CHAPTER

III

A simple economic analysis of some issues included in the Buenos Aires Plan of Action

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CONTENTS

1. Introduction

This brief paper provides simple economic analyses of some key issues relating to institutional design of the Cooperative Implementation Mechanisms (CIMs) included in the Buenos Aires Plan of Action (BAPA). The mechanisms, set up under the Kyoto Protocol ("Protocol") are Emissions Trading (ET), Joint Implementation (JI), and the Clean Development Mechanism (CDM). Emissions trading (Article 17) allows Annex B Parties to trade their Assigned Amount Units (AAUs) given in Annex B to meet their greenhouse gas (GHG) emissions limits. Joint Implementation (Article 6), on the other hand, allows Annex I Parties of the UNFCCC to transfer or acquire emissions reduction units (ERUs) resulting from projects located in them, to similarly count towards meeting their respective Annex B GHG limits. The Clean Development Mechanism (Article 12) is similar to Joint Implementation in that it is based on projects, but these projects must be located in non-Annex I Parties, and primarily meant for their sustainable development. The Certified Emissions Reductions Units (CERs) generated by them may be transferred to Annex B Parties to count towards fulfillment of the latter's Annex B GHG abatement targets.

In this paper I first try to clarify exactly what are the equity issues involved in the BAPA. This is followed by an economic analysis of key issues in the BAPA, in particular,

the benefits and costs to different categories of stakeholders which may result from alternative outcomes of the negotiations on the institutional design of BAPA.

2. Equity Issues in the Cooperative Implementation Mechanisms

Climate change is a global intergenerational problem, and in its context, "equity" has several dimensions

The term "equity" as employed in public policy refers to "justice" or "fairness" in allocations of rights, entitlements, obligations, and responsibilities, between policy stakeholders with respect to positively valued resources or negatively valued impacts or damages. In the case of Climate Change, the stakeholders are global, and intergenerational. "Equity" would refer to (at least) the following aspects:

(i) allocations of entitlements to GHG emissions across countries and generations, recognizing that such entitlements comprise a valued economic resource;

(ii) given particular allocations of GHG emissions rights, rules for use or exchange of such entitlements to ensure that the outcomes in terms of actual economic benefits received by different Parties are "fair"; and

(iii) questions of liability, compensation, and restitution, for damage due to Climate Change impacts.

While many physical scientists and economists tend to view notions of "equity" as essentially subjective, and not amenable to structured, dispassionate analysis (termed "non-cognitivism), policy analysts tend to accept that norms of justice comprise a kind of formal knowledge (termed "cognitivism) and draw on the philosophical discipline of Ethical Theory, to provide the basis for formal discourse on alternative criteria of equity in terms of methodologies which parallel scientific discourse. In this paper, I do not debate the justifications for alternative equity norms in these aspects (i)–(iii) above, being outside its scope.[1]

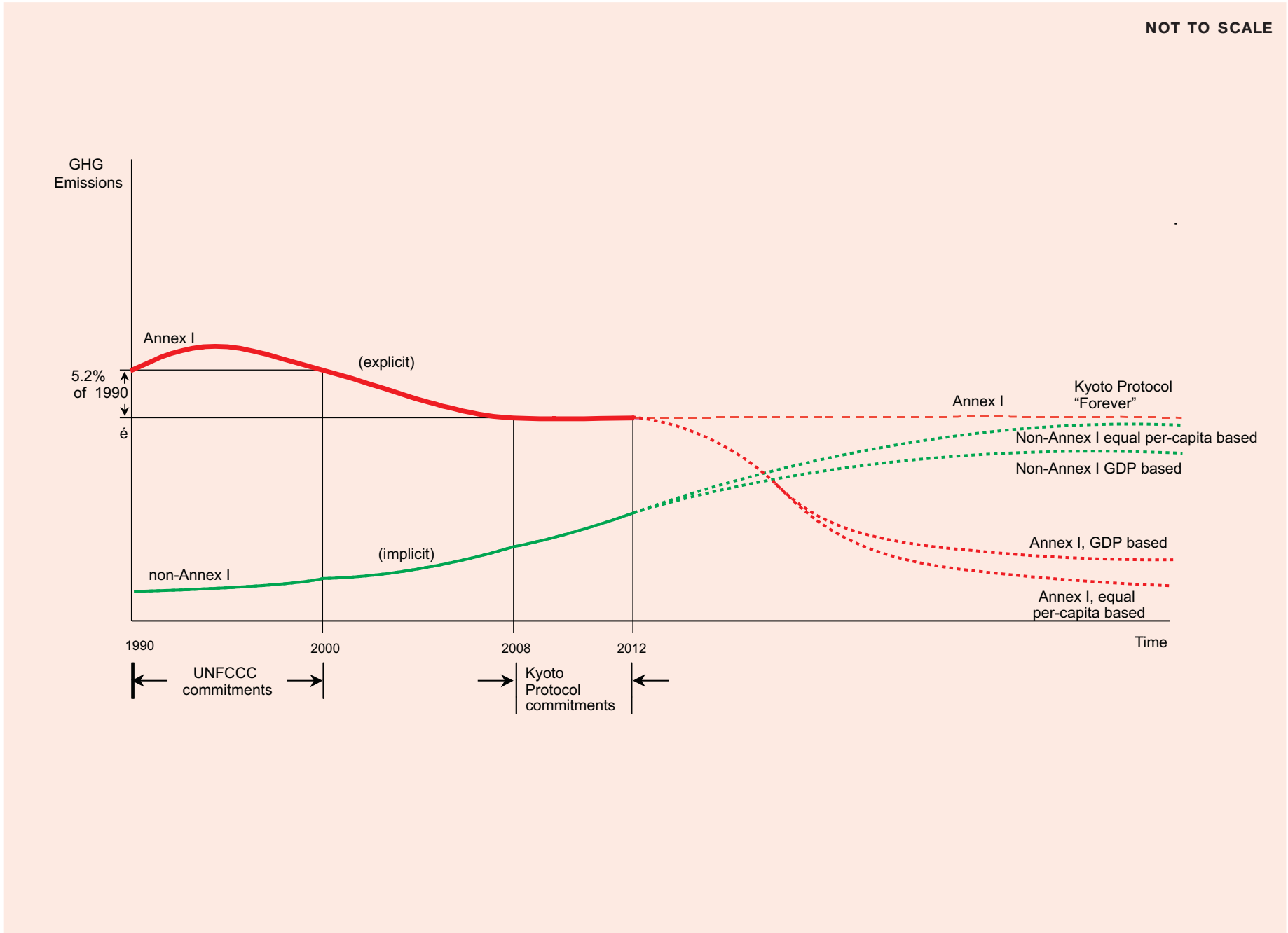
Annex B of the Protocol furnishes a partial (restricted to industrialized countries), and interim (restricted to the first commitment period, 2008-2012), quantitative restrictions of GHG emissions by these countries. On the other hand, the FUNCCC and the Protocol exempt non-Annex I Parties from any quantitative restrictions on GHG emissions, recognizing that their economic growth must not be constrained. The implicit allocation of GHG emissions entitlements to non-Annex I countries, is, accordingly, the quantities that are necessary for their economic growth, but the Preamble (*"…change in the Earth's climate and its adverse effects are a common concern of mankind"*), besides other provisions in the UNFCCC (e.g. Article 4 (1) [b]), would suggest that non-Annex I countries should abstain from GHG emissions which are not necessary for their economic growth. These (interim) allocations may be amended in the future by negotiation at COP/MOP. Figure 1 illustrates current (explicit/implicit) allocations, and possible alternative future paths based on population and GDP norms (not to scale). Of course, other bases for future allocations of GHG emissions rights are also possible.

The BAPA, which relates, inter alia, to negotiations on the institutional arrangements for ET, JI, and CDM, included in the Protocol, does not seek to reopen these explicit (for Annex B) in the first commitment period and implicit (for non-Annex I) allocations of GHG emissions limits. Rather, the outcomes matter for (ii), i.e., the relative costs and benefits to Parties flowing from the mechanisms during the period that these GHG emissions allocations are in force. Indeed, a major challenge in the design and implementation of the CDM, i.e., definition of GHG emissions baselines for projects[2] relates to ensuring that the implicit allocation of GHG emissions to non-Annex I Parties is maintained, without allowing unnecessary emissions. At this stage it is important to appreciate that GHG emissions rights, given global limits on GHG emissions, are a valuable economic resource. This is because Parties would need to spend economic resources on abating GHG emissions to meet their target, or alternatively, buy negative carbon (-C) with money to meet their targets, or, if they have surplus GHG emissions rights, these may be exchanged for money or other valuable resources.

As we shall see below, aspects of institutional design of the CIMs, may impact the economic surplus (or loss) available to entities engaged in GHG abatement transfers, by facilitating, or impeding the formation of different kinds of -C markets. For example, some arrangements may favor segregation of -C suppliers by Annex B investors and transfer of (part or whole) of the suppliers' surplus to the former. On the other hand, other arrangements may favor supply side cartelization, and transfer (part) of the buyer's surplus to the suppliers. Some other arrangements may facilitate the formation of competitive markets, with intermediate (between the above two alternatives) distribution of surplus between buyers and sellers.

In the following analysis, various market outcomes are compared with the "competitive market" situation. One property of a competitive market is that it maximizes the sum of surplus to buyers and sellers for a given initial allo-

Figure 1: **Current and Possible Future GHG Emissions Paths Under Alternative Allocation Norms**



Whether a competitive global market for -C is realized, or there is some other market structure, depends largely on the outcomes of COP negotiations

cation of resources (in this case, GHG emissions limits), but the distribution of this aggregate surplus across buyers and sellers depends on technological and economic factors which determine the location and shape of the marginal abatement cost curves (Figure 2). Comparisons of alternative market outcomes with the competitive market situation provides a useful frame of reference for the outcomes in that one is enabled to determine the loss in aggregate surplus, as well as changes in its distribution entailed in any particular alternative structure, but it needs to be appreciated that neither the competitive market, nor any other particular market outcome is divinely ordained. It largely depends on the outcomes of the negotiations at COP.

I now provide some concepts which are essential to the analysis that follows:

3. Some Important Concepts

Fungibility

The question of "fungibility" among these three mechanisms refers to the inter-changeabiity of the emissions credits which count towards the fulfillment of Annex B GHG limits.[3] It needs to be recognized, however, that while the three mechanisms (ET, JI, and CDM) are legally distinct, and the transferable emissions credits in each (AAUs, ERUs, and CERs respectively) are separately accountable, since the credits may be used for fulfillment of the same commitment (Annex B QELRCs), and in fact have no particular value to the Parties outside of these commitments, the three types of credits are perfect substitutes. The question of "fungibility" thus has little relevance except to keep AAUs, ERUs, and CERs separate for accounting purposes. In the following discussion, accordingly, the fact of the substitutability of GHG abatements resulting from the three mechanisms will be explicitly assumed.[4]

GHG Abatement Markets

The Kyoto Protocol provides for voluntary transfers of AAUs, ERUs and CERs, being things of value, between Annex B and non-Annex I Parties, in lieu of mutually agreed things of value (i.e., the transfers may be effected for monetary or in-kind considerations). Any mechanism for voluntary exchange of things of value by agents entitled to these things of value is a market. The Protocol, accordingly, provides for the setting up of markets for -C in the form of AAUs, ERUs, and CERs.

Several of the questions of institutional design of the cooperative implementation mechanisms relate to the market structure for trades in emissions credits. Several possible market structures may emerge, depending upon how these questions are resolved, with different implications for costs and benefits to Annex B and non-Annex I Parties.

Marginal abatement cost

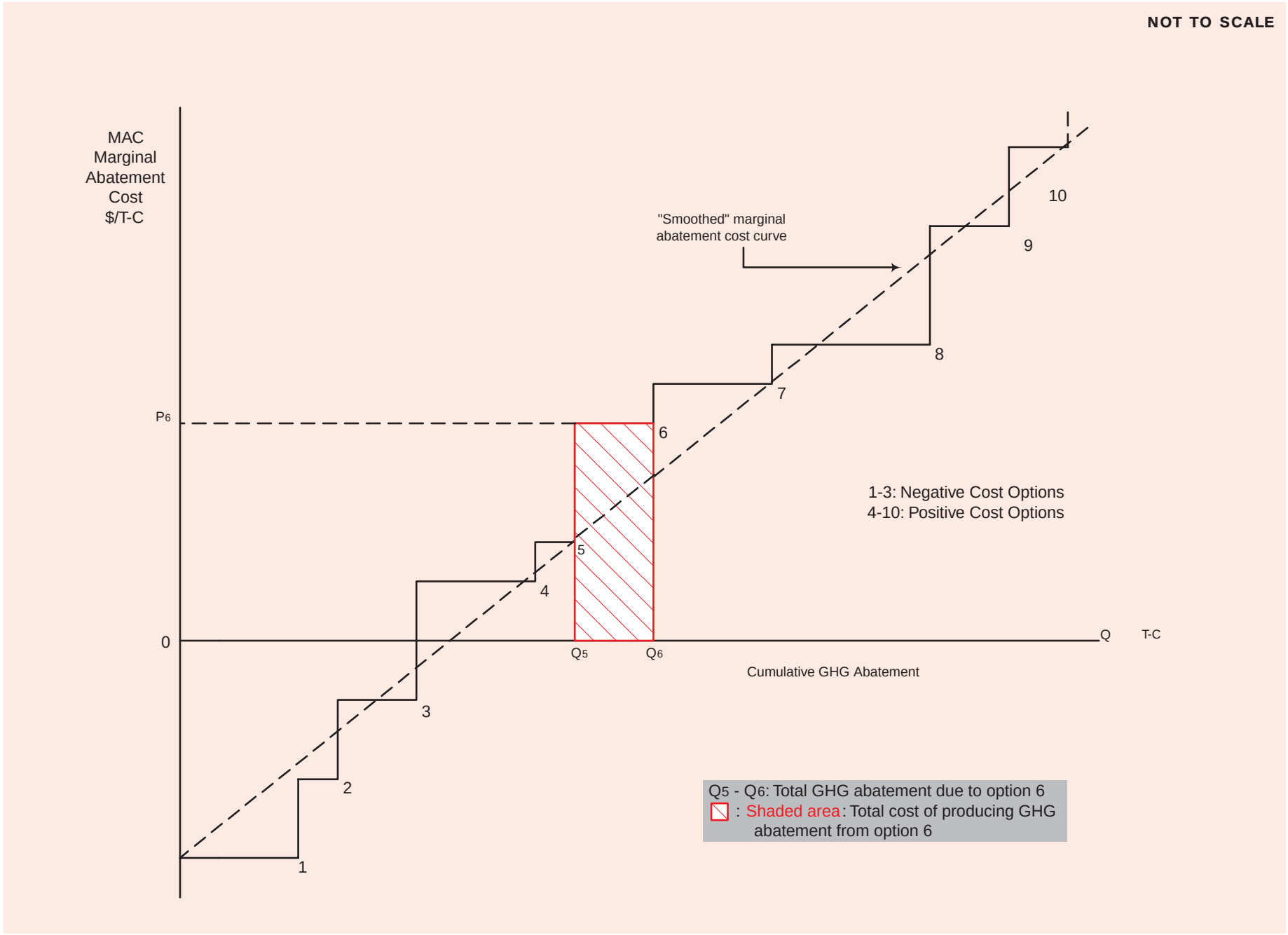
If a commodity (e.g., electricity) is initially (i.e., in the absence of any GHG reduction targets) supplied at least cost, by some technical option (e.g., coal-based generation) which emits GHG, then the replacement of this option to supply the same quantity of the commodity i.e., electricity by another option (e.g., natural gas-based power) which emits less GHG will involve a positive cost. (The "cost" in each case must be reckoned with as the initial capital costs and the operations and maintenance (O&M) costs discounted at an appropriate discount rate to the starting point in time of the option). The difference between the quantity of GHG emitted by the initial option (coal-based) and the quantity emitted by the abatement option (natural gas based), is the quantity of GHG abatement produced. The difference in the costs of the two options is the total abatement cost of the abatement option (and as marginal abatement cost may be expressed in terms of $ per ton carbon abated).[5]

It is also possible that the initial option (e.g., incandescent light bulbs) is not the least cost option for the commodity in question (lighting service) due to various systemic inefficiencies or constraints. In that case, it is possible that an abatement option (e.g., compact fluorescents) may provide an equivalent quantity of the service (lighting) at lower cost than the initial option, and this would result in GHG abatements at negative cost (i.e., the GHG abatement option may be profitable to undertake even without considering any possible exchange value of the GHG abatements realized).[6]

In a real world economy, there are usually several negative cost GHG options, as well as positive cost options. As the quantity of GHG abatements required to be generated by an economy increases (i.e., GHG emissions increasingly reduced), the negative cost options may be expected to be exhausted first, followed by other options in order of increasing marginal abatement cost.

This is shown in Figure 2. The horizontal axis is the cumulative GHG abatement required to be accomplished (in a given time period) in tons of carbon, and the vertical axis, represents the marginal abatement cost in US dollars per ton of carbon. The steps 1, 2, 3…etc. represents the GHG abatement and marginal abatement cost of abatement options 1, 2, 3…etc. respectively.

Figure 2: **A Country's Marginal GHG Abatement Cost Curve**



Consider the GHG abatement from Q5 to Q6. This is the quantity of GHG abatement attributable to option 6 (its GHG abatement potential), with a marginal abatement cost (MAC) of P6. It would be clear that the shaded area, represents the total GHG abatement cost (quantity times MAC) of abating GHG from Q5 to Q6.

In a real world economy, there may be hundreds of GHG abatement options, each with its GHG abatement potential and MAC. In that case, for exposition purposes, the country's marginal abatement cost curve may be drawn as a smooth line, as shown in Figure 2.

4. Supply and Demand Curves

Now consider Figure 3, which shows the (smoothed) GHG abatement cost curve (S" S S') of a country. The portion S' S represents negative cost GHG abatement, and the portion S S" represents positive cost GHG abatement. Suppose the total quantity of GHG abatement to be accomplished is Q*. A little algebra would show that the total cost of abating quantity Q* of GHG is the area S Q'* Q* (positive costs) minus area S S' O (negative costs).

It should be clear that the line O S S" is the GHG abatement supply curve of the economy, i.e., every point on this line represents the price (vertical axis) at which firms may supply the quantity (horizontal axis). Why is the portion S' S not part of the supply curve? The answer is that while firms may be able to produce any quantity of -C up to S at negative cost, there is no reason why they should voluntarily supply this -C at negative price (i.e. pay, to transfer) to someone who values it. At best, they may be willing to transfer OS quantity of -C at zero price (at no cost to the buyers, but realizing the benefit represented by the area S S' O).

For any quantity of GHG abatement required by the (Annex B) economy to meet its target (say Q*), the marginal abatement cost were the economy to accomplish this quantity of GHG abatement solely on its own, would be P*. The economy may be willing to purchase this quantity of GHG abatement from outside suppliers only if they were willing to accept a price (just) below P*. However, if the domestic suppliers of -C were free to sell their -C either domestically or in the international market, the suppliers of -C (who now comprise both domestic and outside suppliers) would perceive a single vertical line at Q* as the country's demand curve for GHG abatement.[7] In the rest of the discussion, it will be assumed that in respect of a country with a GHG abatement requirement (Annex B), the domestic suppliers of GHG abatements are free to transfer the emissions credits to domestic or international buyers (via JI).

The Kyoto Protocol imposes an inflexible demand for -C in the market in the aggregate

Why should any domestic entities wish to purchase GHG abatement credits, given that it is only the country as a whole which has a GHG emissions limit? The answer is that a country's GHG emissions result from the activities of a number of (economic) actors, i.e., firms and consumers. To meet its GHG emissions limits, the government will require these actors to individually reduce their GHG emissions, so that the permitted total for the country is not breached. It may do this in a number of ways,[8] but ultimately, economic actors would have to adopt various GHG abatement options (or reduce aggregate economic output or consumption), or alternatively, the domestic GHG regulatory regime may allow such GHG abatements to be accomplished by domestic or international purchase of GHG emissions credits. These entities may then be expected to undertake their own ("in-house") GHG abatement, or purchase -C, whichever is cheaper for them.[9]

5. Global Supply Curve for GHG Abatements

In Figure 4, countries 1, 2, 3,… (which may be Annex B or non-Annex I) have individual supply curves labeled S1" S1, S2" S2, S3" S3, …etc. At any given price of GHG abatements, say P*, the respective quantities of -C that may be supplied by each country may be read off from the country's supply curve, i.e. Q1, Q2, Q3, …etc. The total quantity that may be supplied by all countries together, at the price P*, is Q1 + Q2 + Q3 + … = Q*. The global supply curve for -C, i.e., $S_G S"_G$, is thus simply the horizontal summation of the individual country supply curves.

Alternatively, suppose that the individual supply curves refer not to countries, but different mechanisms for GHG emissions credits, i.e., ET=1, JI=2, CDM=3. That is, S1" S1 is the aggregate supply of -C from all ET sources, and similarly for JI and CDM. Once again, the global supply curve of -C is $S_G S"_G$ and is obtained by horizontal summation of the individual supply curves (of the mechanisms, in this case).

6. A Competitive Global Market for GHG Abatements

I first consider the likely outcomes of a competitive global market for -C, and later for other possible market structures.

Consider Figure 5. The global supply curve for -C is S S", aggregated over all participating countries and mechanisms, but the suppliers also produce GHG abatements at negative cost in the portion S' S. The aggregated global

Figure 3: **A Country's Supply Curve for GHG Abatements**

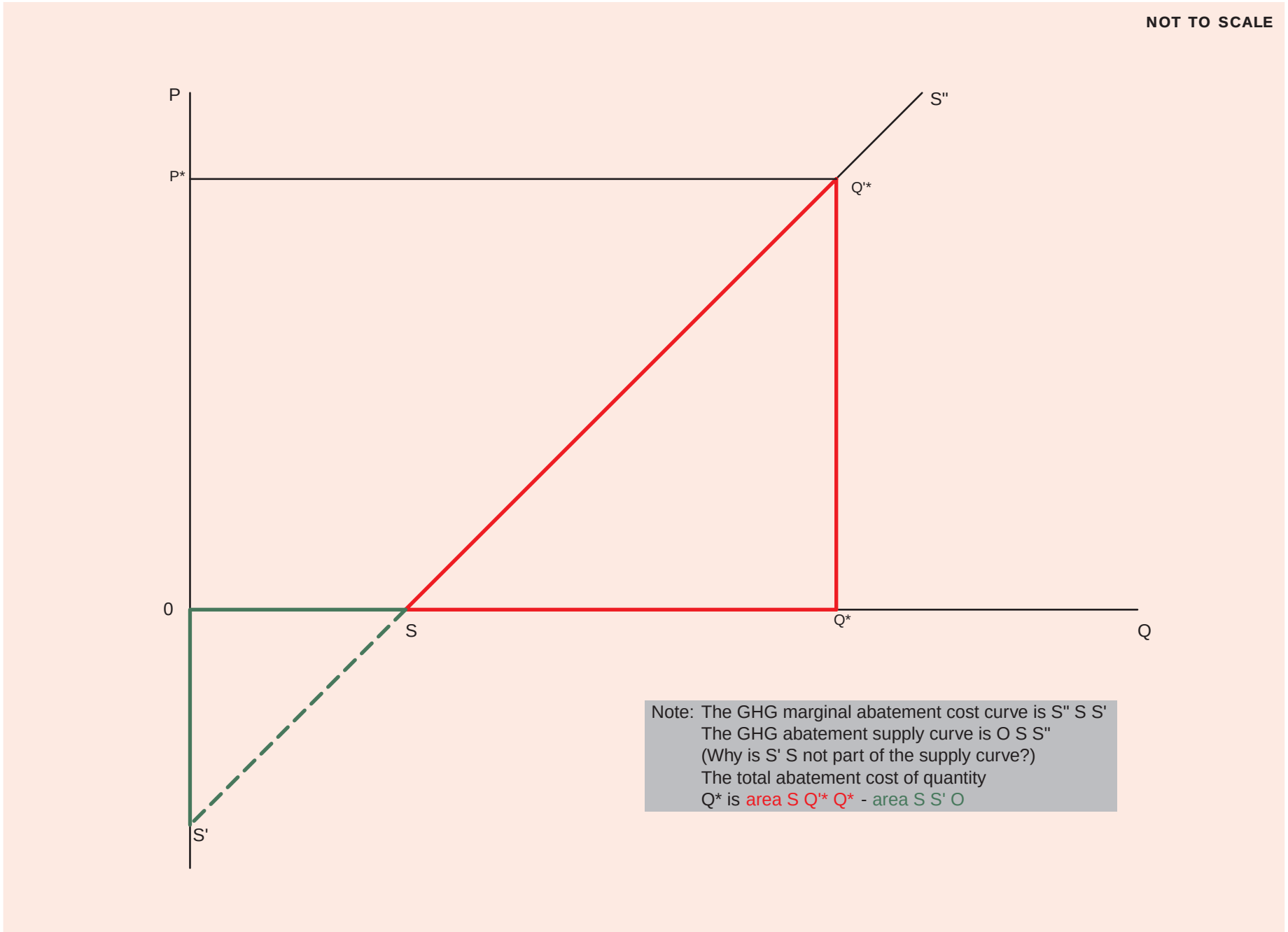


Figure 4: **The Global Supply Curve for GHG Abatement is the Horizontal Summation of the Individual Supply Curves (By Countries or By Mechanisms — ET, JI, CDM)**

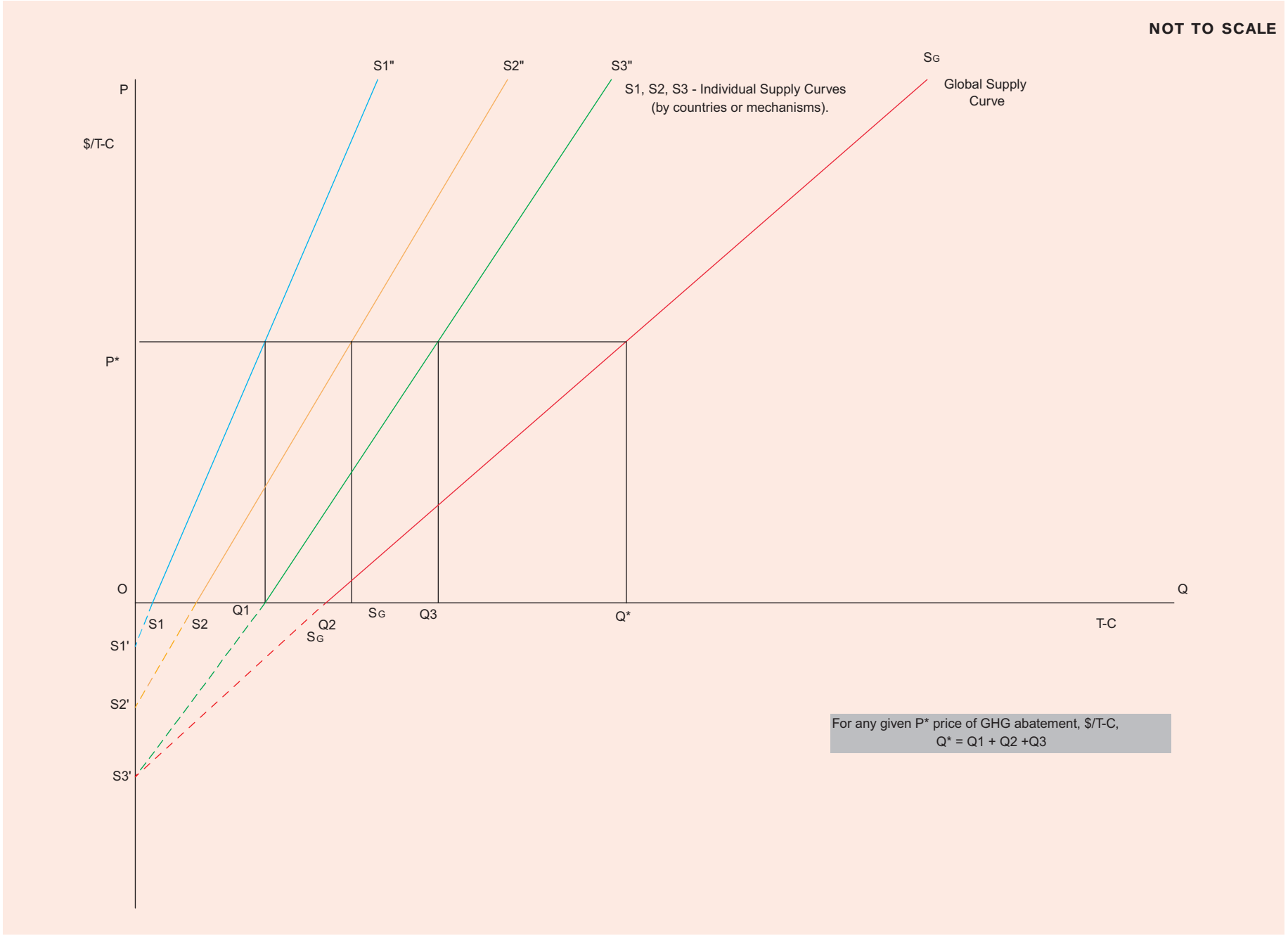
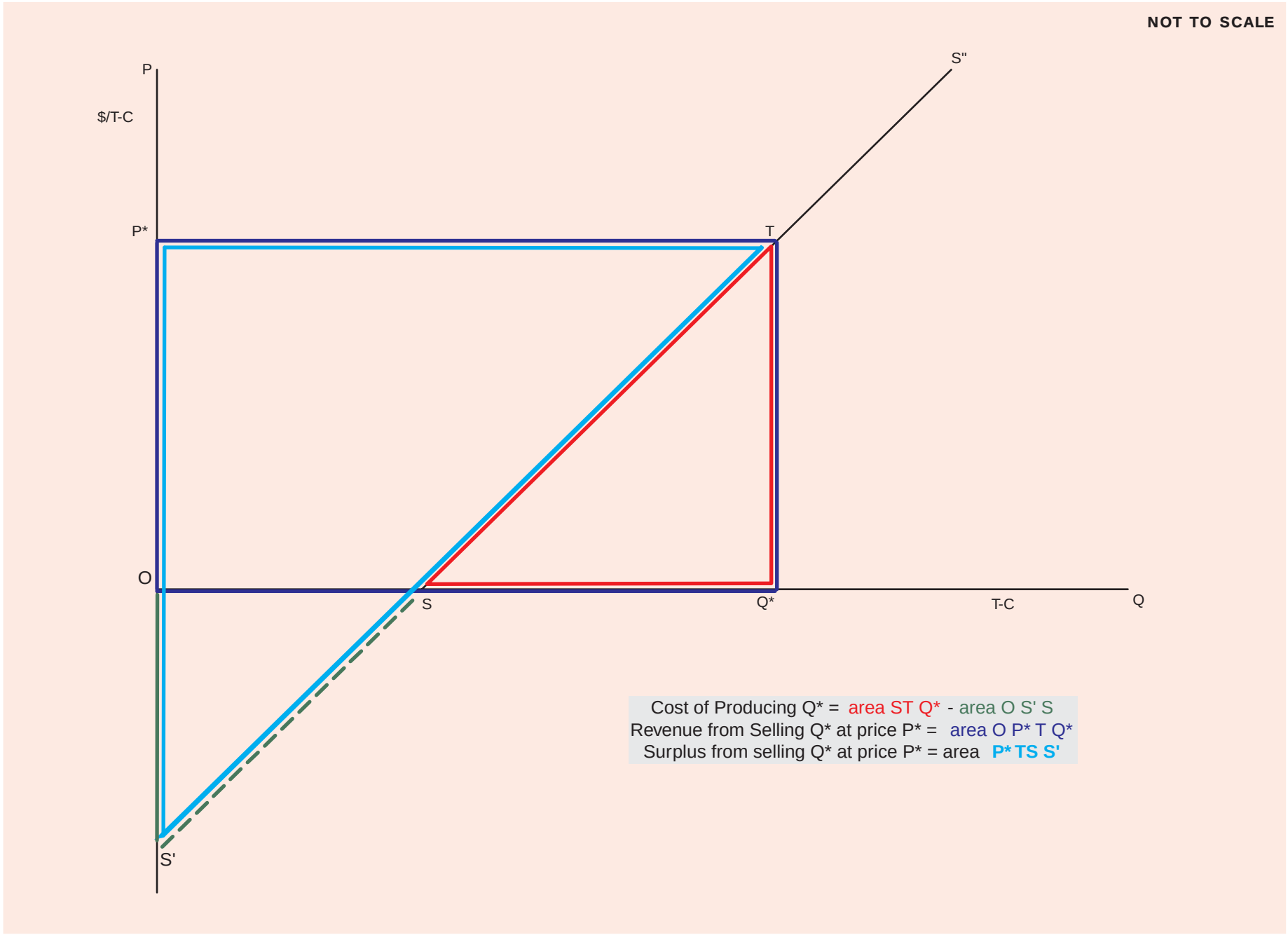


Figure 5: **Costs of Producing GHG Abatements and Surplus to Sellers of GHG Abatements in a Competitive Market**



In a competitive global market for -C, all sellers and buyers of -C gain in relation to the situation without a market

demand (i.e., GHG abatements required to meet Annex B limits) is Q*. In a competitive market, all Q* units may be transferred at a single price, P* per ton carbon.[10] The global cost of producing Q* units of -C is the area S T Q* - area O S' S, while the revenues received by the -C suppliers is the area O P* T Q*. The difference is the net revenue or surplus to suppliers of -C, i.e., [area O P* T Q* - (area S T Q* - area O S' S)], i.e., area P* TSS'.

This would establish that suppliers of -C (by whatever mechanism) may gain from producing and transferring -C in a competitive market. What is the incentive to potential buyers of -C i.e., Annex B countries or entities to participate in such a competitive market? Since the Annex B targets are mandatory, the alternative to participation in a -C market is for these entities to undertake GHG abatement on their own. In Figure 6, $S_B S"_B$ is the own supply curve for -C of Annex B entities (or, the ET + JI supply curves when these mechanisms become operational), while $S_A S"_A$ is the -C supply curve from CDM suppliers. The aggregated global supply curve is $S_G S"_G$, and the aggregate Annex B GHG abatement target is Q*. In the absence of a competitive market for -C transfers, the total cost of abating Q* units of -C would be: (area S_B Q'* Q* - area O S_B S'_B). However, if a competitive market for -C operates, with ET, JI, and CDM suppliers of -C, Q_{CDM} units of -C are supplied by the CDM suppliers, and Q_B units by the ET + JI suppliers. The surplus to the CDM -C suppliers is: (area O P* A S_A + area O S_A S'_A), and similarly, the surplus to ET + JI suppliers is: (area O P* B S_B + area O S_B S'_B). The benefit to the Annex B -C buyers, on the other hand, is the difference between the cost of own abatement and the cost of purchasing Q* units of -C from ET, JI, and CDM sources: [(area S_B Q'* Q* - area O S_B S'_B) – (area O P* B Q_B + area O P* A Q_{CDM})]. Under a plausible set of assumptions about the shapes and slopes of the -C supply curves (principally that $S_B S"_B$ is not less steep than $S_A S"_A$, signifying that each additional unit of -C costs at least as much to produce in Annex B countries as in non-Annex I countries, this will be positive, i.e., Annex B buyers will benefit, or at least not lose, from participating in a competitive -C market in relation to undertaking own abatement.

"Price fixing" for CDM by Annex B buyers of -C is possible, but under somewhat stringent conditions

What are the conditions for a competitive market in -C to happen? There are four (main) necessary conditions. One, that the quantities of -C generated and transferred must be clearly established. This would refer to Annex B countries making proper inventory for ET, and establishing "additionality" for JI and CDM, which is why the issue of determining project baselines is very important. For all mechanisms, proper accounting and registration of trades is also essential. Two, there should be a large number of individual buyers and sellers of -C. If demand for -C is dominated by a few large entities (firms or countries), or alternatively or additionally, -C supply is dominated by a few large entities (firms or countries), the large entities in each case may be able to set prices or manipulate quantities to their advantage. Three, entities should be aware of the prevailing price for -C in the market; this may happen through various means such as buyers and sellers inviting open bids for -C transfers, a secondary market for -C i.e., the transfers take place not directly between buyer and seller, but through specialized intermediaries (e.g., akin to a foreign exchange market), etc. However, this does not mean that the price of -C transfers must be reported to the body registering the trades. The participating entities may simply misrepresent the price, especially if a percentage of the monetary proceeds were to be realized for "administrative costs" or for a V&A fund. Finally, (in the case of JI and CDM) the buyers should not be able to directly perceive the GHG abatement cost of a particular project, as well as have management control over the project. Possible market structures when these conditions are not realized are discussed below.

7. "Price Fixing" of CDM by Annex B Buyers of GHG Abatements

An apprehension frequently expressed by policymakers and NGOs in non-Annex I countries, is the possibility of "price fixing" of the -C price supplied by means of the CDM (or alternatively, the JI) mechanism, to the detriment of non-Annex I (or Annex I JI) suppliers. What are the conditions under which this may happen?

Consider Figure 7, where $S_{EJ} S"_{EJ}$, $S_{CDM} S"_{CDM}$, are the supply curves of the ET and JI suppliers (together), and CDM suppliers, respectively, and $S_G S"_G$ is the global supply curve of -C. In a competitive market, the total quantity of -C required, Q*, would command a market price P*, and $Q*_{EJ}$, and $Q*_{CDM}$ would be the quantities supplied by the ET+JI, and CDM suppliers respectively. Suppose that the Annex B buyers collude to set the price of -C supplied by the CDM at $P^\wedge_{CDM}$, i.e., lower than the competitive market price, P*. In this case, the quantity supplied by CDM suppliers would fall to $Q^\wedge_{CDM}$, corresponding to price $P^\wedge_{CDM}$ on the CDM supply curve. The fall in quantity of -C supplied by the CDM suppliers would have to be made good by ET+JI suppliers, since the required GHG abatement is inflexible, and the quantity of -C supplied by ET+JI suppliers would accordingly increase to $Q^\wedge_{EJ,}$ i.e., by the exact

Figure 6: **A Competitive Market for GHG Abatements**

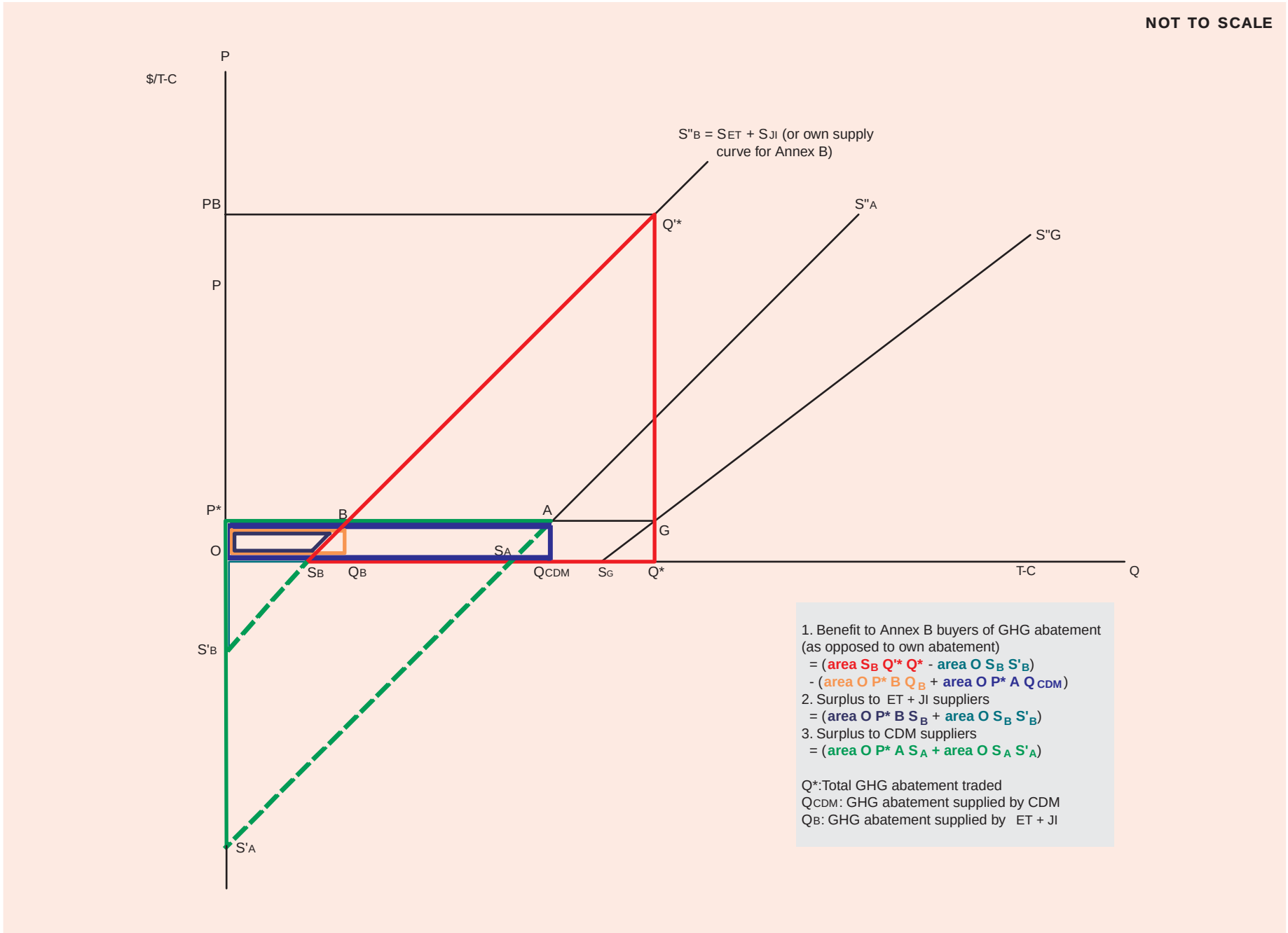
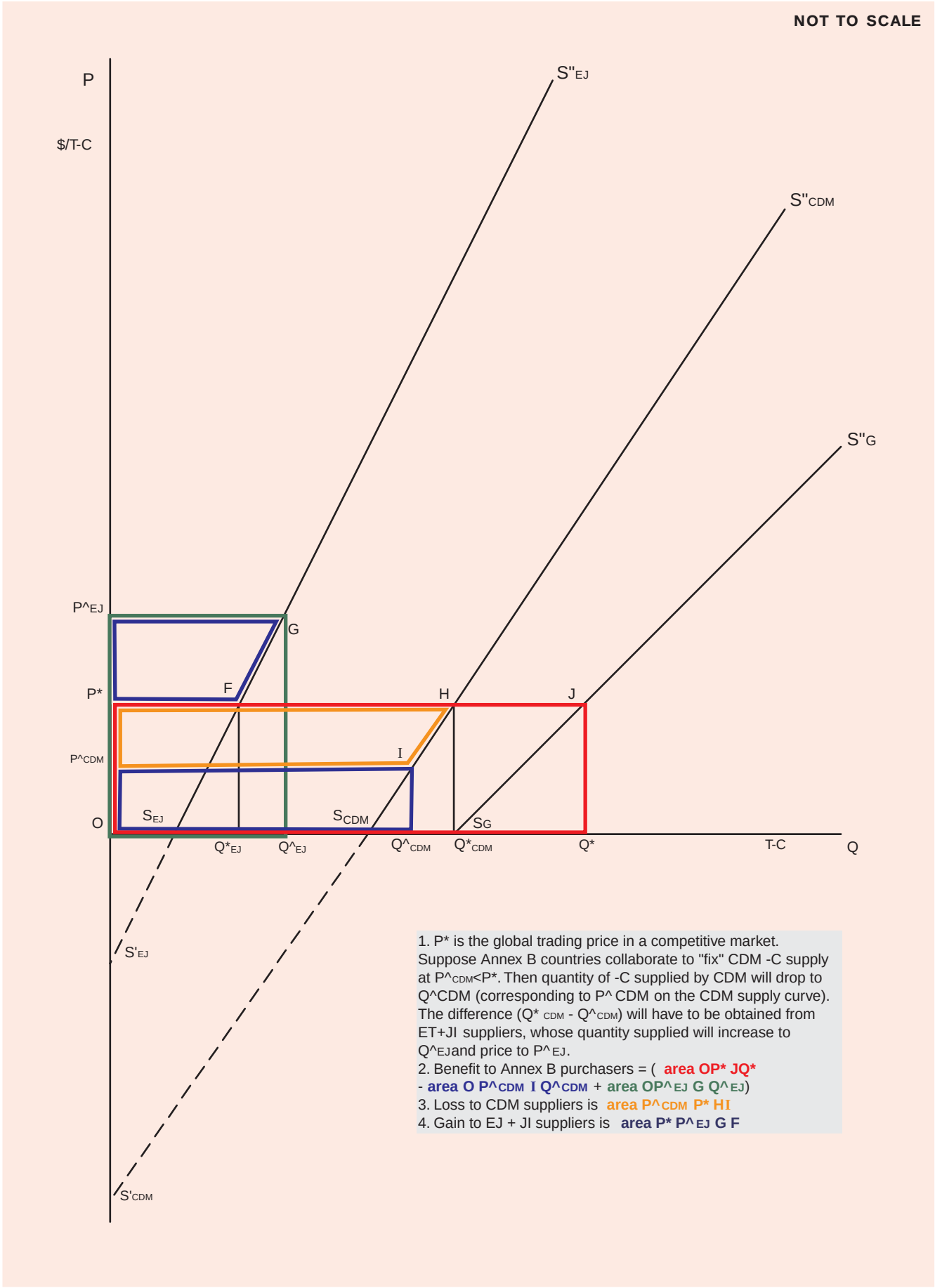


Figure 7: **“Price Fixing” of CDM by Annex B Buyers**



amount of decrease in supply by the CDM suppliers. This would raise the price of -C supplied by ET+JI suppliers to $P^{\wedge}_{EJ}$, corresponding to $Q^{\wedge}_{EJ}$ on the ET+JI supply curve.

What is the advantage to Annex B buyers of -C from such price fixing for CDM suppliers? In the competitive market situation, they would have paid the area O P* J Q* to purchase Q* units of -C from CDM and ET+JI suppliers together. In the "price fixing" situation, they would pay area O $P^{\wedge}_{EJ}$ G $Q^{\wedge}_{EJ}$ to the ET+JI suppliers, and area O $P^{\wedge}_{CDM}$ I $Q^{\wedge}_{CDM}$ to the CDM suppliers. However, the gain from such "price fixing" to these Annex B buyers of -C from the CDM is not categorically positive. Appendix I furnishes a simple analytical derivation of the conditions (specified in terms of parameter values of the MAC curves) under which the gain would be positive. It turns out that they are fairly restrictive. A less than rigorous interpretation of the conditions is that the scope for price-fixing would increase if CDM suppliers started out with much lower initial marginal abatement costs than ET + JI suppliers, and if the slopes of both MAC curves, but that of the MAC curve for CDM suppliers in particular, were not steep.

On the other hand, the suppliers of ET+JI (also located in Annex B countries) gain categorically from such "price fixing" of –C from CDM by Annex B buyers, equivalent to the area P*$P^{\wedge}_{EJ}$GF. Further, the CDM suppliers categorically lose in relation to the competitive market situation, the loss in surplus in their case being the area $P^{\wedge}_{CDM}$P*HI.

Suppose further, that the Annex B buyers of -C from CDM and sellers of -C from ET+JI agree among themselves to share the gains and losses (if any) of the surplus from "price fixing" of CDM. Would the net gain in surplus be positive, and thus provide an incentive for such collusion? Appendix 1 shows that indeed the net gain in surplus would be categorically positive. Such collusion may become institutionally more feasible if the Annex B governments were enabled to intervene in the -C market on behalf of Annex B buyers and sellers of -C, and moreover, had at their disposal, domestic policy instruments enabling sharing of the net gains in surplus. Collusion, either just by Annex B buyers of CDM, or these entities together with EJ + JI supplies, becomes less likely if many such players operate in the market.[11]

It may also be noted that such "price fixing" of the CDM suppliers of -C is the same as "buyers side cartelization" of the CDM market, the only exception being that in the latter case the Annex B buyers of -C (or buyers together with ET+JI suppliers) would reduce the quantity of -C purchased from the CDM rather than the price. However, the effect on -C price from the CDM, and changes in surplus to all agents would be the same as in the case of "price fixing".

8. Market Segregation of CDM/JI Suppliers by Annex B Buyers

There is however, at least one other possible way, in which Annex B buyers may be able to reduce or eliminate altogether the surplus to CDM (and/or JI) suppliers. That is, if Annex B buyers have full information about the actual GHG abatement cost of each CDM/JI project, and moreover, have sufficient control over the project proponents to negotiate a separate -C price for each project independently of the -C price from other projects or the global market generally.

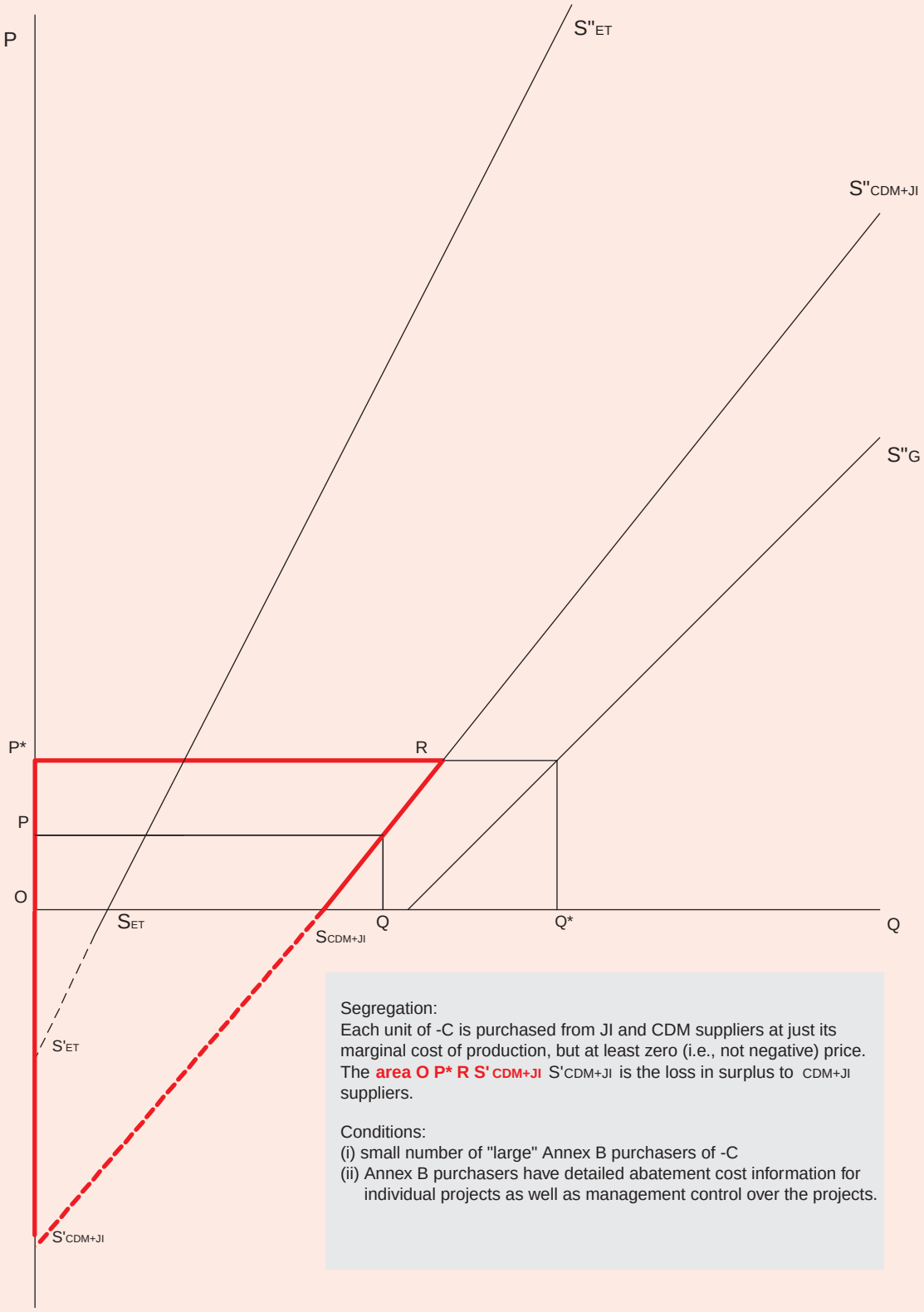
Market segregation of CDM/JI suppliers of -C may, in the extreme case, lead to complete loss of surplus to such suppliers. However, remedies exist to minimize prospects of market segregation

Figure 8 shows the (extreme case) situation under such market segregation. In the figure, S_{ET} S"$_{ET}$, S_{CDM+JI} S"$_{CDM+JI}$, and S_{G} S"$_{G}$ are the ET, CDM+JI, and the global -C supply curves respectively. Once again in a competitive market, the total quantity of -C transferred would be Q* at uniform price for all buyers and suppliers P*. Consider a small quantity of -C produced by a single project (CDM/JI) with a marginal GHG abatement cost of P, which is below P*. If a Annex B buyer has both complete information about the marginal abatement cost (P), as well as sufficient control over the project firm, it could negotiate (or impose) (up to the lowest limit of) a price P for the -C produced by that firm. The CDM/JI supplier in this case would have no surplus from producing -C (but would not encounter an actual loss). If all CDM/JI firms were thus vulnerable, in the extreme case, no CDM/JI supplier would have any surplus from producing -C. The area O P* R S'$_{CDM+JI}$ is the loss to CDM+JI suppliers of -C in relation to the competitive market situation, in this extreme case.

Such market segregation may be feasible in situations when the Annex B buyer has or acquires controlling shares in the CDM/JI project, enabling management control, which may also suffice to gain complete knowledge of the underlying GHG abatement cost of the project. Possible safeguards against such market segregation include [(i) the host country disallowing local firms controlled by Annex B firms from supplying -C; (ii) local CDM/JI suppliers inviting competitive bids for -C (or auctioning them); and (iii) third party entities undertaking buying and selling of -C in a global market. Of course, there may be other means of transferring surplus from suppliers of -C to buyers, for example, through monopoly pricing of proprietary technology that may be employed in the project. However, in general, if the number of individual buyers of -C are large,

Figure 8: **Segregation of CDM/JI Market by Annex B Buyers**

NOT TO SCALE



Segregation:
Each unit of -C is purchased from JI and CDM suppliers at just its marginal cost of production, but at least zero (i.e., not negative) price. The **area O P* R S' CDM+JI** S'CDM+JI is the loss in surplus to CDM+JI suppliers.

Conditions:
(i) small number of "large" Annex B purchasers of -C
(ii) Annex B purchasers have detailed abatement cost information for individual projects as well as management control over the projects.

and no set of individual buyers control a large share of -C demand, and project level suppliers of -C are not controlled by individual buyers, the likelihood of such transfers from -C suppliers to buyers, will diminish. Clearly, prospects of market segregation will increase if CDM/JI are viewed strictly as vehicles for Foreign Direct Investment (FDI) and not open to local entities.

9. Supply Side Cartelization of the GHG Abatement Market

Paralleling the fears of non-Annex I countries that the GHG abatement market may be manipulated by Annex B buyers of -C to the latter's advantage, Annex B countries may be apprehensive that some -C suppliers could form a cartel to their own advantage. What, if any, are the circumstances that this might happen?

Figure 9 illustrates the possibility. $S_1 S"_1$ is the supply curve of -C suppliers (ET, JI, CDM together) who are not included in the cartel, while $S_2 S"_2$ is the supply curve of -C suppliers who have agreed among themselves to form a suppliers' cartel. The global supply curve, obtained as before, by horizontal summation of these two supply curves is $S_G S"_G$. In the situation of a (non-cartelized) competitive market, the total quantity of -C required, Q* is supplied at a uniform price P*, with $Q*_C$ being supplied by (potential) cartel members, and Q*n supplied by (potential) non-cartel members. The cartel would have to operate by assigning quotas of -C supply to each of its members. The alternative of directly fixing the price of -C would likely be unworkable because the actual price contracted by each member with its buyers would be difficult to observe, and each member of the cartel would have an incentive to undercut the others and increase its surplus to the detriment of the rest of the cartel.[12]

Suppose the assigned quotas to the cartel members aggregate to Q^c, i.e., it is smaller than the competitive market supply by the cartel members, Q*c.[13] The difference, Q*c – Q^c would have to be made good by increase in the supply by the non-cartel members, and will involve a rise in price of -C. Note, however, that since the cartel does not directly control the price at which its members (or others) sell -C, the market price of -C would be the same for everybody. The resulting (equilibrium) market price would be P^ where the non-cartel members are exactly able to make good the shortfall in the supply of -C by the cartel members.[14]

Would such cartelization benefit the members and/or the non-cartel members? The gain in surplus to the cartel members in relation to the competitive market situation is the difference between their surplus in the cartelized market and in the competitive market, i.e., area P^ Q'^c Q^*c P*c – area P* Q'*c Q^*c P*c. Under most conditions of slopes of cartel and non-cartel countries' supply curves for -C, this would be positive. However, the non-cartel members would gain too, due to the enhanced price of -C as well as the quantity supplied by them in the cartelized market, i.e., area P^ Q'^n Q'*n P*. Annex B buyers categorically lose in relation to the competitive market situation, since they have to buy a total quantity Q* of -C at price P^, i.e., their loss is Q* times (P* - P^).

Supply side cartelization of the -C market is possible, but under fairly stringent conditions

What are the necessary conditions for such cartelization to take place? First, a small number of potential members may be more easily able to reach agreement on sharing the supply cuts in -C required, than a large number of potential members. Second, these potential members should together account for a large share of the global -C supply, as otherwise cartelization would make little or no difference.[15]

Third, it should be feasible for the cartel to effectively monitor the adherence to the -C supply shares agreed by its members. Essentially, this would require that all transfers of emissions credits in fulfillment of Annex B commitments be compulsorily registered, and the information made available in the public domain.

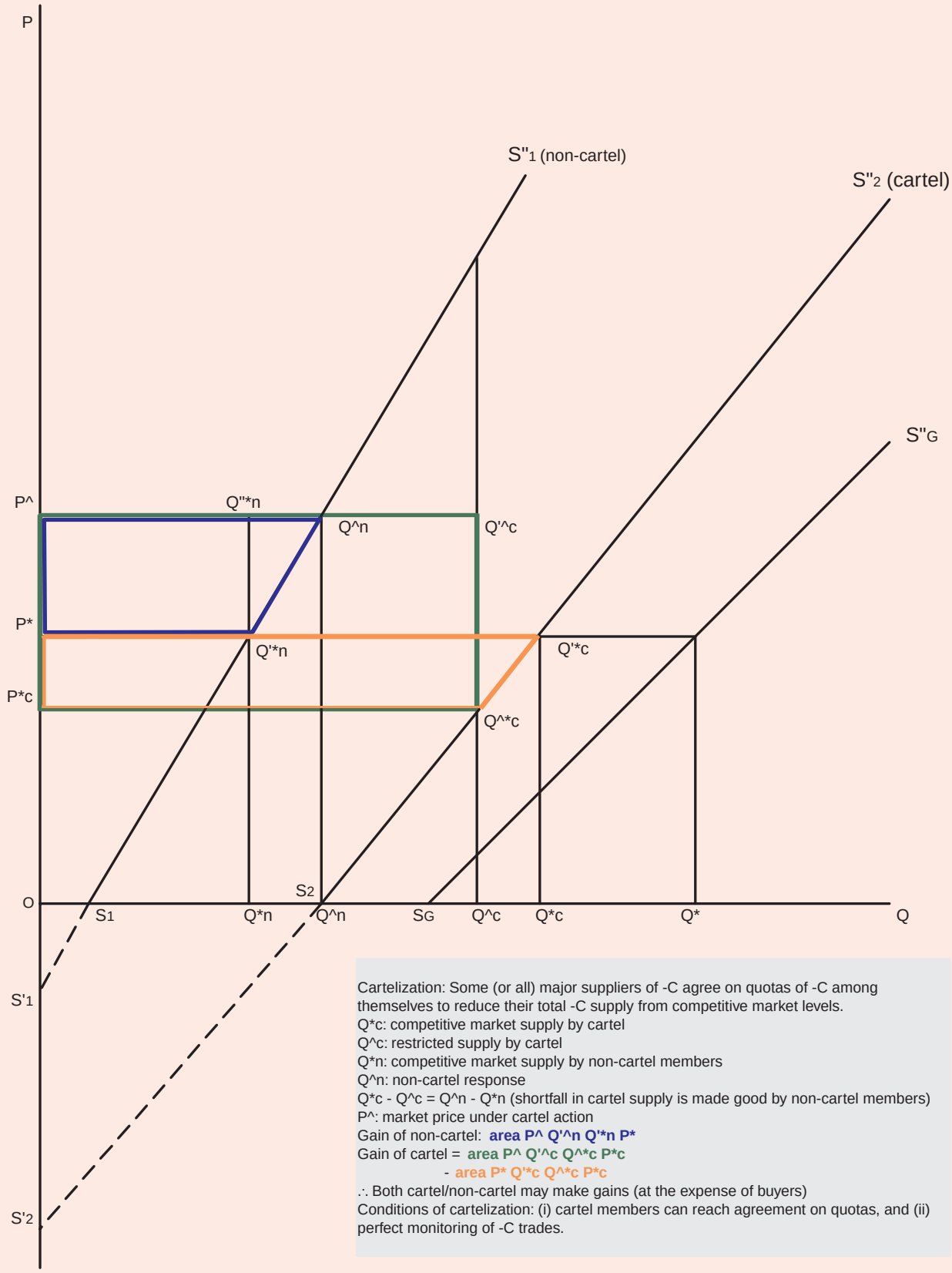
10. Effect of "Taxing" CDM, but not ET, JI

The Protocol requires that part of the proceeds of CERs transferred under the CDM be collected for adaptation activities, and also that administrative costs of the mechanism may be similarly recovered.[16] Such provisions, which may be considered to impose a "tax" on the projects under the CDM, are absent in the Protocol in respect of ET and JI. What is the effect of such "tax" on the CDM, but not on ET or JI?

Figure 10 illustrates the situation. The supply curve of the ET+JI suppliers of -C is $S_{EJ} S"$, and that of the CDM suppliers of -C is $S_{CDM} S"_{CDM}$ without such tax. If a uniform "tax" (whether administrative costs or levy for adaptation) on each unit of -C transferred is imposed on CDM projects, the supply curve for the CDM suppliers of -C shifts upward by the amount of the tax (since the tax would raise the marginal cost of producing each unit of -C). The new supply curve (with "tax") is shown as $S^T_{CDM} S"^T_{CDM.}$

If otherwise a competitive market in -C operates, the shift in the supply curve for the CDM mechanism will bring about a new equilibrium in which the quantity of -C sup-

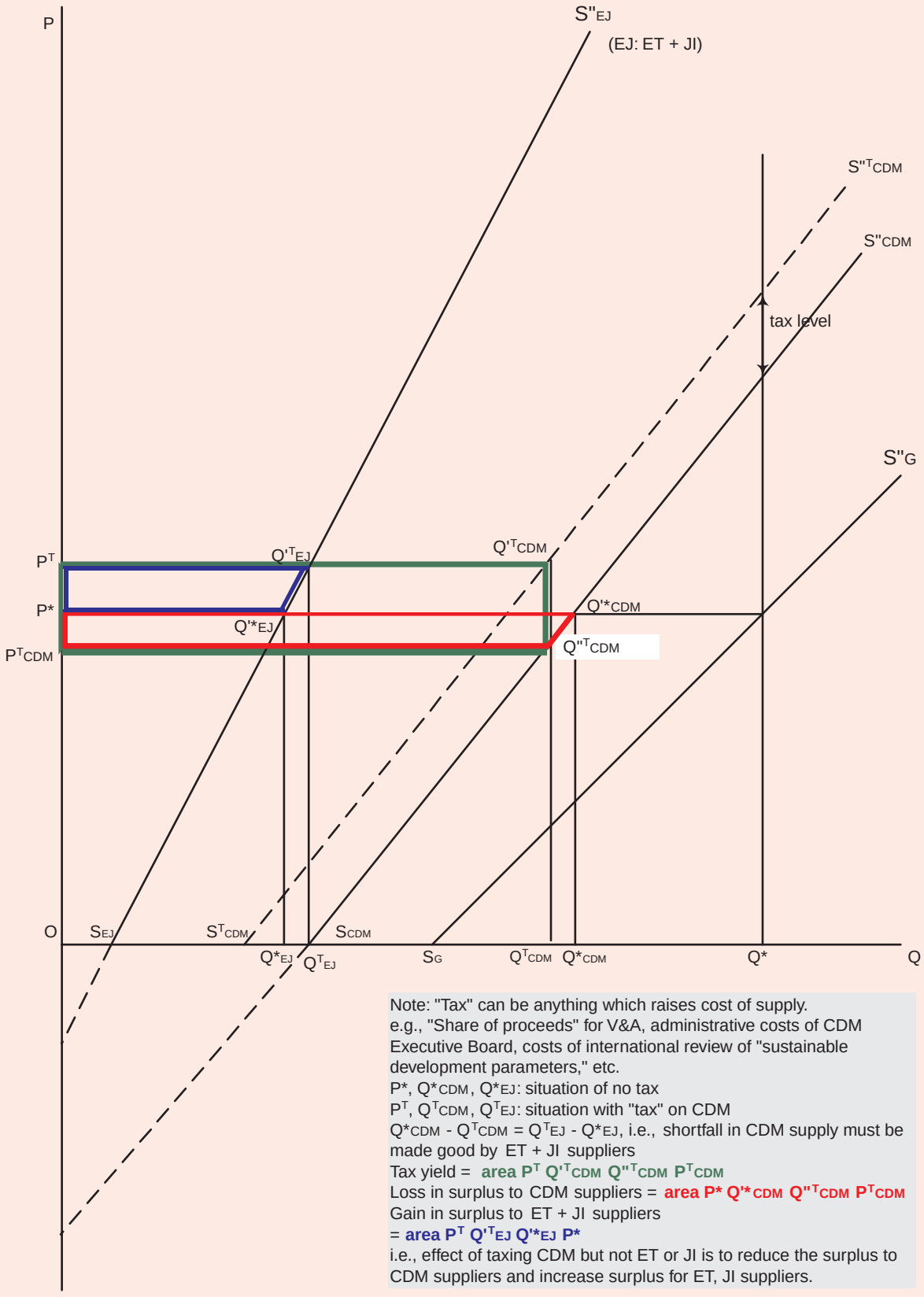
Figure 9: **Supply Side Cartelization of the -C Market**



Cartelization: Some (or all) major suppliers of -C agree on quotas of -C among themselves to reduce their total -C supply from competitive market levels.
Q*c: competitive market supply by cartel
Q^c: restricted supply by cartel
Q*n: competitive market supply by non-cartel members
Q^n: non-cartel response
Q*c - Q^c = Q^n - Q*n (shortfall in cartel supply is made good by non-cartel members)
P^: market price under cartel action
Gain of non-cartel: **area P^ Q'^n Q'*n P***
Gain of cartel = **area P^ Q'^c Q^*c P*c**
- **area P* Q'*c Q^*c P*c**
∴ Both cartel/non-cartel may make gains (at the expense of buyers)
Conditions of cartelization: (i) cartel members can reach agreement on quotas, and (ii) perfect monitoring of -C trades.

Figure 10: **Effect of "Taxing" CDM but not ET, JI in a Competitive -C Market**

NOT TO SCALE



Note: "Tax" can be anything which raises cost of supply.
e.g., "Share of proceeds" for V&A, administrative costs of CDM Executive Board, costs of international review of "sustainable development parameters," etc.
P^*, Q^*_{CDM}, Q^*_{EJ}: situation of no tax
P^T, Q^T_{CDM}, Q^T_{EJ}: situation with "tax" on CDM
$Q^*_{CDM} - Q^T_{CDM} = Q^T_{EJ} - Q^*_{EJ}$, i.e., shortfall in CDM supply must be made good by ET + JI suppliers
Tax yield = **area P^T Q'^T_{CDM} Q''^T_{CDM} P^T_{CDM}**
Loss in surplus to CDM suppliers = **area P^* Q'^*_{CDM} Q''^T_{CDM} P^T_{CDM}**
Gain in surplus to ET + JI suppliers
= **area P^T Q'^T_{EJ} Q'^*_{EJ} P^***
i.e., effect of taxing CDM but not ET or JI is to reduce the surplus to CDM suppliers and increase surplus for ET, JI suppliers.

"Taxing CDM but not ET or JI will lead to loss in surplus by CDM suppliers of -C, and gain in surplus by ET, JI suppliers

plied by CDM suppliers falls from to $Q'^*_{CDM}Q^T_{CDM}$ and this fall is made good (since total GHG abatements are unchanged), by an exactly equal increase in the quantity of -C supplied by ET and JI suppliers, from Q'^*_{EJ} to Q^T_{EJ}. The market price of -C will rise (for all three mechanisms) to P^T, which includes the "tax", but the actual price received by the CDM suppliers will fall to P^T_{CDM}. The surplus to CDM suppliers of -C (in relation to the "without tax" situation) will be reduced by the area $P^* Q'^*_{CDM} Q"^T_{CDM} P^T_{CDM}$.[17] On the other hand, since the quantity of -C supplied by ET+JI suppliers will increase, as will the price received by them (since they face the same market price, but do not face the "tax"), their surplus will increase by the area $P^T Q'^T_{EJ} Q'^*_{EJ} P^*$. The revenue yield of the "tax" is given by the area $P_T Q^T_{CDM} Q"^T_{CDM} P^T_{CDM}$.

11. The "Supplementarity" Issue

The Kyoto Protocol affirms that the cooperative implementation mechanisms, ET, JI, CDM, are intended to supplement the domestic efforts of Annex B countries in meeting their GHG abatement targets. In all cases, whether a competitive market for -C comes about, or a market with buyer's or seller's market power (price fixing, segregation, cartelization), some quantity of -C would always be supplied by its own abatement. Among the proposals before the COP, however, is imposing minimum requirements on each Annex B Party for domestic GHG abatement, before it may obtain emissions credits from ET, JI, CDM ("supplementarity"). What might be the effects of imposing such requirements?

Imposing quantitative supplementarity requirements on Annex B Parties will lead to loss in surplus by all CIM suppliers of -C

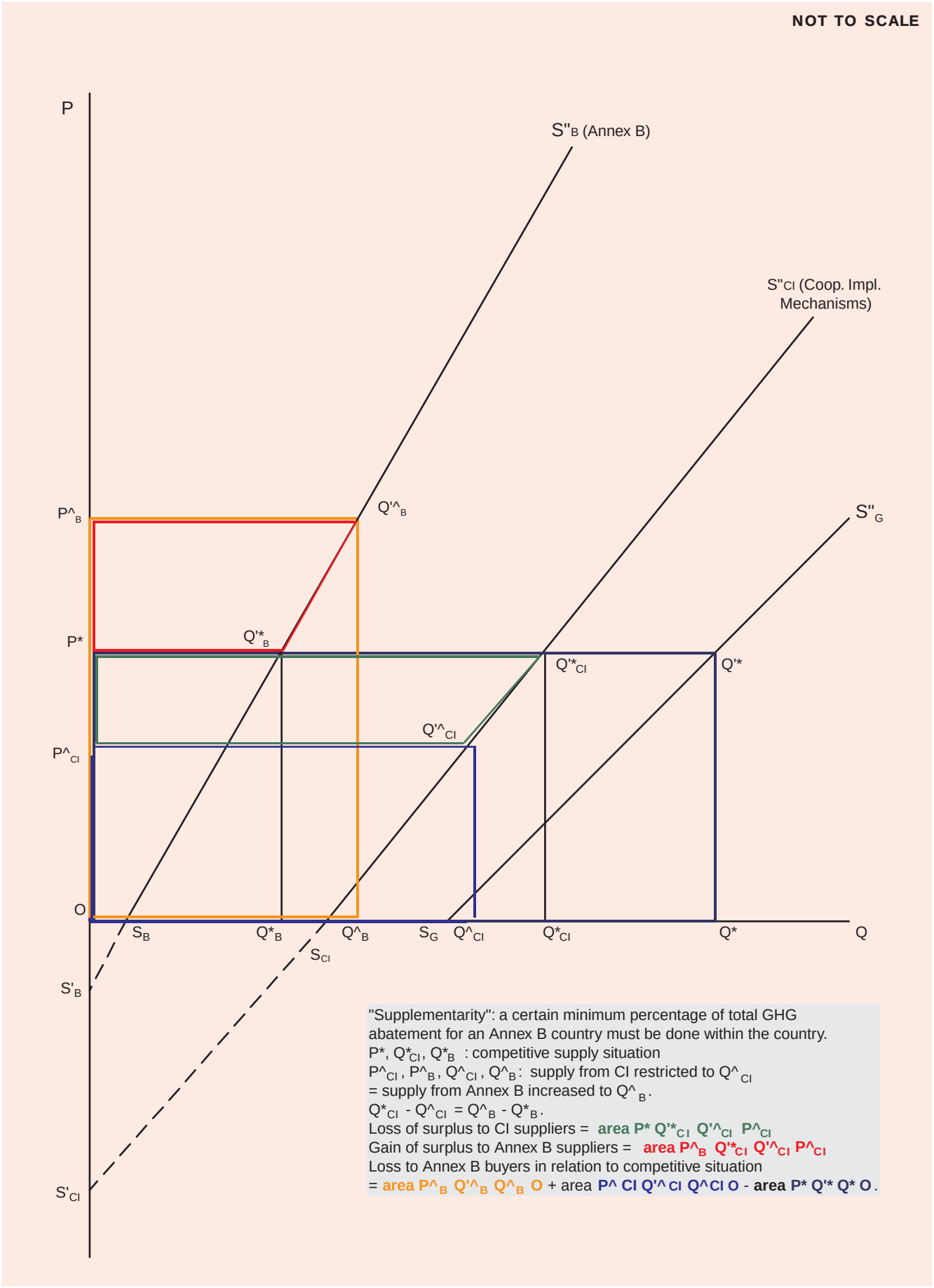
In Figure 11, $S_B S"_B$, and $S_{CI} S"_{CI}$ are the -C supply curves from Annex B own abatement (who do not participate in international ET, JI) and other -C suppliers from ET, JI, CDM, respectively. The global supply curve of -C is $S_G S"_G$.

In the competitive market situation (without minimum domestic GHG abatement requirements), the total quantity of -C required by Annex B Parties is met at market price P* by Q^*_B units from own suppliers, and Q^*_{CI} units from cooperative implementation mechanism suppliers (ET, JI, CDM). Suppose that the supply from own abatement is enhanced to $Q^\wedge_B$ (above the level in the competitive market situation). In that case, as required by "supplementarity", the quantity of -C acquired from ET+JI+CDM would decrease by the difference between the enhanced quantity from own abatement and the competitive market level of -C from own abatement, to $Q^\wedge_{CI}$. However, the "price" of own abatement would diverge from that in the -C market, and would increase to $P^\wedge_B$. The overall result would be a loss in surplus to the ET, JI, CDM suppliers equal to the difference in surplus in the competitive market situation and the situation with "supplementarity", i.e., area $P^* Q'^*_{CI} Q'^\wedge_{CI} P^\wedge_{CI}$. Conversely, the gain in surplus to Annex B own abatement -C suppliers is also the difference in surplus received by them in the two situations (competitive market and with imposed "supplementarity"), i.e., area $P^\wedge_B Q'^\wedge_B Q'^*_B P^*$. Moreover, the Annex B buyers would experience a loss in relation to the competitive market situation, being the difference in cost of acquiring Q* units of -C in the two situations, i.e. area $P^\wedge_B Q'^\wedge_B Q^\wedge_B O$ + area $P^\wedge_{CI} Q'^\wedge_{CI} Q^\wedge_{CI} O$ – area $P^* Q'^* Q^* O$. If one assumes that the Annex B own abatement supply curve for -C is steeper than for the ET, JI, CDM taken together, the gain in surplus to the Annex B own abatement suppliers will be less than the loss to Annex B buyers of -C. Insistence on a minimum level of own abatement by Annex B Parties may thus be to the detriment of all cooperative implementation mechanism suppliers of -C, as well as in the net, Annex B Parties themselves. A practical difficulty is that the level of own abatement is essentially unobservable, whether in a competitive market, or a market with supplementarity requirements. This will make if difficult to stipulate a meaningful quantitative restriction on access to CIMs. A moral argument for imposing such minimum own abatement requirements would then have to be that the Annex B GHG abatement requirements are a dessert for past profligacy in GHG emissions, rather than a commitment reflecting the principle of "common but differentiated responsibility".[18] A practical, long-term implication is that this would focus research efforts on technologies which are relevant to Annex B, rather than non-Annex I, requirements.

12. "Hot Air"

The term "hot air" is a colloquialism which refers to the fact that largely on account of economic downturn during the transition to a market economy, several Annex I countries in FSU/East Europe may be expected to emit lower quantities of GHG than inscribed in Annex B in their case, without taking special measures or policies to reduce GHG emissions. The extent of such "hot air", conceptually, the level of their Annex B emissions limits and the GHG emissions that would now be expected to take place without any specific abatement measures, which respond to the Protocol, cannot be directly observed. It may be estimated by economic modeling, but these are not definitive, because both modeling assumptions and parameter

Figure 11: **The "Supplementarity" Issue**



The availability of "hot air" leads to a categorical gain in surplus to Annex B buyers of -C, and loss in surplus to -C suppliers who do not have "hot air." However, the "hot air" countries do not categorically gain or lose

values are uncertain. The availability of "hot air" would inevitably increase the potential supply of emissions credits (under ET) from these countries. What would be the effect of the availability of such "hot air"?

In Figure 12, Sc S"c is the supply curve of -C from these countries (together) if there was no "hot air", and S_H S"$_H$ the corresponding supply curve with "hot air" (shifted to the right by the extent of "hot air". The supply curve of all other suppliers (including from the ET, JI, and CDM mechanisms) is S_O S"$_O$ and the global supply curve (without "hot air") is labeled S_G S"$_G$. If a competitive market for -C were to prevail *without* "hot air", the quantity of -C required, Q*, commands a price P*. The quantities of -C supplied by the potential "hot air" countries in this case is Q*c, and that supplied by others is Q*$_O$.

In the event of "hot air" being available in the competitive market for -C, the outward shift of the supply curve from "hot air" countries would lead to a drop in the global price of -C from P* to P_H, besides increase in the quantity of -C transferred from "hot air" countries from Q*c to Q^$_H$, and decrease in the -C supplied by others by an exactly equal amount, from Q*$_O$ to Q^$_O$. The difference in surplus to the "hot air" countries is the difference between the area P* Q'*c Sc O and the area P_H Q'^$_H$ S_H O, and *is not categorically positive or negative*. On the other hand, other suppliers experience *a categorical loss in surplus*, given by the area P_H P* Q'*$_O$ Q'^$_O$. Annex B buyers of -C, also experience a categorical gain, because they now purchase the same quantity of -C (i.e., Q*), but at a lower price, P_H i.e., their gain is Q* times (P_H - P*).

Non-Annex I countries can resolve their dilemma over when to utilize their "low hanging fruit" by rational economic criteria. However, the CDM regime needs to be sufficiently flexible for them to act upon such criteria

13. "Low Hanging Fruit"

This expression is another colloquialism referring to the apparent dilemma of non-Annex I countries on whether they should utilize their low (or negative) MAC GHG abatement options to supply -C in the near term (say, first commitment period), or "save them up" for the future when they may have their own binding GHG abatement commitments.

Figure 13 illustrates one approach to resolving this dilemma. Consider two periods, O (near term), and T (future). There are no GHG abatement commitments for the given country in period O, but it expects to have a GHG emissions limit of Q_T in period T. The country's -C supply curve in period O is S_O S"$_O$ if it does not sell off its expected future GHG abatement commitment of Q_T in period O. Similarly, if it has in fact sold off Q_T units of -C in period O, its supply curve for -C in period T is S_T S"$_T$. Suppose that the actual global market price for -C in period O is P_O, and the expected market price in period T is P_T. (These prices may have no particular relationship to the marginal abatement cost of the expected commitment Q_T in period T, except that P_O should at least equal the MAC for Q_T units if the country is to sell Q_T units of -C in period O). In that case, the surplus to the country from selling Q_T units of -C in period O is the area P_O B Q"$_T$ = Benefit O. On the other hand, having sold off Q_T in period O and faced with a GHG abatement commitment of Q_T in period T, the country would incur a cost in period T equaling the area S_T C D O (own abatement) + area C A' Q_T D (market purchase). In order to compare monetary values accruing in different time periods, it is necessary to discount (inflate) them to the initial (later) period. Accordingly, if the country wishes to base its decision on the criterion that its benefit from an action should exceed its cost of not doing so, then the country should "save up" Q_T units if the discounted value of cost of future abatement exceeds the near term benefit of selling Q_T units.

A specific answer, therefore, to whether a country should sell its -C from the "low hanging fruit" options in the near term, or save these for the future, depends on (i) the actual MACs of these GHG abatement options; (ii) the global price of -C in the near term; (iii) the expected -C price in the global market in the future; (iv) whether or not it expects to have GHG abatement commitments in the time-frame in question; and (v) the discount rate chosen (e.g., the interest rate on risk-free investments available to its economic agents).

One needs to also consider that some apparent low MAC GHG abatement options may simply become technologically obsolete with passage of time for reasons unrelated to GHG abatement[19]. In any event, if the cooperative implementation mechanism rules provide for non-Annex I Parties to hold ("own" and "bank") -C even if they have no GHG abatement commitments, this would enable them to meet any future expected GHG abatement commitments from their "low hanging fruit" options which are available now, or sell them at a time of their choosing, rather than immediately.

Figure 12: **Case of "Hot Air"**

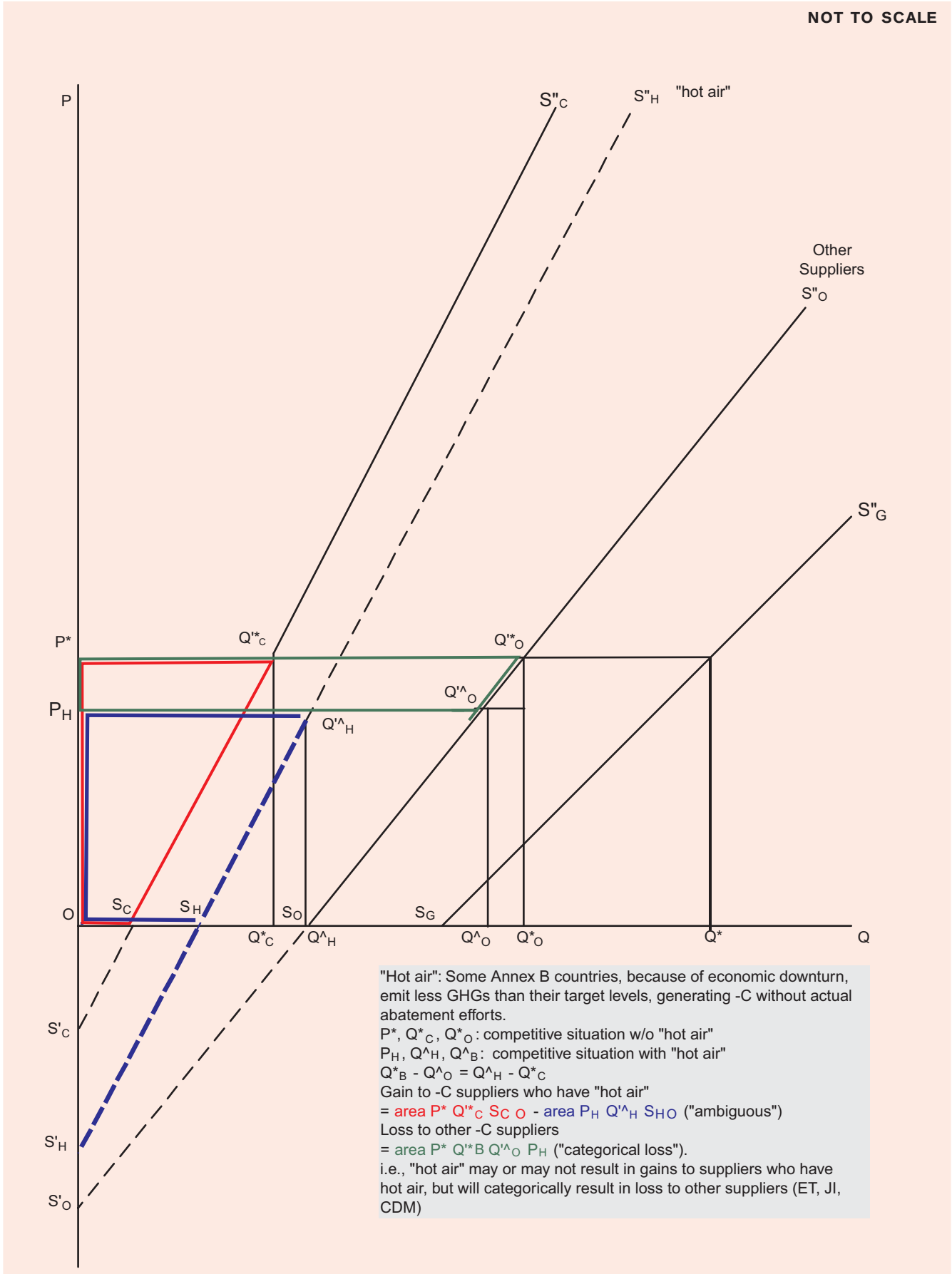


Figure 13: **Should a Non-Annex I Country "Save Up" Its GHG Abatements to a Future Period When It May Have Its Own Abatement Commitments?**

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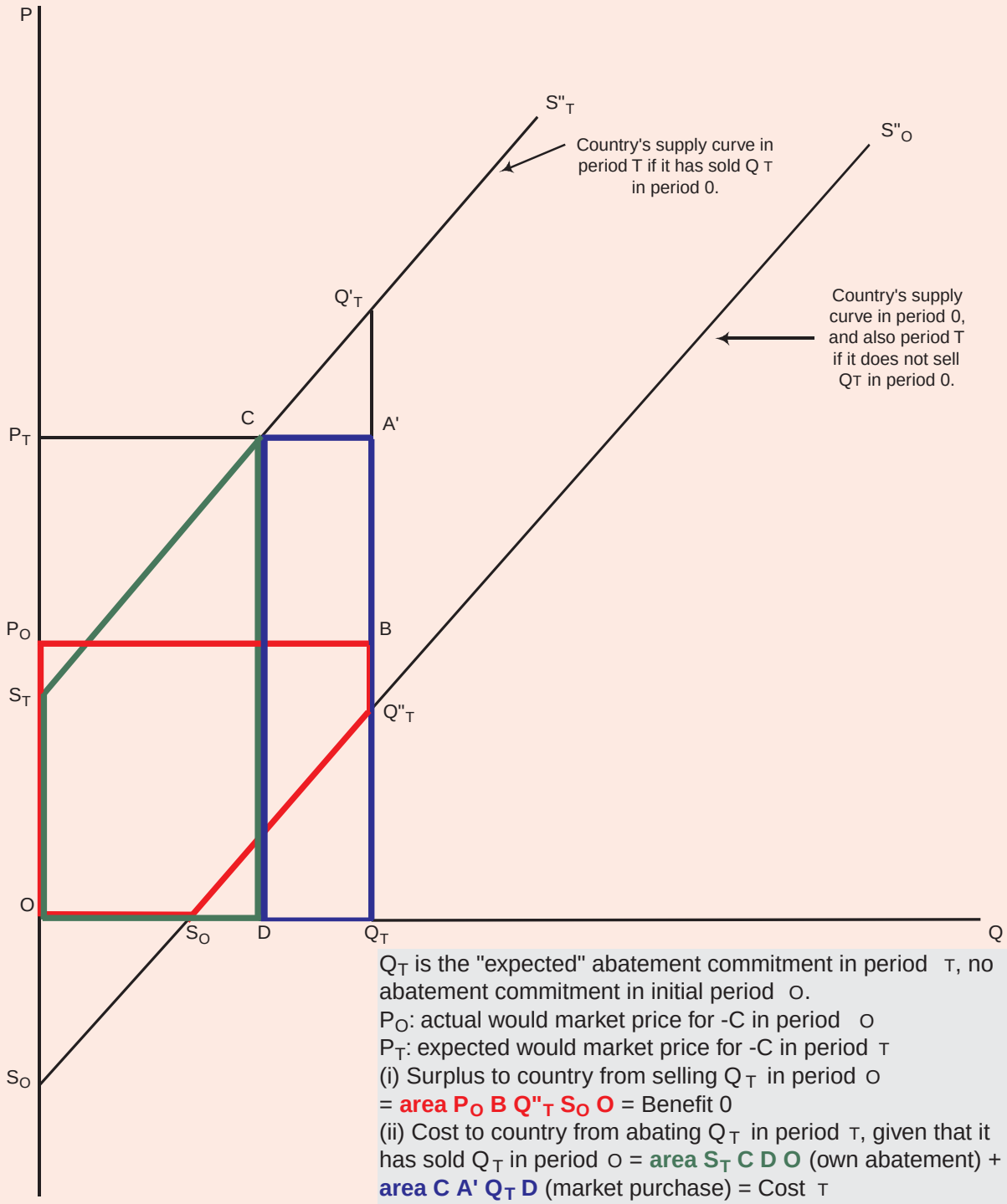

Q_T is the "expected" abatement commitment in period T, no abatement commitment in initial period O.
P_O: actual would market price for -C in period O
P_T: expected would market price for -C in period T
(i) Surplus to country from selling Q_T in period O
= **area P_O B $Q"_T$ S_O O** = Benefit 0
(ii) Cost to country from abating Q_T in period T, given that it has sold Q_T in period O = **area S_T C D O** (own abatement) + **area C A' Q_T D** (market purchase) = Cost T
Then: "save up" if Cost T < Benefit 0 $(1+r)^T$, r = discount rate
=> if P_T is expected to be much higher in the future, then do not save up!

Notes

1 For an example of formal justification of particular allocation norms (equal per-capita allocations), see Ghosh (1993).

2 Editor's note: for a detailed discussion of issues involved in determination of baselines for CDM and JI projects see the paper by Deshun and Rogers in this volume.

3 i.e., Quantitative Emissions Limitation and Reduction Commitments (QELRCs).

4 In the rest of this paper, AAUs, ERUs, and CERs will be treated identically as "GHG abatements," or "-C" (short for negative carbon).

5 This simple explanation ignores complications due to possible different lifetimes of the two options, as well as the fact that the quantities of GHG emitted by the options may vary over their lifetimes.

6 The GHG abatements in this example are actually realized by reduced electricity consumption in switching to the abatement option, if the generation of electricity results in GHG emissions.

7 When an entire economy is required to abate GHG, there may be numerous second-order effects, including structural change in the economy, changes in trade patterns, exchange rates, consumption patterns, government revenues and spending, price levels, wages, interests and land rents, etc. Such changes may be tracked by computable general equilibrium (CGE) models. See, for example, Ghosh (1990). A discussion of such general equilibrium effects is outside the scope of this paper.

8 For example, by imposing a domestic GHG emissions tax, or permits (tradeable or otherwise) for GHG emissions, etc.

9 If the domestic regulatory regime only permits "own" abatement by each GHG emitter, there may be little scope to take up low cost GHG abatement options by the economic actors, and the aggregate cost of the required level of GHG abatement will increase. Reverting to Figure 2, such a regime may mean that options 7, 8, 9, may be taken up (costlier), and not options 1, 2, 3 (cheaper).

10 In a competitive market there are numerous buyers and sellers, each is individually too small to influence the price, and all have correct information about the prevailing price.

11 For example, the international oil market, which arguably shares many features of the potential -C market, has displayed little coordinated action by buyers, unlike the sellers side.

12 As an example of a similar cartel for another commodity, the OPEC operates by assigning oil production quotas to its members.

13 There would be no point in increasing the aggregate quantity to be supplied by the cartel members in relation to the competitive situation since the requirement of –C by Annex B buyers is fixed, and the cartel would be unable to effect reduction in supply by non-cartel members by this means.

14 What would be the total supply cut agreed by the cartel? In principle, the cartel would determine the supply cut at the level which would maximize its gains in the aggregate, and share the supply cut among its members in some manner by negotiation. This level could be worked out analytically (mathematically) or graphically, and one solution (due to Neha Khanna) is given in Appendix 2. For the cartel to actually carry out such an exercise, however, it would require detailed information on marginal abatement costs for all countries, which is extremely unlikely in practice.

15 On the other hand, if all (or most) non-Annex I Parties, together with some large potential suppliers of -C from Annex B, were able to agree on a satisfactory allocation of -C quotas, this may solve the problem of equitable sharing of CDM projects.

16 Other proposals, for example, that of verifying that CDM projects actually contribute to sustainable development being entrusted to an international body, may also have the effect of raising administrative costs of the CDM mechanism.

17 Editor's note: It is assumed that the proceeds of the tax are not recylced to the CDM suppliers.

18 For example, in criminal convictions, the costs of penalty (incarceration) are borne by society generally through taxation, and not only by the offender (loss of freedom and earnings). On the other hand, where responsibility is mutual, e.g., payment for a police service through differentiated levels of taxation, it is impermissible to tax anyone for more than the legally stipulated amount, directly or indirectly.

19 For example, Integrated Gasifier Combined Cycle (IGCC) power generation technology may count as a GHG abatement option when the baseline technology is Conventional Pulverized Coal technology, but not if the latter becomes obsolete for economic reasons unrelated to GHG abatement in the future.

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Appendix 1

Analytical Derivation of Conditions Under Which "Price-Fixing" of CDM is Feasible

Consider Figure 7

We assume that in the range of interest, the marginal abatements costs are all linear, and are thus expressed as:

For ET + JI suppliers: $P_{EJ} = p_{EJ} + m_{EJ} . Q$ (1)

For CDM suppliers: $P_{CDM} = p_{CDM} + m_{CDM} Q_{CDM}$ (2)

Where the P_S refer to marginal abatement cost in each case, Q_S refer to quantities supplied by each group of suppliers, and the ps and ms are parameters with the usual interpretations.

We then have:

Loss in surplus to CDM suppliers from "price fixing" of CDM

$= ½ (P^* - P\hat{}_{CDM}) (Q^*_{CDM} + Q\hat{}_{CDM}) > 0$ categorically (3)

Similarly, gain in surplus to ET + JI suppliers from "price fixing" of CDM

$= ½ (P\hat{}_{EJ} - P^*) (Q^*_{EJ} + Q\hat{}_{EJ}) > 0$ categorically (4)

Further, gain in surplus to Annex B buyers of CDM due to "price-fixing" of CDM

$= P^* Q^* - P\hat{}_{CDM} Q\hat{}_{CDM} + P\hat{}_{EJ} . Q\hat{}_{EJ}$ (5)

Now let $\Delta Q = Q^*_{CDM} - Q\hat{}_{CDM} = Q\hat{}_{EJ} - Q^*_{EJ} > 0$ (6)

This relationship follows from the requirement that the total abatement commitment Q* is fixed.

Expression (5) may be written as:

$\Delta Q [m_{CDM} Q\hat{}_{CDM} - m_{EJ} Q\hat{}_{EJ}]$ (7)

Using expressions (1) and (2), expression (7) may be written as:

$\Delta Q [(p_{EJ} - p_{CDM}) - m_{CDM} (m_{CDM} + m_{EJ}) (P^* - P_{CDM})]$ (8)

Since $\Delta Q > 0$, for the gain in surplus to the Annex B buyers of CDM from "price fixing" of CDM to be categorically positive, we have the condition:

$(P^* - P_{CDM}) < [(p_{EJ} - p_{CDM}) / m_{CDM} (m_{CDM} + m_{EJ})]$ (9)

Expression (9) thus allows the possibility of such "price-fixing" by Annex B buyers of CDM acting collusively, but limits the scope for such "price-fixing", depending on parameter values of the MAC curves. The scope for price-fixing will increase if $(p_{EJ} - p_{CDM})$ increases, or if values of m_{EJ}, and in particular m_{CDM} are small.

Consider further the possibility of Annex B buyers of CDM and Annex B suppliers of ET + JI acting collusively for "price-fixing" of CDM to ensure positive gains for the two groups as a whole.

The sum of gains to buyers of CDM suppliers of CDM (i.e., Annex B Parties)

$= [P^* Q^* - P\hat{}_{CDM} . Q\hat{}_{CDM} + P\hat{}_{EJ} . Q\hat{}_{EJ}] + ½ (P\hat{}_{EJ} - P^*) (Q^*_{EJ} + Q\hat{}_{EJ})$ (10)

Using $Q^* = Q^*_{CDM} + Q^*_{EJ}$, expression (10) expands to:

$= P^* Q^*_{CDM} + ½ P^* Q^*_{EJ} - P\hat{}_{CDM} . Q\hat{}_{CDM} + 3/2 P\hat{}_{EJ} . Q\hat{}_{EJ} + ½ P\hat{}_{EJ} Q^*_{EJ} - P^* Q\hat{}_{EJ}$ (11)

Noting that $P^* Q^*_{CDM} > P\hat{}_{CDM} . Q\hat{}_{CDM}$

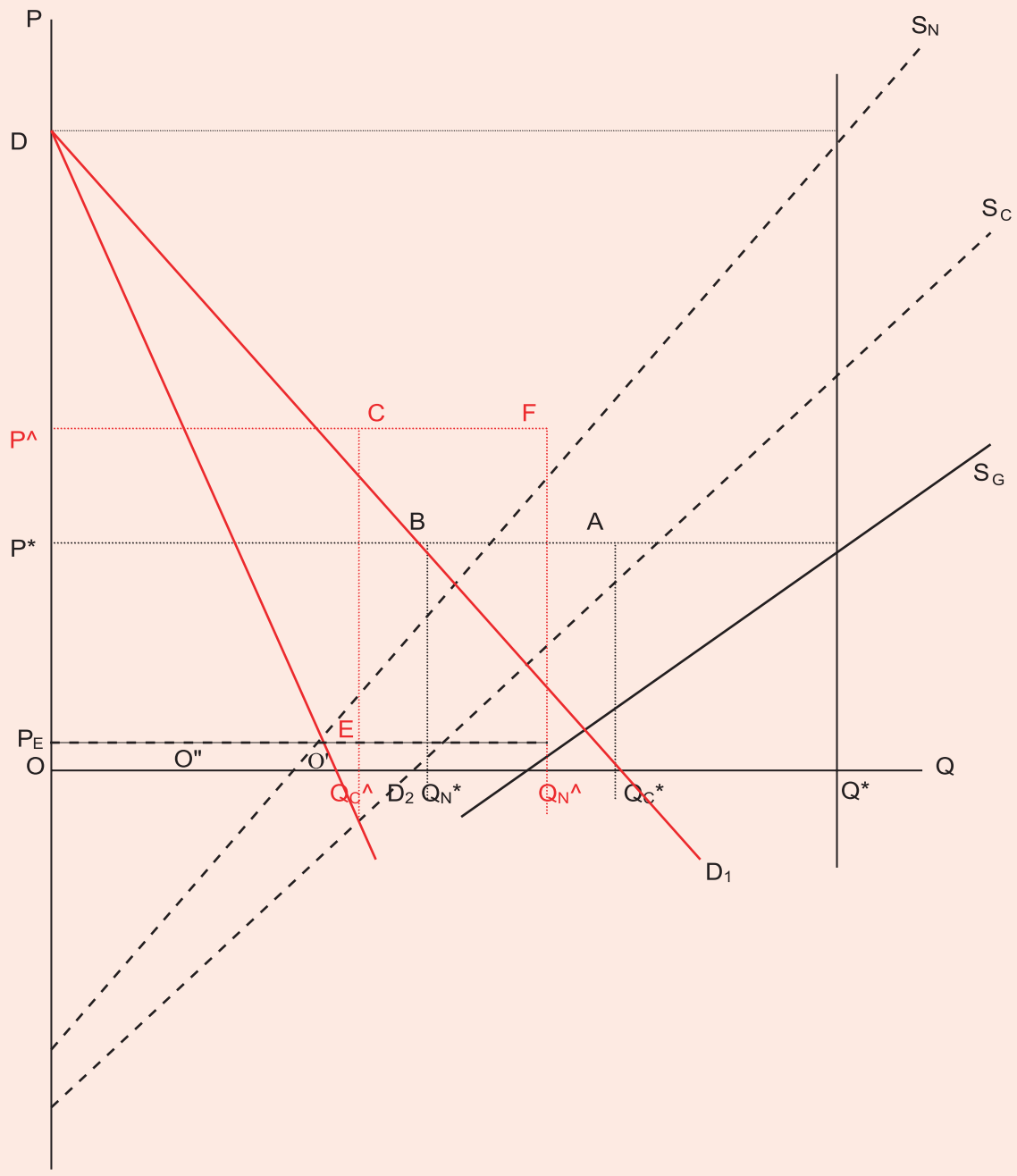
and

$3/2 P\hat{}_{EJ} . Q\hat{}_{EJ} > P^* Q\hat{}_{EJ}$

It is clear that expression (11) is categorically positive.

We thus conclude that if Annex B buyers of CDM and suppliers of EJ + JI could agree to share the benefits and costs of "price-fixing" of CDM, it would be in their advantage to do so.

Figure A1: **Surplus Maximization By A Supplier's Cartel for -C**



Appendix 2

Surplus maximization by a suppliers' cartel[1]

The following details one possible market structure which might facilitate surplus maximization for a sellers' cartel for -C and the resulting economic implications for various parties.

We assume that the low cost suppliers of -C (e.g., the non-Annex 1 countries) form a cartel which acts as a unified economic entity that wishes to exercise monopoly power in the -C market. By this is meant that the cartel members wish to maximize the surplus for the cartel as a whole , which may then be distributed to the individual members by a side-agreement. This cartel cannot control the -C supplied by non-cartel members. So it attempts to set a price and then supplies the demand for -C not met by the non-cartel firms, which are assumed to be operating under a perfectly competitive structure (Kahn, 1997).

In Figure A1, S_N refers to the supply curve of the countries not in the cartel where as S_C is the supply curve of the cartel members. The global supply curve, S_G, is obtained by the horizontal summation of these two supply curves. Q* represents the demand for negative carbon, which is price inelastic given the legally binding commitments under the Protocol. Under a perfectly competitive equilibrium, the price of -C would be P*, with the cartel supplying Q_C* and the non-cartel firms the remaining Q_N*.

Consider that the cartel takes the supply of -C by the non-cartel members. The demand curve facing the cartel is the downward sloping curve DD_1, which is obtained as the residual demand not met by the non-cartel firms suppliers acting competitively at each price. The demand curve for the cartel DD_1 is derived as the horizontal distance between S_N and Q* at each price. The corresponding marginal revenue curve for the cartel is DD_2.[2]

Given the marginal revenue and marginal cost curve of the cartel, it supplies Q_C^ in order to maximize its monopoly surplus. The corresponding price is P^. At this price, the non-cartel fringe supplies Q_n^ = Q* - Q_c^ by construction). In Figure A1, the price P^ may be derived from the relationship: $(P^ - P_E)/P^ = 1/e_N$, where P_E is the price at which Q_C^ units of –C would be supplied by the cartel members if they operate in a competitive market, and e_N is the elasticity of the supply curve of the non-cartel members.[3]

The economic implications of such a cartelization are the follows:

- The total cost of reducing carbon by Q* by Annex B buyers increases since the same amount of -C is being purchased, but at a higher price. The increase in total cost is (P^ - P*)Q*.
- The surplus to both cartel and non-cartel suppliers of -C increases. The increase in the surplus to the countries in the cartel is represented by (area OP^CEO') - (area OP*AO'); the increase in the surplus to the non-cartel, competitive fringe countries is (area OP^FO") - (area OP*BO") = area P*P^FB. A priori it is uncertain which group of suppliers of -C has more to gain from the cartelization.

The outcomes of this model should be treated with some caution. It has been pointed out earlier that a price fixing cartel would not be viable as it would be difficult to monitor the exact price agreements between the cartel members and Annex B buyers.

This would provide an incentive for each cartel member to undercut the others and increase its surplus. This incentive would be reinforced if the increase in surplus accruing to the non-cartel countries is greater than that accruing to the cartel members. In this case, the monopoly power of the remaining cartel would be further diminished. As the size of the non-cartel members increases, represented by a rightward shift in the MC curve of the non-cartel, the size of the market available to the cartel shrinks, reducing its monopoly power.

As a final cautionary point, note that as the cartel attempts to set a higher price in an attempt to earn higher surplus, the non-cartel members are able to meet a larger part of the total demand for -C. Thus, the market share of the cartel decreases.

1 This Appendix is contributed by Neha Khanna.
2 The derivation of the marginal revenue curve is standard for a monopoly.
3 The elasticity of the non-cartel supply curve is the percentage increase in quantity of –C that would be supplied by the non-cartel members for a one percent change decrease in price under competitive conditions.