Unconditional and conditional NDCs under the Paris Agreement: Interpretations and their relations to policy instruments

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Abstract in Norwegian:

Ubetingede og betingede utslippsmål under Paris-avtalen: Tolkninger, og forhold til klimapolitikken

Jon Strand

I dette arbeidet diskuteres sammenhenger mellom “ubetingede” og “betingede” nasjonale bidrag (NDCs) fra lavinntektsland (L land) til Paris-avtalen (PA) om begrensning av klimautslipp fram mot 2030. Ubetingede målsetninger antas å utgjøre landenes egne frivillige bidrag til avtalen. De betingede målsetningene er mer ambisiøse. En forutsetning fra L landenes side for å implementere disse, er at landet må bli støttet økonomisk utenfra av en gruppe høyinntektsland (H land) med ambisjoner om større globale utslippsreduksjoner.

Et viktig formål med arbeidet er å studere hvor omfattende finansiell støtte fra H land til L land som trengs for å implementere slike større utslippsreduksjoner, og dessuten hvilket omfang av støtte H land ønsker å gi til L land.


Arbeidet viser mer generelt at det er en nøye sammenheng mellom landenes ubetingede og betingede nasjonale målsettinger for utslippsreduksjon under PA, og de karbonpriser som kreves for å implementere slike reduksjoner. Kostnadseffektiv implementering av et lands utslippsreduksjon innebærer dessuten at alle aktører i landet står overfor samme karbonpris. Slike forhold er mindre godt kjent blant mange lands myndigheter, som tidligere ofte ikke har operert med karbonpriser i det hele tatt.
Unconditional and conditional NDCs under the Paris Agreement:
Interpretations and their relations to policy instruments

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NB: Highly preliminary. Do not cite or quote. Comments welcome.

Abstract

This paper discusses relationships between “unconditional” and “conditional” nationally determined contributions (NDCs) submitted by individual countries under the Paris Agreement, and instruments to fulfill these targets, with focus on targets set by “low-ambition” (L) countries. Unconditional targets are considered voluntary and implementable without outside support. More ambitious conditional targets are assumed to be set conditional on either financial support from a “high-ambition” (H) bloc of countries, or conditional on supportive climate-related policies pursued by other countries. Financial support is assumed to either support only mitigation activity in the L country directly, or to support also its renewables investments. I show that the conditional targets by L countries will be more ambitious than their unconditional targets, but less ambitious than the H bloc’s own mitigation targets. Equilibrium carbon prices will be higher in H countries than in L countries. This could make it difficult to establish a global carbon market with a unified carbon price. While there is a close relationship between the NDC targets of an L country, and the carbon price required for its implementation, this relationship may be unfamiliar to each L country government itself.
Summary for policymakers

This paper analyzes nationally determined contributions (NDCs) submitted by countries under the December, 2015 Paris Agreement (PA) for limitation of greenhouse gas (GHG) emissions. We discuss relationships between the targets implied by the NDC contributions, and policies required to reach them. The focus is on lower-income countries (dubbed “L countries”). Most of these countries might need, and/or expect to receive, international support from outside (from higher-income, H, countries) to reach some of their targets.

In analyzing the PA and its outcomes, it is first important to understand that the PA is not a cooperative agreement for globally efficient GHG mitigation. It can instead in its current form be viewed as a collection of voluntary contributions, from individual countries, that together add up to a hopefully sizeable contribution to global mitigation. The PA may however contain elements of cooperation between countries, e.g., in the form of “climate clubs” whereby similarly-minded countries cooperate on issues such as the group’s own mitigation, and climate policy-related transfers to other countries. This paper must be viewed in such a context.

Many L countries have submitted two sets of NDC targets: unconditional targets, to be implemented without any explicit external support; and conditional targets. The latter are more ambitious than unconditional targets, and require external support for their fulfilment. Two types of external support are indicated by many countries as necessary for additional mitigation to take place. The first type is outside financial support, to establish or implement the mitigation required to reach the conditional target. Such support can be in pure money or financial terms, or as support to particular investments, in particular in renewable energy capacity. The second is policies or action in other countries which support or facilitate a given country’s mitigation policy, or make this policy more favorable or less costly to implement. Examples of the latter are access to the use border taxes, or widespread use of carbon taxes in other countries, that ensure that L countries’ own energy intensive export industries are not unduly hurt when carbon taxes or charges are imposed on these.

The first part of the paper derives analytical solutions to unconditional and conditional NDCs for individual L countries, in certain simple, stylized, cases. Defining and deriving such solutions is relatively uncontroversial for unconditional targets, but are more controversial for conditional targets, as we then also need to consider the nature of the support policies likely to be offered to L countries, which are highly uncertain.

It seems reasonable that L countries will set and implement their unconditional mitigation policies in a decentralized and non-cooperative way, optimally from each country’s point of view only. A GHG emissions (or carbon) tax equal to the marginal damage to a country itself from its own
emissions, constitutes such a policy, and is assumed to be the one and only policy instrument imposed by the L country. Such a tax, correcting for the carbon externality only, is likely to be very low unless the country has considerable impact on global GHG emissions, and also incurs considerable damage from climate change. But “co-benefits” for the country from its own GHG mitigation policies (such as reduced air pollution when burning less coal, or less urban road congestion with less motorized road traffic) could increase the country’s own benefits from emissions reductions, and at the same time increase the country’s self-interest to mitigate. We expect certain middle-income countries with large co-benefits, substantial impacts on global emissions, and substantial damage from climate change (China; to a lesser degree India, South Africa, Brazil and Mexico), to have a self- interest in relatively ambitious unconditional GHG mitigation policies.

The conditional targets of L countries will depend on support received from H countries toward reaching these targets. The paper derives both optimal mitigation policies within the H country bloc, and also analyzes optimal support policies from H to L countries.

The optimal mitigation policy for a bloc of H countries acting together (as a “climate club”) is simply to set a (uniform) carbon tax equal to the marginal GHG emissions damage cost within the bloc (which may include co-benefits for the countries in the bloc).

Deriving the H bloc’s optimal support policies to incentivize mitigation in L countries is more complex. It depends first on what policies are available to the H bloc. We here conservatively assume that the H bloc is not allowed to influence the mitigation policy of the L country, only its mitigation levels. In particular, the H bloc is assumed not to be able to push an L country to set a higher than otherwise domestic carbon tax. It instead incentivizes additional mitigation more directly, as with the CDM under the Kyoto Protocol. I then show that, for the H bloc, the support to mitigation in L countries is less than the bloc’s ambition to mitigate domestically. Several factors can be responsible for this. A first obvious issue (not treated formally in my model) is that the H bloc would prefer to set a carbon tax domestically, which provides net fiscal revenues, while mitigation support to L countries entail fiscal costs for the H bloc, and provides rents for L country firms. Secondly, payments targeted to incentivize L country mitigation are subject to leakage and lack of additionality, which have been serious problems with the CDM, but not with a domestic carbon tax.

A main conclusion is that the level of ambition regarding the H bloc’s willingness to support L countries’ conditional mitigation lies in between the carbon price set by H countries themselves, and that set by L countries for their own unconditional mitigation. This points to a “hierarchy” of carbon prices under the framework of the PA:

- A “low” carbon price, set by L countries for implementing their unconditional NDCs;
- a higher carbon price supported by H countries to help implement the conditional targets in L countries; and
- an even higher carbon price applied by the H bloc of countries themselves, for their own mitigation.

This conclusion points to two dilemmas likely to result under the PA. First, global mitigation will be inefficient (global costs for implementing a given global mitigation effort will be excessive as carbon prices are different in different parts of the world). Global mitigation is still likely to be more efficient than with no support to mitigation from H to L countries. The reason is that all carbon prices (even those set by and within H countries themselves) are too low from a global welfare point of view; so that any policy to increase the carbon price, in any part of the world, will lead to efficiency improvements. Secondly, a single unified global carbon market, a proclaimed ambition of the PA, becomes very difficult to achieve. This conclusion follows naturally from the decentralized nature of the PA, with widely divergent targets by country and region, and with requirements to implement these targets efficiently.

I have so far only discussed optimal unconditional and conditional NDCs, and said less about how actual NDC policies are likely to look like. Many countries probably know little about what policies are required to reach their stated targets by 2025, or 2030. This problem is particularly serious for conditional policies, as the degree of support that will be forthcoming to L countries from the outside, to support such conditional policies, is yet unknown. Most countries are probably also likely to not apply uniform carbon pricing domestically, required for optimal mitigation. I argue that my analysis here can still be useful in countries’ planning, by pointing to ways in which mitigation should be modeled and planned.

In the simple analytical model presented, the reduction of carbon emissions due to mitigation is proportional to the carbon price set. This can be an acceptable approximation when low or moderate carbon pricing is applied uniformly within a given economy. The rule can be readily assessed and calibrated for each economy, and then help policy makers understand the value and impact of carbon pricing, and the approximate levels of carbon pricing required to reach given (unconditional and conditional) targets for any given country. Note however that many L countries are likely to have “cheap” options for mitigation available (that can be implemented with very low or even zero carbon prices). This means that there could be scope for non-trivial mitigation activity below “baseline” even for relatively low carbon prices; given only widespread willingness to use energy resources more efficiently than under the baseline. The same effect may occur when baseline or BAU carbon emissions are set unrealistically high, perhaps for strategic reasons.

A question is what form the policy by H countries to support mitigation in L countries should take: as a general support to (any form of) mitigation, or as more specific support to renewables investments. This paper argues that investments in renewable energy capacity is often the most
efficient vehicles for such support. Reasons are a) that it is difficult to identify good “general” objects for mitigation support thus making it likely that such support will be wasted, while projects to support renewable energy will be much more easily identifiable and targeted; b) that support to renewables investments are likely more “transformational” for many L countries and thus have a greater development potential; and c) that such investments are also often more difficult for the receiving countries to implement on their own. I show that easier identification of good subsidy targets leads to greater donor support to renewables investments than to more general emissions-reducing mitigation. This tends to make renewables finance the most attractive targets for such support, and then also the preferable way for many L countries to fulfill their conditional NDCs.

Two further lessons from economics can be drawn. First, efficient implementation of a country’s NDC target requires a uniform GHG emissions price applied to the entire economy. Secondly, when GHG emissions pricing is uniform, a given NDC target corresponds to a given GHG emissions price (or tax). Many policy makers may not have had carbon pricing in mind when setting their countries’ NDC targets; many may still have no ambition to apply any type of general carbon pricing whatsoever. These policy makers need to realize that a failure to apply uniform carbon pricing makes a given NDC target more difficult and costly than otherwise to reach. More forceful instruments must then be applied to reach the quantitative mitigation targets that have been set.
1. Introduction

Many countries, both low- and high-income, are today uncertain about how to implement their nationally determined contributions (NDCs), pledged toward the December, 2015, Paris Agreement (PA) on international climate policy action. Most countries have not specified which mechanism(s) they intend to use to fulfill their NDCs.\(^1\) Issues leading to further uncertainty are the necessity to ramp up and tighten these targets gradually over time, to fulfill the overall and longer-run ambition of the PA in terms of global climate control; what such stricter targets may imply for countries’ climate policy instrument use; and what burdens these imply for the respective economies, in the longer run.

Many countries (among these, most “low-ambition”, or L, countries) have announced two sets of mitigation targets to be reached under the PA: an “unconditional” target to be reached without outside support; and in addition a “conditional” target. “Conditionality” is not very precisely specified by many countries. I will distinguish between two broad types of conditionality, relevant in for most countries’ NDCs. Under the first type, which is by far the most common, reaching the given mitigation policy is made conditional on particular categories and/or levels of financial and/or technical support received from the outside. The second type conditions the country’s climate policy on particular, climate-related, policies pursued by other countries.

Table 1 below shows the stated NDCs for a few selected countries, with indication of required or expected type of external support to fulfill the conditional NDC target. Almost all countries indicate “financial support” as at least one support type; although most countries do not say how

\(^1\)Obergassel and Gomik (2015) point out that 23 countries, out of 86 countries that anticipate market mechanisms to be used to implement the PA, specify the CDM as one such mechanism.
much support is required. Countries are also generally strikingly unspecific in terms of what types of mitigation is involved, in what sectors, and are also unspecific in defining the “business-as-usual” (BAU) benchmark against which the NDC targets are set. Common for all is that the conditional targets are more ambitious than the unconditional targets; in some cases by a wide margin, as for countries like Mexico, Morocco, and Nigeria.

Table 1: NDCs for some selected “L countries”

<table>
<thead>
<tr>
<th>Country</th>
<th>NDC unconditional contribution by 2030 relative to BAU</th>
<th>Similar NDC conditional contribution</th>
<th>Types of required support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>15%</td>
<td>30%</td>
<td>Financial support</td>
</tr>
<tr>
<td>Colombia</td>
<td>20%</td>
<td>30%</td>
<td>Financial support</td>
</tr>
<tr>
<td>Mexico</td>
<td>25%</td>
<td>40%</td>
<td>Policies; technological support</td>
</tr>
<tr>
<td>Peru</td>
<td>20%</td>
<td>30%</td>
<td>Financial support</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>15%</td>
<td>25%</td>
<td>Technology transfer; finance</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>5%</td>
<td>15%</td>
<td>Financial support; technology transfer</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>4%</td>
<td>16%</td>
<td>Financial support</td>
</tr>
<tr>
<td>Thailand</td>
<td>20%</td>
<td>25%</td>
<td>Financial support; technological transfer</td>
</tr>
<tr>
<td>Vietnam</td>
<td>8%</td>
<td>15%</td>
<td>Financial support</td>
</tr>
<tr>
<td>Algeria</td>
<td>7%</td>
<td>22%</td>
<td>Financial support; technological transfer</td>
</tr>
<tr>
<td>Morocco</td>
<td>13%</td>
<td>32%</td>
<td>Access to technology; financial support</td>
</tr>
<tr>
<td>Nigeria</td>
<td>20%</td>
<td>45%</td>
<td>Not specified</td>
</tr>
</tbody>
</table>

Source: UNFCCC (2016).

I will in this paper discuss some ways in which the “unconditional” and “conditional” NDCs, and the alternative definitions of conditionality, can be interpreted, and implemented. I will try to make sense of the relationships between policies and targets. I will not try to explain how countries have actually (so far) set their targets for the PA. The idea is rather, given that both unconditional and
conditional targets are set rationally subject to actual and known constraints and can realistically be implemented, how would they be set. I then also discuss the amount of support that H countries can realistically be expected to provide, and the principles behind such support.

The NDC targets are easier to set than to implement. Many countries probably do not know exactly what is required in terms of policy to reach a target of, say, a 20% or 30% reduction in their GHG emissions level below a “benchmark” level (often set by a vaguely defined BAU emissions path, or relative to a historical benchmark) by 2025, and/or by the current end date for the PA, 2030.

To implement conditional targets in response to outside financial support, we may think of two potential alternatives for international trading of credits for reduced GHG emissions (“international tradeable mitigation outcomes” or ITMOs; see World Bank (2016)) under the PA. In a first alternative, (high-income, H) “buyer” countries are credited, as with the Clean Development Mechanism (CDM) under the Kyoto Protocol (KP). In the second alternative, lower-income (L) country “sellers” but not “buyers” are credited to. L countries then receive compensation (from H countries) for implementing their (stricter) conditional GHG emissions targets.

It is not yet fully clarified which of the two alternatives, if either, will be the main mechanism to be applied under the PA. Many countries however (explicitly or implicitly) count on the second alternative. An example is Peru, which states in its NDC document:\footnote{See UNFCCC (2016).}

“Peru is considering selling emission reductions provided this is not an obstacle for the compliance with the national commitment.”
Apparently, Peru counts on receiving financial compensation for emissions reductions, while at the same time having these reductions credited toward its conditional NDC target; such an anticipation seems to be a widespread under the PA. This arrangement would not be compatible with a CDM-like offset mechanism crediting offset buyers. The money would instead need to come e.g. from sovereign nations or funds set up for the purpose. Bradford (2004) has proposed an international institution, the “International Bank for Emissions Allowance Acquisitions (IBEAA)”, funded by a pool of finance (from high-income, H, countries), for purchasing (and retiring) emissions allowances (from L countries), allowing these countries to meet conditional, stricter, targets with respect to GHG emissions mitigation. Under the PA, such mitigation outcomes could be credited to the (L) countries implementing these emissions reductions.

Below I discuss how a mechanism similar to the IBEAA might work for international emissions trading, with the aim to implement a (more) efficient global mitigation outcome; and discuss its relationship to NDCs and their implementation for many L countries. There are however some differences between my model and the IBEAA. Most importantly, the financing entity in my model is not global: it provides finance only for L countries. I assume that the H countries carry out mitigation on their own, possibly using other mechanisms. As will be seen, H countries will tend to have more ambitious climate policies, with higher carbon prices, than those incentivized in L countries.

I also consider the alternative interpretation of conditional GHG mitigation policies, namely conditional on climate-related policies in other countries. I discuss one broad set of such policies, considered by many L countries, namely, conditionality on carbon prices “elsewhere”, relevant to the competitiveness of L countries’ exporting industries.
It can be argued that a globally efficient solution would be endorsed by all countries and involve a global carbon trading scheme. This is discussed further in the final section, where I argue that such a single scheme would have problems, in terms of both feasibility, and efficiency.

2. Unconditional mitigation policies

I build on a simple model based on Strand (2013; 2016c). Consider two groups of countries: “Group H”, “high-ambition” (-income) countries with their own (ambitious) climate policy targets. I will for the sake of argument assume that the H countries behave as a unified group or bloc. Importantly, they define a carbon value (marginal climate damage value) $v_H$ jointly for the group and on which they agree. We may consider the group of H countries as a “climate club”.3 “Group L” consists of “lower-ambition” (and usually lower-income) countries whose NDCs under the PA are the central objective of this study. I assume that these countries behave independently (although they may form groups or clubs which could join forces and act commonly; for such cases a given “club” is identified as “country” in my presentation).

In this section, I focus on L countries’ unconditional NDCs: these are targets that the countries themselves have set independent of policy or support from the outside. In the model, assume that the aggregate profit function related to fossil-fuel consumption in an L country with no current climate policy, but which may be given incentives to adopt one, can over a (limited) range of relevant energy prices be approximated by the following quadratic relationship:

$$ W_L = R_L - \frac{1}{2} \gamma R_L^2 - (p + q_{lw}) R_L , \quad (1) $$

3 See Nordhaus (2015).
where $\gamma_L > 0$ is a positive fixed parameter, $R_L$ is fossil-fuel consumption in carbon-equivalent units in this country, $p =$ the international trading price of fossil fuels, and $q_{LU} =$ a unit excise tax imposed on fossil-fuel consumers in the L country, according to the L country’s unconditional mitigation policy. (1) is a simple “linear-quadratic” second-order Taylor approximation to the economy’s true macro profit function (as a function of fossil fuel consumption only).\(^4\) This may be quite accurate over a limited range for $R$ relevant here. Its advantage is to deliver simple and easily interpretable results at least for cases with small or moderate changes in GHG emissions. (Note that, under the PA, even the conditional mitigation targets of most L countries can in most cases be implemented using relatively moderate carbon prices.)

The solution chosen by the macro producer in the L country is found setting the derivative of $W_L$ with respect to $R_L$ equal to zero, yielding

\begin{equation}
R_{LU} = \frac{1 - p - q_{LU}}{\gamma_L},
\end{equation}

where $q_{LU}$ is the carbon tax imposed by the L country itself. Consider, for reference, the optimal $R$ set by emitters in the L country with no carbon taxes, $q=0$, which is

\begin{equation}
R_{L,0} = \frac{1 - p}{\gamma}.
\end{equation}

$R_{L,0}$ serves as a “baseline” or “business-as-usual” (BAU) level of fossil-fuel consumption in the L country, against which any (unconditional or conditional) target can be compared or measured.\(^5\)

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\(^4\) This formulation thus does not consider carbon emissions from land use changes, which for some countries constitute a major part of GHG emissions, and separate reason for climate action.\(^5\) This is assuming no baseline inflation or exaggeration effects. For discussions of the risk of baseline inflation see Strand (2011), Strand and Rosendahl (2012).
Mitigation relative to BAU, induced by the carbon price (or tax), $q_{LU}$, equals

$$M_{LU} = R_{LU} - R_{LU} = \frac{q_{LU}}{\gamma}.$$ 

Assume that the L country is subject to a social cost (representing marginal climate costs, plus possible national or regional “co-benefits”, as valued by the country when fossil-fuel consumption is reduced) equal to $v_L$ per unit of emissions. Consider the optimal program for the L country in isolation. The only difference in country’s objective function relative to (1) is to replace $q_{LU}$ by $v_L$, the marginal social cost of fossil fuel consumption in the L country. Clearly then, the optimal carbon tax for the L country, $q_{LU}$, equals its marginal climate cost, $v_L$.

3. **L country policies conditional on financial support**

3.1 Introductory remarks

We now consider the determination of the L country’s stricter “conditional” GHG emissions target $R_{LC} < R_{LU}$. I will assume two broad types of such conditionality. Under the first, a stricter climate policy is implemented on condition that the L country receive (sufficient) outside financial support when implementing this stricter target. Such cases are treated in sections 3-4.

Under the second type of conditionality, the stricter climate policy is implemented if and only if certain basic other policies are also at the same time implemented internationally, shielding the L country against certain adverse impacts from implementing its stricter climate policy. This case is treated in section 5 below.

Both types of conditionality are relevant for understanding and characterizing submitted NDCs under the PA. An example is Mexico, whose unconditional mitigation target by 2030 implies a
reduction in GHG emissions by 25% below its “baseline” or BAU, by that date. The Mexico plan also states: \(^6\)

“The 25% reduction commitment expressed above could increase up to a 40% in a conditional manner, subject to a global agreement addressing important topics including international carbon price, carbon border adjustments, technical cooperation, access to low-cost financial resources and technology transfer, all at a scale commensurate to the challenge of global climate change.”

The stricter target is thus said to be conditional on several aspects which include border taxes and/or other protective tax or policy measures broadly implemented in other countries. Certain financial support measures (“low-cost financial resources and technology transfer”) are also mentioned, but appear to play a less central role.

In most other NDCs, the stricter target is much more directly conditional on “international financial support”. An example is Argentina, whose NDC implies a 15% unconditional reduction in GHG emissions below its “BAU emissions” by 2030. The conditional target is stricter:

“Argentina could increase its (unconditional) reduction goal under the following conditions: a) Adequate and predictable international financing; b) support for transfer, innovation and technology development; c) support for capacity building. In this case, a reduction of 30% GHG emissions could be achieved by 2030 compared to projected BAU emissions in the same year. Argentina could increase its reduction goal to 30% GHG emissions by 2030 compared to projected emissions in the BAU the same year, with international support.”

A reasonable interpretation is here that financial support be required for Argentina to implement the stricter measure, although it is not said in detail what type of financial support is required

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\(^6\) See UNFCCC (2016); the same reference holds also for the remarks on Argentina below.
(direct transfers; access to offset markets; easier credit to or financing of low-carbon investments), nor how much.

3.2 Optimal H country support given perfect identification of subsidy targets

Assume that the H country or bloc induces an L country to carry out GHG mitigation beyond its unconditional mitigation level, to fulfill its conditional NDC target, by giving it financial support for any additional mitigation beyond L’s unconditional mitigation level, \( q_{LU} \). Assume that the L country’s unconditional policy then remains unaltered.

The optimal level of support to L countries, from the bloc of H countries, will in the following be seen to depend on various factors including the H bloc’s ability to identify worthy object for subsidy, its ability to bargain over rents to mitigating L country units, and the degree of additionality of the mitigation induced among the target emitters.

In this sub-section I assume that the H bloc can perfectly identify the units that require subsidy in order for mitigation to take place, and that there is no leakage. Mitigation among subsidized units, induced by the H country policy, is then fully additional.

Assume the H bloc makes an incentive payment to the L country, equal to \( q_{LC} > q_{LU} \) per unit of additional mitigation \( R_{LU} - R_{LC} > 0 \) induced in the L country by this policy, and makes such payments only for these units of mitigation. Importantly, all such (externally induced) mitigation adds to the level chosen unconditionally by the L country itself.

The welfare function for country L (or as defined by the L country government) is in this case

\[
W_{LC} = R_{LC} - \frac{1}{2} \gamma R_{LC}^2 - (p + v_L) R_{LC} + q_{LC} (R_{LU} - R_{LC}),
\]

(5)
where \( q_{LC} \) is the carbon price set by the H bloc, applying to mitigation induced by this price; and \( R_{LU} \) is determined by the L country’s unconditional climate policy, still given by (2). Assume that country L perceives the support from country H to be a constant (marginal) subsidy per unit of extra emission reduction \( R_{LU} - R_{LC} \) (but where the actual subsidy to any given unit may differ; see discussion below). The optimal energy consumption of country L is found by setting the derivative of \( W_{LC} \) with respect to \( R_{LC} \) in (5) equal to zero, which yields

\[
R_{LC} = \frac{1}{\gamma} (1 - p - v_L - q_{LC}).
\]

One possible implementation mechanism is where the L country government receives this compensation from the H country, but where the L country simply imposes a uniform carbon tax of \( v_L + q_{LC} \).

Another logical way to implement this solution is that those who would emit carbon facing a carbon price of \( v_L \), but would abate when facing a carbon price of \( v_L + q_{LC} \), receive a subsidy from either the H country or their own host L country, equal to \( q_{LC} \) for each unit of carbon abatement thus induced. This corresponds closely to a scheme were the H bloc purchases “offsets” from L country emitters, to implement the overall lower emissions rate (as under the CDM). This is the interpretation generally chosen here. The two solutions are technically equivalent in terms of induced mitigation for given carbon price facing a given emitter. They however differ in certain important respects. In particular, a system with “offsets” tends to be less efficient as it is subject to problems of asymmetric information: it is attractive to emitters and give them incentives to exaggerate their emissions levels. They will also differ terms of net revenue for the government and private-sector parties.
We here wish to derive the optimal level of such support from the H country to the L country, from the point of view of the H country or bloc, assuming that such an “offset” policy must be used. The induced additional mitigation in the L country due to this subsidy equals \( \frac{q_{LC}}{\gamma} \).

In this sub-section we consider cases where the H bloc may bargain with individual mitigating units in the L country, so that the average cost for the H bloc of inducing such mitigation is reduced. This is based on the assumption that each micro unit in the L country, subject to such subsidies, is very small and has constant mitigation cost, and that these units in aggregate have mitigation costs which corresponds to the mitigation cost function corresponding to (6), on the range of mitigation from \( R_{LU} \) to \( R_{LC} \). Note that infra-marginal mitigation units then enjoy lower marginal mitigation costs than \( q_{LC} \). Under (complete information) bilateral bargaining between the individual unit and an “offset buyer” from the N bloc, some of the resulting relation-specific gains from such matching are appropriated by the H bloc. I will argue that this is a realistic outcome given that both sides of the market have some relation-specific bargaining power. Note that under the CDM, offset prices were very variable and in most cases lower than the prevailing EU-ETS trading price, often by a wide margin; this may indicate that there was positive bargaining power to the offset buyer side.

For analysis see in particular Bréchet et al (2012) and Strand (2016d); see also Liski (2001) and Liski and Virrankoski (2004).

Formally, assume that the average price per emissions reduction, paid by the H bloc (or relevant units within this bloc making the payments), is reduced by a non-negative fraction \( \lambda \) of the difference between \( q_{LC} \) and the mitigation cost for the actual carbon unit that is being mitigated.

Retaining the linear-quadratic structure of the model, the average mitigation cost to the H bloc,
across all units mitigated, is reduced by a fraction $\lambda/2$ of the difference $q_{LC} - v_L$ (where $\lambda = 1$ would eliminate all resulting profits of project hosts).\(^7\) This is expressed as

$$V_{HC}(0) = v_H \frac{q_{LC}}{\gamma} - \left( q_{LC} - \frac{\lambda}{2} q_{LC} \right) \frac{q_{LC}}{\gamma}.$$  

The first main term in (7) is the utility gain for the H country, and the second term the cost (in terms of the total amount of subsidy paid from H to L country in return for the additional mitigation induced). Maximizing (7) with respect to $q_{LC}$ yields

$$\frac{dV_{HC}(0)}{dq_{LC}} = \frac{v_H}{\gamma} - \frac{(2-\lambda)q_{LC}}{\gamma} = 0,$$

and thus

$$q_{LC} = \frac{v_H}{2-\lambda}.$$  

$q_{LC}$ is here lies between $v_H/2$ and $v_H$. The former solution occurs when $\lambda = 0$ and no buyer bargaining power. The latter is the limit case of $\lambda = 1$, where the buyer has all the bargaining power.

The former case ($\lambda = 0$) is similar to that of a regular monopsonist. Intuitively, setting $q_{LC} = v_H$ would leave the H bloc with zero net return from its support policy (as the cost to the bloc would be equal to the gain from all units of mitigation supported). Most producers in the L country would benefit from this mitigation policy, with higher profits; such profits do not enter the H country’s

\(^7\) The reason for having one half in this formula is that, with a linear supply function for “offsets” as considered here, the average mitigation cost on the range $R_{LU}$ to $R_{LC}$ equals $(q_{LU} + q_{LC})/2$, and the average surplus to be shared equals $(q_{LC} - q_{LU})/2$. 

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utility function. The H bloc then wishes to set \( q_{LC} \) below \( v_H \) so as to extract (an optimal) net return from the policy.

The case of \( \lambda = 1 \) is technically similar to that of a “perfectly discriminating monopsonist”, which extracts all potential relationship-specific surplus (from the buyer-seller matching of mitigation outcomes), and thus leaves producers in L countries with no increase in net profits. It is in this case well-known that a socially optimal solution can be achieved. (This corresponds to the marginal gain from the policy for the H bloc, \( v_H \), equal to the marginal cost, \( q_{LC} \)).

The amount of (conditional) mitigation induced through incentive payments from the H bloc to the L country is

\[
M_{LC} = \frac{1}{\gamma} \frac{v_H}{2 - \lambda}.
\]

The induced conditional mitigation is greater, the greater is the bargaining power \( \lambda \) of the H bloc in individual bargains over the sharing of surpluses in mitigating units in the L country.

Assume as noted that the L country has already imposed a uniform carbon tax \( v_L \), and that the H bloc incentivizes additional mitigation through a payment of \( q_{LC} \) per unit of emissions reduction below \( R_{LU} \), achieved through the domestic carbon tax (\( v_L \)) alone. The effective “carbon price” in the L country (relevant for implementing the country’s conditional INDC target) is then

\[
q_C = q_{LC} + v_L = \frac{v_H}{2 - \lambda} + v_L.
\]

An interesting result here is that with no bargaining power to the H bloc in the individual “offsets” market (\( \lambda = 0 \), the maximum payment by the H bloc to induce additional mitigation in the L country is exactly half of the H bloc’s marginal climate cost, \( v_H \); where the latter also is the optimal
domestic carbon tax within the H bloc. As already discussed, the H bloc limits its unit payments related to mitigation in the L country as it is averse to the resulting rent gain for the L country. The more specific result, that the optimal support rate from the H bloc to L countries is exactly half of the optimal rate for the H bloc in the case of no bargaining power, is not general but follows from the linear-quadratic structure of this model; see also Strand (2013; 2016a).

As $v_H$ can be expected to be “high” relative to $v_L$, when $\lambda$ is close to zero, $q_{LC}$ is likely close to $v_H/2$. The L country itself imposes a general (low) carbon tax $v_L$, and the H bloc adds by paying for emissions reductions beyond those achieved by the carbon tax alone, with a purchase price $q_{LC}$.

The case of $\lambda$ close to one may seem as less likely in practice. First, experience from the EU-ETS and the CDM under the Kyoto Protocol seems to have been relatively low effective bargaining power of H bloc units (“buyers” in the carbon market, from the EU), at least in part due to insufficient supply of viable CDM projects. There has been a tendency to take the EU-ETS price as the relevant benchmark or natural price at which offsets needed to be purchased. If this situation persists, $\lambda$ will likely remain low for the foreseeable future. Following my model above, this will take the form of the H bloc posting a price (lower than its own carbon price) at which emissions reductions are purchased, and retired.

Additional factors, not formally dealt with in this model, will in practice limit the H bloc’s support price to mitigation in lower-income countries, relative to the internal carbon price within the H bloc. The optimal domestic policy for the H bloc is as noted to implement a general carbon tax (something that it obviously cannot implement in L countries), thus providing perhaps large fiscal revenues. This is fiscally much more attractive than the policy needed to induce additional mitigation in L countries: which implies fiscal costs to the H bloc. A fiscal implication of climate
policies is that mitigation policies provide revenues to governments, while adaptation policies are costly to them; see Jones, Keen and Strand (2013). This principle however does not hold when the party in charge of mitigation policies has no authority to tax (such as here), which makes such policies less attractive.

3.3 Imperfect identification of subsidy targets

I have so far assumed that the mitigation units for subsidy in the L country can be perfectly identified by the H bloc, which is likely not to hold. The assumption implies that the L country implements mitigation up to $M_{LU}$, and the H bloc pays for only additional mitigation $M_{LC}$. The emitting units in the L country, that are subject to mitigation by the L or H country, however all have an incentive to appear as most-cost units within this group and thus receive the support benefit, paid to them by the H bloc when mitigation takes place.

An opposite extreme case is where the H bloc cannot at all distinguish these units from the lower-cost units targeted only by the domestic mitigation $M_{LU}$. The H bloc must then pay $q_{LC}$ for all the units $M_{LM} + M_{LC}$. Supporting mitigation policy in the L country will then be more expensive for the H bloc. We here focus on the case of $\lambda = 0$. The objective function of the H bloc can now be expressed as:

$$V_{HC}(l) = v_H \frac{q_{LC}}{\gamma} - q_{LC} \frac{v_I + q_{LC}}{\gamma}. \tag{12}$$

Maximizing (12) with respect to $q_{LC}$ yields

$$\frac{dV_{HC}(0)}{dq_{LC}} = v_H \frac{v_I + 2q_{LC}}{\gamma_L} = 0 , \tag{13}$$
which leads to the following condition on $q_{LC}$:

\[(14) \quad q_{LC} = \frac{v_H - v_L}{2}.\]

The total carbon price in the L country, facing “conditional mitigation”, is then

\[(15) \quad q_L = q_{LU} + q_{LC} = \frac{v_H + v_L}{2}.\]

The maximum additional carbon price paid by the H bloc to L countries is now further reduced, so that the total carbon price, including both the general carbon charge by the L country and the supplementary mitigation support by the H bloc, is now $(v_H + v_L)/2$. This is still greater than the L country’s own carbon price, $v_L$, but closer to this price.

In this case it would not be fully consistent to consider bargaining in the way considered in the previous sub-section; this justifies our focus on the case of $\lambda = 0$. This is because such bargaining solutions require, formally, complete information for the H bloc about true mitigation costs of each unit in the L country with which it bargains. Such complete information precludes the additional inefficiency assumed here.\(^8\)

3.4 Implications of leakage and lack of additionality

So far I have assumed that certain key recognized problems associated with the CDM, notably leakage and lack of additionality, do not represent a problem for the conditional INDCs under the PA. Arguably, these problems will be less severe under the PA than under the KP, as individual countries have now set national mitigation targets to be met, and need to ascertain the integrity of

\(^8\) One might here consider incomplete information bargaining, which is more realistic in such a setting, but analytically more complicated. This is here ignored but may be the subject of follow-up work.
these policies, so that they deliver the required net mitigation at the macro level.\(^9\) This was not the case under the CDM. Still, however, emitters who receive mitigation support (from the H bloc) could behave strategically in order to maximize this support (thus compromising additionality); and some leakage might occur when fossil-fuel markets are largely national or regional; see Rosendahl and Strand (2011).

To reflect such ideas, assume in the model variant below that only a fraction \(1 - \rho < 1\) of the potential increased mitigation leads to reductions in global carbon emissions, due to leakage related to the L country’s conditionally induced mitigation. We then rewrite (12) as follows:

\[
(16) \quad V_{HC}^\gamma(1) = v_H (1 - \rho) q_L \frac{v_L + q_L}{\gamma} .
\]

The donor group here recognizes that some of the L country’s mitigation that is induced by this policy “disappears”, possibly via induced price changes in domestic energy markets; see Rosendahl and Strand (2011). Maximizing (16) by the H bloc now yields

\[
(17) \quad \frac{dV_{HC}(0)}{dq_L} = \frac{(1 - \rho)v_H - v_L + 2q_L}{\gamma} = 0 ,
\]

which can be written as

\[
(18) \quad q_L = \frac{(1 - \rho)v_H - v_L}{2} .
\]

The optimal carbon price offered by the H bloc to the L country is now

\[^9\text{As is by now well understood, the anticipation of incentive payments related to the CDM have led to perverse increases in emissions prior to (or at early stages of) the implementation of such solutions. See e.g. Fischer (2005), Strand (2011), and Strand and Rosendahl (2012). Such problems are likely to persist also here, albeit arguably in a milder form.}\]
We see that leakage further reduces the optimal (conditional) carbon price offered for the purchase of emissions reductions, by the H bloc to L countries. Leakage impacts mitigation negatively, in two different ways. It has first a direct effect of reducing the amount of effective net mitigation for the L country in question, for a given targeted mitigation volume. It secondly has a policy-driven effect of reducing the level of (constrained) optimal support from the H bloc to mitigation in the L country, as the carbon price offered is reduced. Note that for (18) to be meaningful we must require \((1 - \rho)v_H - v_L\) to be positive. Under reasonable assumptions about leakage this appears likely to hold, as \(v_H\) likely exceeds \(v_L\) by a substantial margin.\(^{10}\)

For the carbon support price from the H bloc to L countries, I find a wide range of possibilities, from a high level of \(v_H\) (the complete information with perfect rent extraction by the H bloc from L country emitters, and no leakage), to a low of \([(1 - \rho)v_H - v_L]/2\) (no information on mitigation projects, and leakage rate \(\rho\)). Given that the L country also establishes a carbon price of \(v_L\), applicable to all units of domestic emissions, the overall carbon price in the L country will lie somewhere between \(v_L\) and \(v_H + v_L\); most reasonably between \(v_L\) and \(v_H\).

4. Renewable energy investments

In this section I consider an alternative (additional) policy for carrying out mitigation in L countries: replacing fossil fuels with renewable energy in one sector of the L country’s economy.

Consider an L economy with two sectors. Sector 1 still relies completely on fossil energy. Sector 2 has the option of switching, fully or partly, to renewables as its energy source.

\(^{10}\) Simulations in Rosendahl and Strand (2011) indicate that likely leakage from the CDM was around 30% on average. As argued, leakage under the PA is likely to be no higher, and probably less.
I assume that the unit cost of investment in renewables capacity is a smooth and increasing function of the amount of renewables investment taking place in the L country. Consider the following profit function for sector 2 in the relevant L country:

\[ W_{L2} = R_{L2} - \frac{1}{2} \frac{\gamma}{1-h} R_{L2}^2 - (p + v_L) R_{L_f} + q_{LC}(R_{LU} - R_{L_f}) - (r - s) R_{Lr} - \frac{1}{2} \frac{\sigma}{1-h} R_{Lr}^2. \]

I assume that the L country maintains a general carbon tax on fossil fuels equal to \( v_L \), as in section 3. I now consider two possible instruments for the H bloc to affect mitigation in the L country: first as before a carbon tax equal to \( q_{LC} \); but now also a subsidy to renewable energy of \( s \) per unit of fossil fuel equivalent. \( R_{LU} - R_{LF} \) represents additional direct mitigation in terms of less fossil fuel consumption, induced by the support from the H bloc to such mitigation, in similar way as in section 3. \( \sigma \) is a “scaling” parameter indicating the scope for renewables in the L country’s overall energy portfolio, as seen below. The cost function for renewables capacity is assumed to be quadratic in the amount of renewables investments induced, and similar to the utility function for energy consumption in section 3. Given this function, marginal renewables costs start at zero and increase linearly in \( R_{Lr} \). Assume that renewables are subsidized at a fixed rate \( s \) per unit by the H bloc (in terms of how fossil fuels are replaced). Assume that the L country at equilibrium consumes both some fossil fuels and some renewable energy, so that the marginal product of fossils and renewables in sector 2 are equal. Assume as above that the solution yields \( R_{Lr} < R_{L2} \), and \( R_{Lf} > 0 \). Noting that \( R_{L2} = R_{Lf} + R_{Lr} \), taking the derivative in (20) with respect to \( R_{Lf} \) and \( R_{Lr} \) yields

\[ \frac{dW_{L2}}{dR_{Lf}} = 1 - \frac{\gamma}{1-h} R_{L2} - p - v_L - q_{LC} = 0 \]

(21)

\[ \frac{dW_{L2}}{dR_{Lr}} = 1 - \frac{\gamma}{1-h} R_{L2} - r + s - \frac{\sigma}{1-h} R_{Lr} = 0. \]

(22)
The solutions for $R_{L2}$, $R_{Lf}$ and $R_{Lr}$ are now found as:

\begin{align}
    R_{L2} &= \frac{1-h}{\gamma} (1 - p - v_L - q_{LC}). \\
    R_{Lf} &= \frac{1-h}{\gamma \sigma} \left[\sigma + \gamma (r-s) - (\gamma + \sigma)(p + v_L + q_{LC})\right]. \\
    R_{Lr} &= \frac{1-h}{\sigma} (p + v_L + q_{LC} + s - r).
\end{align}

In (24), the last term expresses a “double impact” of fossil-fuel pricing on fossil-fuel consumption: first in terms of the direct mitigation thus induced, which leads to reduced demand for energy; and secondly as more of the energy demand will be met through renewables, since also renewables switching is induced by general carbon pricing. In addition, switching to renewables is induced by the specific renewables support payment from the H bloc, $s$. Note that the solution for renewable energy use implies a gradual phasing-in of renewables when the subsidy rate increases (given quadratic renewables costs this phase-in is proportional to the subsidy rate).

We can here view $q_{LC}$ as a “basic” support to renewables, and $s$ as an “additional” support. The total support level to renewables from the H bloc is the sum of these two components. In addition, the carbon tax imposed by the L country itself, $v_L$ has the same effect.

To derive the optimal subsidy level to mitigation activities in the L country, chosen by the H bloc, the analysis is very similar to that in section 3. First, the support policy to direct fossil-fuel mitigation, $q_{LC}$, can derived in exactly the same way as before. The H bloc’s optimal total support to renewables may also now face different optimal policies, depending on the precision with which renewables units for subsidy in the L country can be identified by the H bloc.
Assume first that the H bloc can perfectly identify the units of renewable energy investments that need to be subsidized in order to materialize, in amount \((1-h)s/\sigma\). Assume also that the H bloc can identify the investment cost for each renewable energy producer in country L, and bargains with each L country agent over the specific surplus in the same way as in subsection 3.2, with a relative bargaining strength \(\lambda\) to the H bloc units (and \(1-\lambda\) to L country emitters). As a special case, \(\lambda = 0\) with no possibility for the H bloc to observe the exact surplus, and with no bargaining possibility. The optimal support level to renewables, \(q_{LC} + s\), is then the same as for general mitigation in section 3, namely

\[(9a) \quad q_{LC} + s = \frac{v_H}{2 - \lambda} .\]

\(\lambda = 0\) can also mean that the H bloc simply posts a subsidy rate \(s\) to all eligible L region units that invest in renewables, and does not bargain with L country emitters. Then in the same way as in section 3, \(q_{LC} + s = v_H/2\).

If instead the H bloc cannot separate those units that would already be incentivized by the L country carbon tax, \(v_L\), from those directly incentivized by the subsidy \(s\), the optimal subsidy level would be lower and correspond to the solution from (14) (given no leakage), namely

\[(14a) \quad q_{LC} + s = \frac{v_H - v_L}{2} .\]

In either case, \(s\) would be derived by taking the expressions (9a), respectively (14a), and insert the respective solution for \(q_{LC}\) from section 3. Solutions with \(s > 0\) then correspond to cases where the informational constraints are less severe with respect to renewables, than with respect to general GHG mitigation.
The amount of mitigation induced in sector 2 by the L country government, and the H bloc’s support policy, respectively, are:

\[
M_L = \frac{1-h}{\gamma\sigma} (\gamma + \sigma) v_L. 
\]

\[
M_H = \frac{1-h}{\gamma\sigma} [\gamma s + (\gamma + \sigma) q_{LC}]. 
\]

These mitigation levels are found as combinations of reduced general energy consumption, and as renewables take over a larger share of total energy consumption.

Note that mitigation is inversely related to \(\sigma\), the steepness of the renewables investment supply function, as function of the support price: the less steep supply function, the more renewables are incentivized for a given increase in the net price advantage enjoyed by renewables relative to fossil fuels. When \(\sigma\) is sufficiently small (implying that the renewables potential is high), \(R_{1L}\) from (25) may exceed \(R_{12}\) from (23). The model then yields a corner solution with all energy use in sector 2 switching to renewables. This case will be ignored here.

Consider now the choice of mitigation, versus more general, economy-wide, mitigation as discussed in section 3. This is determined via the specific support price to renewables, \(s\). A key issue is here the willingness of donors (in the H bloc) to support these two types of mitigation. Essentially, this boils down to how easy it is for donors to identify good subsidy targets in the two cases. It seems intuitively clear that such control and identification could easily be for renewable energy investments (which are likely to often be executed directly by H bloc parties), than for general emissions-reducing activities from existing emitters. If so, the H bloc’s willingness to pay for mitigation in L countries will be greater when mitigation takes the form of renewables.
investment project, than when emissions are reduced from existing facilities. A factor strengthening this conclusion is that renewables investment could be more “transformational” to L countries, in terms of both development impact and increasing the receiving countries’ energy production capacities, and also often embed an element of favorable technology transfer.

The analysis above might in such cases speak in favor of a relatively low general support price to mitigation, \( q_{LC} \) (as this could be poorly targeted and subject to problems of additionality and leakage), and a higher specific renewables support, \( s \).

Note that the general mitigation support \( q_{LC} \) here plays a dual role of reducing overall energy consumption directly, and at the same time substituting out fossil fuels for renewables. A key lesson is that policies which aim to directly incentivize renewables investments, are much easier to carry out when there is also a positive price on carbon emissions.

5. **Conditionality tied to climate policy elsewhere**

I will now, more briefly, discuss the other main interpretation of “conditional NDC”, namely as conditional on and in response to climate action “elsewhere”; or conditional on access to certain policy tools that do not directly (only indirectly) affect emissions. I will then first assume that the L country has a sector which is exposed to international competition (call it again sector 2), and that this sector comprises a fraction \( 1-h \) of the total economy, in the same way as in section 4. I will assume that this sector would be considered (or would consider itself) to be subject to an “unfair” disadvantage by its own-country (L) government if it were to face a positive carbon price which is not imposed on the sector’s foreign competitors. Assume that the profit function of the typical producer in the exposed sector 2 can be expressed as
\[ W_{L2} = (1 + \alpha q_0)R_{L2} - \frac{1}{2} \frac{\gamma}{1-h} R_{L2}^2 - (p + q)R_{L2}. \]

Here \( q_0 \) denotes the average carbon price faced by the country’s foreign competitors, \( \alpha \) being a parameter between zero and one, which indicates the degree to which the international export price of the good produced in sector 2 is affected by international carbon pricing. The first-order condition for producers in this sector gives the following solution for optimal energy use:

\[ R_{L2} = (1-h) \frac{1-p-q+\alpha q_0}{\gamma}. \]

From (29), in the special case of \( \alpha = 1 \), there is no impact of simultaneous and equal domestic and international carbon pricing on energy use, nor carbon emissions or output, in sector 2. We would however in practice expect international carbon pricing to have some impact on the output of exportable goods (otherwise there would be no effect of \( q \) as a climate policy instrument); so realistic values of \( \alpha \) are less than unity.

Sector 2 profits can be expressed as

\[ W_{L2} = (1-h) \frac{(1-p-q+\alpha q_0)^2}{\gamma}. \]

I consider three cases.

In case 1, the L country would not impose any carbon tax on its exposed sector in the absence of similar taxation elsewhere. But the country would impose a carbon tax in response to carbon taxation in other countries, at a level that retains the same profit level in the export sector as before the imposition of any carbon taxes. We see, from (30), that the (maximum) carbon tax the country
would impose in this case is $q = \alpha q_0$. This level is positive, but lower than the average carbon tax elsewhere.

This is a case with a “weak” conditional carbon tax policy to protect the exposed sector. We here do not specify any unconditional policy. Carbon emissions, exposed sector output, and sector profits would here be the same under domestic and foreign carbon taxes, as in the case of no carbon taxes in either region.

One may in this case plausibly argue that no additional mitigation actually takes place in the L country. But it may alternatively be relevant consider the situation with positive carbon taxes on average “elsewhere” (perhaps mainly in H countries), and no carbon tax in country L, as the “baseline” against which any policy instruments are evaluated. Under this baseline, the L country’s energy consumption, and emissions, would be higher, namely

$$(31) \quad R_{L2} = (1-h) \frac{1-p + \alpha q_0}{\gamma}.$$  

Against this new and higher baseline level, (31) with $q = \alpha q_0$ represents an emissions reduction, in the (future) period when positive carbon taxes will be imposed “elsewhere”.

In case 2, assume that the L country would regardless impose an unconditional carbon tax $v_L$ on the export sector, and in addition respond as in case 1 above, so that the carbon tax facing the export sector would be $q = v_L + \alpha q_0$. Carbon emissions from (the exposed) sector 2 would be

$$(32) \quad R_{L2} = (1-h) \frac{1-p-v_L}{\gamma}.$$  

Carbon emissions, output and profits would then be reduced in the L country. Carbon emissions would be reduced by $(1-h)v_L/\gamma$. 

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In case 3, the L country is willing to engage in more cooperative behavior by matching any outside average carbon price. The carbon price facing the export sector would be \( q_0 \), and energy use (or carbon emissions) would be

\[
R_{L2} = (1-h)\left(1 - \frac{1-p-(1-\alpha)q_0}{\gamma}\right).
\]

Profits would be reduced to

\[
W_{L2} = (1-h)\left(1 - \frac{(1-p-(1-\alpha)q_0)^2}{\gamma}\right).
\]

Profits would here however be reduced by (perhaps considerably) less than if only the L country increased its carbon taxation, and other countries did not.

(33) defines the most ambitious conditional policy of the L country considered in this section.

Case 3 gives no determination of an unconditional policy. Note however that the carbon tax of an L country, which applies to the entire economy, would be the sum of the unconditionally-motivated tax, and the conditionally-motivated part of it. By such reasoning, the conditionally-motivated carbon tax would equal \( q_0 - v_L \) (which we assume is positive).

There are some fundamental differences between the policies considered in this section, and those in sections 3-4 which depend on financial contributions. First, in contrast to previous sections, I here do not assume any individual (non-cooperative) optimizing framework. The presentation of alternative policies is more ad-hoc and only indicative of some ways in which benign cooperation can be forged between parties to the PA. More analytical work is clearly needed. Secondly, the policies discussed in this section involve no financial transfers. This obviously makes them more
attractive to H countries, and less attractive to L countries, compared to policies discussed earlier, as there is no direct financial reward to L countries, and no financial costs for H countries. But the solutions indicated here could easily be more efficient. Domestically imposed carbon taxes are likely to work better than externally imposed carbon purchase schemes; although the inefficiencies related to the latter are complex and far from fully explored here.

6. Conclusions and final comments

I have in this paper discussed GHG mitigation policies for parties to the PA, focusing on “unconditional” and “conditional” nationally determined contributions (NDCs) of “low-ambition” (L) countries, and on how these can or should be interpreted, and possibly supported by donors or “high-ambition” (H) countries.

A key conclusion is that quantitative GHG mitigation targets should preferably be formulated as carbon price targets. The climate policies considered in sections 3-4 involve uniform carbon price targets for an entire economy, thus making overall mitigation target least costly to reach.

Unconditional NDCs are interpreted in a very simple way, namely as carbon tax policies established by individual L countries, equal to each country’s marginal damage cost from its own emissions (including co-benefits). Three forms of conditional NDCs are considered. The two first are conditional on financial support from the H bloc to the L country, either directly in support of all emissions-reducing activities, or to investments in new renewable energy capacity. Thirdly, mitigation action in L countries can be conditional on particular policies by other countries, or new options for policy choice. This could include the condition that carbon taxes be imposed by other countries; or that the L country can use border taxes to protect its own exposed industries. The two
former types of conditionality is associated with financial transfers from H to L countries, which makes them less attractive for the former and more attractive to the latter country group.

A conclusion is that establishing a (robust) economy-wide carbon price will be essential to achieving substantial and efficient mitigation in L countries. An optimal mitigation policy for an L country will, generally speaking, entail both a scaling-back of its fossil-fuel consumption, as discussed in section 3; and a switch from fossils to renewables, as discussed in section 4. A robust, economy-wide, carbon price is useful for both and also makes technology switches from fossil fuels to renewables more attractive to outside financing sources.

In section 3 I find that optimal support payments from an H region to induce (conditional) GHG mitigation in L countries, tend to be lower than the carbon tax or price the H region would itself impose internally. Such support payments still imply higher conditional carbon prices than the unconditional carbon prices that the L countries themselves are willing to impose. This leads to a “hierarchy” of carbon prices:

- a “high” carbon price, $v_H$, within the H bloc, for the H bloc’s own mitigation activity;
- “Intermediate” carbon prices for the H bloc’s support to (conditional) mitigation in L countries, typically between $[(1-\rho)v_H + v_L]/2$, and $v_H$;
- “Low” carbon prices $v_L$ corresponding to the unconditional NDC targets of L countries.

Another implication is that when an unconditional NDC is set arbitrarily by an L country, there can be no guarantee that this NDC will correspond to the marginal valuation $v_L$, related to the country’s own mitigation, required for optimality.
A similar argument holds for conditional NDC targets, and the carbon prices implied by these. Most L will not know, a priori, the amount of future support required for such implementation, nor the amount of mitigation induced by a given support.

This analysis can be interpreted both normatively and positively. First, normatively: what carbon price is needed to achieve an L country’s stated NDC? Positively: If the country applies instruments “optimally” (setting a uniform carbon price for the entire economy), would mitigation (say, by 2030) correspond to the stated NDC? Both are important for understanding the policy ambition needed to achieve outcomes compatible with NDC targets under the PA.

Fundamentally, setting different carbon prices in different countries and regions is globally inefficient. A global solution that minimizes mitigation costs for given global mitigation action requires a single global carbon price. Optimal global mitigation action requires a single carbon price equal to (at least) $v_H + v_L$ (when these are the only groups concerned with GHG emissions; otherwise the optimal carbon price is higher).

But the PA is a “bottom-up” agreement, comprising a collection of essentially non-cooperative initiatives by individual countries (but where some groups of these might form “climate clubs”). It does not constitute a framework for implementing anything close to globally efficient mitigation. On the other hand, by raising the effective carbon price in some regions (L countries), beyond the levels chosen by the countries themselves ($v_L$), mitigation will be greater, and more efficient, than without such policies.

It appears difficult within the framework of the PA to establish a global carbon market with a unified carbon price, required for globally efficient mitigation. Holtmark and Midttømme (2016) have recently shown that linking carbon markets, with comprehensive international trading of
permits, can lead to dynamic efficiency improvements when abatement takes the form of investments in renewable and durable energy capacity. Similar optimism is expressed in World Bank (2016), chapter 4; Haites (2015); Ranson and Stavins (2015); and Doda and Taschini (2016). Others including Helm (2003), Rehanz and Tol (2005), Flachsland et al (2009), and Mehling and Haites (2009), and Holtmark and Sommervoll (2012), have warned that linking is not likely to increase countries’ ambitions to mitigate. I do not discuss two practically important caveats. First, setting quantitative GHG emissions targets is inferior to setting taxes in a wide range of circumstances, in particular from the point of view of net energy importers (most countries outside of the OPEC); see Strand (2013); Karp et al (2016). Secondly, high-income countries seem today not willing to make the transfers required for the solutions in sections 3-4.

Additional arguments exist that favor subsidizing renewables, including positive externalities generated by renewables support when technologies are endogenous; and technology transfer to L countries being favorable for economic development. When providing financial support with the aim to increase the carbon price, one runs the risk that such support is poorly targeted, as seeking such funding is attractive to all emitters in L countries, also to those who would carry out mitigation even in the absence of support. This risk might be less for investments in new renewables production capacity. Renewables investments could be more “transformational” to L countries by steering them onto more benign future development paths and increasing their technology levels; see e.g. Fischer and Newell (2008), and Goulder and Parry (2008). Fiscal implications of carbon taxation differ dramatically from providing financial support to mitigation, the second alternative being vastly more expensive to funders, and more distortive when taxation is distortive; see Jones, Keen and Strand (2013). Comprehensive carbon pricing or taxation is politically difficult to implement in most L countries. In part such difficulties are related to the gains from mitigation
support policies which receiving countries would forego when implementing their own carbon taxes or other charges, and which they work hard to retain.

How should support policies from H to L countries be organized? While the KP relied on offset purchases by individual private parties in H countries (and with highly inadequate offset purchase volumes from the point of view of L countries), this may be less viable under the PA. One reason is that many L countries target their conditional mitigation to be credited toward their NDCs: this precludes offsetting as crediting buyers would then lead to double-counting. In theory, the Green Climate Fund could serve the role as a buyer of offsets (to be immediately retired), but its current funding is just a trickle relative to the needed level. All these issues mentioned arise as important challenges for the PA in the time ahead.

A final point is how targets are formulated in countries’ NDCs. Targets are for most countries set either relative to (imperfectly predicted) “business-as-usual” outcomes; or to “benchmarks” for emissions which could be set deliberately high so that the intended policy action is exaggerated. A case in point is Brazil, which specifies an unconditional GHG emissions reduction of 37% by 2025 relative to the base or “benchmark” year of 2005 in its NDC; and a slightly more ambitious target of 43% reduction by 2030. In 2005, Amazon deforestation contributed about half of Brazil’s total GHG emissions (about 1 billion tons CO2 out of a national total of 2.1 billion tons). By 2015, Amazon deforestation had been reduced by about 80% relative to its 2005 level. This reduction alone reduced Brazil’s total GHG emissions almost all the way to the 2025 INDC target level. The real further commitment of Brazil is thus to reduce overall GHG emissions slightly from now on and until 2030. This is a highly laudable target, but less impressive than how it appears on basis of Brazil’s formal INDC.
References:


UNFCCC (2016), Intended Nationally Determined Contributions. (http://unfccc.int/focus/indc_portal/items/8766.php)