also other GHG emissions are converted to carbon credit using a suitable schedule for easy tradability

Analysis of the coalition formation in the strategic factor markets[8]

In a strategic factor market, above normal returns are typically obtained by imperfections in the market or by asymmetry of information (also an imperfection). Lets take the case otherwise, that is, if both the implementer of a strategy and the controller of the resources, have the exactly same and perfectly accurate expectations (obtained from symmetric information) about the future value of the product market strategies before the trade (or implementation), then the price at which the trade would take place will near the expected future value of the resource. This way the gain out of the strategy would be near or exactly zero. Hence imperfections or asymmetry of information are essential. In case of GHG emission trading, lets us consider the resource to be carbon credits[9]. Unless the strategizers don't expect to make an above normal return, which in this case would be additional savings in comparison to any other available option or market, or in worse case this is the only available market for implementing the strategy, he would not trade in the market or more precisely *will not join the coalition.*

We now put forward a simple proposition concerning the formation of coalitions which also forms the basis of our analysis.

Proposition 1a*: Given no barrier to trade and an open market with perfect competition, higher gains can only be attained by forming coalition strategies.*

[8] The theoretical background to the games we are studying here is given in (Brandenburger and Stuart, 1995). They provide a complete framework for analyzing games using a noncooperative-cooperative model. This helps us understand the scenarios that we come across in strategic factor markets and GHG abatement coalitions where we have to solve a dual noncooperative game to understand the cooperative stance of the coalitions.

[9] Since the end result is reduction of GHG emissions, we can always convert any trading strategy portfolio in terms of its equivalent carbon credit trading strategy. This way calculation of the ex ante value of the project could be done in comparison with the expected future values of carbon credits at an established carbon credit exchange market, given one exists.

Proposition 1b*: Also, for a stable coalition, cooperating parties require sustainable complementing factor which makes a positive difference between pre and post coalition values of the whole or they are bound by a contract.*

Argument: Lippman and Rumelt (2003) put forward the concept of resource assembly and more importantly, strategic equilibrium. Strategic equilibrium is the state in which all possible feasible resource transfers that create value have taken place. Going further they state that "Absent strategic equilibrium, it is always possible to create additional value by a reassignment of resources to tasks" This would mean to come to a state of strategic equilibrium, the surplus obtained have to be maximized across all possible assignments of all possible resources to all possible tasks. Under the assumption of the presence of a perfect market[10] where individual players trade, the strategic equilibrium can be attained only if all other feasible scenarios, that is combinations of resources or assignments (players) are exploited for maximizing surplus. Hence the only other possible[11] scenario is the formation of a coalition.

The second proposition is very intuitive in the sense that either the coalition partners have something to gain from its formation which they might not otherwise, or else they are legally or voluntarily bound by a certain agreement which is necessary for the strategy to be implemented on the first place. We will elucidate this further when we discuss the stability of the coalition strategies in Section IV.

The purpose of this analysis is to bring out the conditions or the scenarios under which the coalitions can possibly form. This way we can strategize in a more efficient manner focusing only on those strategies which are feasible and which could be implemented.

[10] consider a carbon credit exchange where the liquidity and dept is high
[11] We use 'possible' because it may happen a coalition may not provide above normal value.

Briefly restating the conditions for coalition formation; either there exist no other market[12] from where the resources needed for implementing the strategy could be acquired, or a higher gain could be obtained by its formation as shown above.

SECTION III

Coalition strategies exemplified

In order to describe the various possible coalition strategies based on the Kyoto Mechanism, we would be using various coalitional structures[13] described by Finus and Rundhagen (2003) and stock pollutant model for trans-boundary flow pollution as suggested by Germain et al. (1998). On the basis of this model[14] we will explain strategies for GHG emission reduction. But we will not go into the details of this model or analytically describe it.

IET based coalition:

The main basis for this kind of coalitional formation would be that the costs incurred by the parties residing in different countries (Annex B), when they undertake measures to reduce or control GHG emissions, would vary from one country to another. This way the parties where mitigation costs are relatively low can become partners in the coalitions. They would undertake a larger share of the efforts required to reach the aggregate emissions target for the whole coalition, by way of which the total costs of abatement-summed across all parties will be lower than if each party controls its emissions in isolation. By simply stating this as trading of AAUs[15] would extenuate the possibilities

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[12] In this sense, we are looking at coalitions as a ‘market forming’ instrument.

[13] Finus and Rundhagen (2003) have essentially described three structures, Open Membership Game (OMG), Restricted Open Membership Game (ROMG) and Exclusive Membership Game (EMG). Further they have shown that in terms of stability OMG < ROMG < EMG, where < implies less stable.

[14] A similar model is described and simulated by Eychmans and Finus (2003)

[15] The Protocol specifies that AAUs will be denominated in metric tonnes of carbon dioxide with 100-year global warming potentials used to calculate the CO_2 equivalence of the other five gases covered by the

these and other Kyoto Mechanisms brings. It implicitly helps to curb or pause global warming, but more so helps in pushing ahead technology transfer and environment friendly R&D efforts and pushes ahead global trade in a different approach. The coalitions thus formed don't just have ecological meaning but economic augmentation coupled with it. The basis for the initial allocation of AAUs among Annex B Parties is each country's target level of emissions. The total number of AAUs is set so that the aggregate reduction in emissions equals the target.

If we analyze this setting as consisting of more than one party which requires either lowering abatement cost or additional AAUs and the coalition also consists of more than one party which can provide the same, then as proved by Chander and Tulkens (1997), all members of the coalition have to decrease their emissions with respect to the non-cooperative equilibrium[16] level. But in case of a simple two-party coalition game, the end result of the negotiations for the sharing of the abatement cost could be brought about very simply by calculating its Nash Bargaining Equilibrium. It is possible do so in case of multiple player games too, which we discussed earlier, but becomes complicated, esp. as the number of players increases. In such a situation, it would be ideal to calculate an equilibrium condition for agreement using the dual non cooperative game as we suggested and based upon this result come up with the final (possible) figures for the division of abatement cost. Hence we put forward fallback non-cooperative equilibrium as the baseline condition for the coalition and the coalition strategy for IET to be

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agreement. Private entities (e.g., companies, individuals, and non-governmental organizations) might also be authorized by their home governments to buy and sell AAUs. The ultimate responsibility for achieving the target level of emissions, however, will rest with the national governments

[16] Germain et al (2003) has given an exquisite framework where they have analyzed the whole dynamic game of transboundary pollutant flow. Here they have also shown the fallback non-cooperative equilibrium condition and further proved the requirements for the parties to cooperate to attain the *coalition optimum* which they term it as international optimum.

implemented with it. On the membership for the coalition, we suggest Exclusive Membership as they are ecologically and economically more efficient (Finus and Rundhagen, 2003). But then there is a trade off one has to make between the efficiency of the coalition and the probability of it forming on the first place. But once formed it can ensure stability in the long run. This is not the only condition required for the coalition stability though. We have to look at this in terms of the game being played in the strategic factor market, which we have done in section IV. There we have outlined the generic condition for coalition stability once the strategy is implemented.

JI based coalition:

JI mechanism is based on the transfer of ERUs derived from emission reduction projects. One of the possible[17] ways in which JI could be brought into play is when parties with Intellectual Property on low cost emission reduction technique and parties which have capital come together. Also there can be ERUs that are based on sink[18] enhancement projects which can act as credits. This can raise the aggregate emissions ceiling of participating Parties by an amount that is comparable to the additional amount of carbon that is removed as a result of the sink enhancement project. Issues like leakages[19], project benefit analysis[20] have to be taken care of in JI.

In a coalition, if one party owns a patent or has a technique(s) which can reduce the emission level at a better cost or to a better level which no one else can at the same cost or resources, then its bargaining potential increases in the complete pie. Further the

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[17] Establishing an accurate baseline is difficult. It is difficult to develop a baseline that compares the business-as-usual scenario against the benefits of a given project and the associated available ERUs.

[18] E.g. of sink is a vast forest or natural reserve which the parties agree to create, maintain or expand.

[19] Emissions from sources and activities grow outside the boundary of the project. Leakages could offset the environmental benefits achieved at the project level.

[20] Failure to accurately account for project benefits or changes in emissions outside the boundary of JI projects could result in a situation where the Annex B host country is unable to comply with its emission commitments at the end of the compliance period.

bargaining stance or power of a party also depends on cost of acquiring the capital which another party may have at hand. A thorough treatment of this subject and the possible outcomes at the end of negotiation is given by Shapley and Shubik (1969). In regards to the membership and stability, refer the IET based coalition.

CDM based coalitions and other hybrid strategies

The CDM provides Annex B parties access to emission reduction credits based on GHG abatement projects undertaken in a non-Annex B country where the costs of reducing emissions might be considerably lower than the costs of comparable reductions at home. Here too, as in case of IET and JI, the key issue would be division of the pie. But there is one critical difference. Here at least one party does not have an emission target to meet. *Hence there will be a net financial or intellectual transfer in its favor in all given scenarios of the game.*

The hybrid strategy would be a case in which in a single consortium, more than one Kyoto mechanisms are implemented. The diversity would esp. arise when the consortium opts for a strategy which includes CDM too. This would mean the game or strategy is being played across different categories of players (Annex B and Non-Annex B) in addition to the cross section of the GHG emission abatement tools opted for. But this scenario will be difficult to analyze as a simple case of the strategic factor market game. The number of combinations could be immense. One possible way for evaluating such strategies would be by taking subsets of coalitions opting for a strategy and solving the division problem in each case. But it does not do apt justice as the complete value of the coalition will not be realized and hence the solution would prove to be an inefficient[21].

[21] That means the solution is not the *strategic equilibrium* and this would result in an unstable coalition.

SECTION IV

Stability of coalitions and related strategies

Dierickx and Cool (1989) bring out the argument that tradability of a resource can hinder the competitive advantage it possessed due to which it was traded on the first place. This would mean that as the market grows, the coalitions would have to rethink the strategy or the strategic factor which binds them on the first place. But Conner (1991) showed how tradability tragedy could be overcome 'if there are complementarities between the resource and the acquirer which are greater than those that would pertain to other acquirers'. Lippman and Rumelt (2003) further state that 'absent complementarities, the only gains to trade in the asset market arise from asymmetric information'. This being one the base conditions for having above normal returns in a strategic factor market. Hence as we had stated earlier in *Proposition 1b*, the coalitions need this basic binding factor[22] for long term stability. Decisions in models like that of GHG abatement coalition rely on complementarities and properties of supermodular functions to establish monotonicity for optimal decisions. The complementarities hence arising are answered by working out the supermodularity of the underlying utility function of the individual coalition members. Supermodularity of a function is implicit through the existence of equilibrium[23] in the coalition. *That implies in absence of equilibrium, there has to be some other binding factor like contractual agreement which can decide the division of the total value generated.* Topkis (1995) has given this very finely by studying the comparative statics of coalition models.

[22] It could be also be a contract as again stated in the proposition. E.g. of factors could be IPR legally protected in that or possibly all markets, restriction imposed by the home govt. making that coalition, the only feasible one, etc.
[23] Nash Equilibrium

The stability of the coalition further lies in how long it can exploit the imperfection in strategic factor with which it has been able to sustain gains. Or how long can it keep finding new imperfections[24]. To understand this, we have outlined a few imperfections which could be exploited in order to prolong the advantage offered by the market and sustain the coalition.

- Differences in firm expectations are the key to above normal returns from acquiring resources from strategic factor markets to implement product market strategies. By having an accurate (or near accurate) expectation of the future value of the resource, it can play the market in wake of less accurate (i.e. pessimist) expectations by other players.
- Uniqueness, such that only one firm can implement a strategy, provides a competitive advantage (i.e. competitive imperfection exists).
- Entry barriers, making it difficult for other players to enter the market on its own

Conclusion

The Flexible market mechanisms articulated in the Kyoto Protocol provides a robust framework for solving the emission reduction issue in a manner that is not just economically efficient, but is also pro-growth for trade. In the presence of liquid or illiquid markets, to attain higher value from the emission trading, coalition strategies provide a pertinent alternative to production optimization measures which may not be feasible at times. We have also outlined the measures needed to provide stability to these coalitions and hence the coalition strategies. Since our framework is based on Cooperative Game Theory, rather than the neoclassical economics, further work could

[24] This would mean that it has to keep modifying its strategies in a manner that it still uses the resources available in that particular strategic factor market.

also be done by looking at the whole game in the perspective of thick and thin markets, wherein we can analyze the coalition with *full appropriation* and *noncomplementarity* (Makowski and Ostroy 1995).

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