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Delayed Participation of Developing Countries to Climate Agreements: Should Action in the EU and US be Postponed?

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Abstract
This paper analyses the cost implications for climate policy in developed countries if developing countries are unwilling to adopt measures to reduce their own GHG emissions. First, we assume that a 450 CO2 (550 CO2e) ppmv stabilisation target is to be achieved and that Non Annex1 (NA1) countries decide to delay their GHG emission reductions by 30 years. What would be the cost difference between this scenario and a case in which both developed and developing countries start reducing their emissions at the same time? Then, we look at a scenario in which the timing of developing countries' participation is uncertain and again we compute the costs of climate policy in developed and developing countries. We find that delayed participation of NA1 countries has a negative impact on climate policy costs. Economic inefficiencies can be as large as 10-25 TlnUSD. However, this additional cost wanes when developing countries are allowed to trade emission reductions from their baseline emission paths during the 30-year delay period. Thus, irrespective of whether NA1 countries are immediately assigned an emission reduction target or not, they should nonetheless be included in a global carbon market. Technology deployment is also affected by the timing of developing countries' mitigation measures. Delayed NA1-country participation in a climate agreement would scale down the deployment of coal with CCS throughout the century. On the other hand, innovation in the form of energy R&D investments would be positively affected, since it would become crucial in developed countries. Finally, uncertainty about the timing of NA1-country participation does not modify the optimal abatement strategy for developed countries and does not alter policy costs as long as a global carbon market is in place.

Keywords
Delayed Action, Climate Policy, Stabilisation Costs, Uncertain Participation

JEL Codes
C72, H23, Q25, Q28

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1. Introduction

The Bali Action Plan reaffirms the principle of common but differentiated responsibilities and respective capabilities, thus emphasizing the different roles that Annex 1 (A1) and non Annex 1 (NA1) countries will play in an international climate agreement. When and how NA1 countries will participate in an international climate agreement, however, is still extremely uncertain.

The reasons why progress towards a global agreement on GHG emission control is slow relate mainly to differences in countries' historical responsibilities, mitigation potentials and climate change vulnerabilities. In particular, developing countries are more vulnerable to extensive damages from climate change, while bearing little historical responsibilities. Another reason that discourages NA1 countries' participation to a binding mitigation agreement is the extremely unequal distribution of emissions per capita around the world. This gives rise to an equity-based argument for postponing any emission-curbing action in NA1 countries. Unwilling to control their GHG emissions, NA1 countries are providing A1 countries with one of the most frequently used motives for postponing abatement: alone, A1 countries cannot do much to stabilise GHG concentrations given the growing international weight of developing countries' economic activities.

Although hard to achieve, an international agreement aiming at stabilising the atmospheric concentration of CO2 at about 450 ppm has been foreseen by the scientific community as the only way to limit the increase in the average global temperature to within about two degrees. The economic cost of such a stringent target is usually computed by assuming the immediate participation of all countries to a global agreement. This is, for example, the assumption underlying the estimates of climate policy costs as reported in the IPCC 4ar. There are just a few recent exceptions (Cf. Edmonds et al., 2007; Keppa and Rao, 2007) but they all concentrate on a first best analysis where incentives for countries to free ride are not taken into account.[1] In addition, these papers do not model a carbon-tradable permit system, nor do they take into account uncertainty affecting the participation of different countries.

This paper aims at filling this gap by investigating the implications of delays and uncertainties in developing countries' participation in a climate agreement designed to achieve a stringent GHG stabilization target. We provide insights in terms of mitigation strategies and economic costs, with a particular focus on the implications for the design of an international emission trading scheme. The analysis is carried out using WITCH, a hybrid climate-economy model of 12 world regions in which energy technologies are carefully modelled. A detailed description of WITCH is to be found in Bosetti *et al.* (2006) [2]. The regional structure of the model allows us to analyze different timing of NA1 countries' participation to an international climate agreement.

The paper is structured as follows. Section 2 summarizes the debate on developing countries' delayed participation, whereas Section 3 describes the model optimisation experiments. Effects of delayed participation on GHG abatement, policy costs and the deployment of different technologies are discussed in Section 4, 5 and 6, respectively. Section 7 contains an analysis of the cost of delayed participation when the timing of participation is uncertain. Some concluding remarks and scope for further research are provided in Section 8.

[1] Either a central planner is assumed or the economic cost is the output of a fully cooperative equilibrium.

[2] See also www.feem-web.it/WITCH

2. Stabilisation targets with immediate and delayed participation of developing regions.

The economic cost of any stabilisation target crucially depends on the reference scenario. In this paper, the reference scenario is obtained by computing the Nash non-cooperative equilibrium of the game between the 12 regions of the world that are modelled in WITCH in the absence of any international climate policy. In the reference scenario, free-riding behaviours are accounted for, along with incentives to reduce GHG emissions deriving from perceived domestic damages.

Figure 1 shows the equilibrium world carbon emissions from 2005 to 2100 in our BaU scenario. Emissions are projected to grow throughout the century, though at a decreasing rate in the second half, to reach about 21 GtC by 2100. Figure 1 also shows the equilibrium emissions when the constraint that GHG concentrations must be stabilised at 450 ppm (CO_2 only) is introduced. Stabilising CO_2 concentrations at 450 ppm (or, equivalently, at a radiative forcing of all GHGs equal to 3.5 W/m^2) would require drastic mitigation efforts, with no emission overshooting and eventually stabilisation at about 2-3 GtC per year in the second half of the century.

The global mitigation effort, i.e. the difference between the reference and the stabilisation emission profile, is shown in red in Figure 1. Such an effort can be shared among world regions according to different burden-sharing rules. In our analysis, we assume a “contraction and convergence” scheme, which implies that allowances are initially allocated on the basis of present emissions, but converge to an equal per capita emissions allocation by 2050. The implied abatement objectives and consequent shares of allowances for A1 and NA1 countries are shown in Figure 2. A1 countries face a higher initial abatement effort (left panel). Over time, NA1 countries take the lead as their share of emissions increases. In terms of the emission target (right panel), this translates into a gradually decreasing target for A1 countries and into a roughly constant one for NA1 countries. However, developing countries might argue that a steady target set around 2005 levels is not compatible with the fast development of their economic systems. This leads us to investigate the implications of a possible delay in NA1 countries' participation.

Figure 1. Global BaU and stabilisation emission profiles (2002-2102)

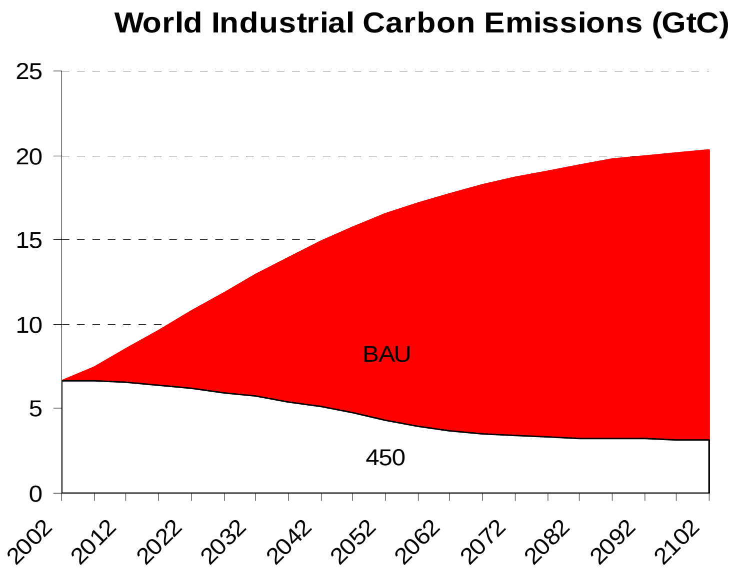
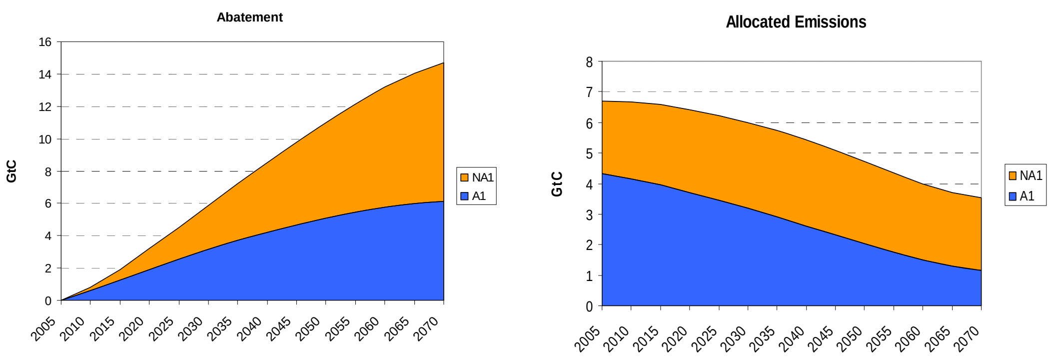


Figure 2 – Abatement and allocated emissions in the immediate participation scenario (2005-2070)



Let us assume that developing countries join a climate coalition for the first time in 2035. From this date, a global cap and trade scheme is implemented. Before 2035, a cap and trade climate policy is operational only in A1 countries. The effect of NA1 countries participating from 2035 is shown in Figure 3. Obviously, A1 countries bear the whole mitigation effort until NA1 countries join (left panel). Given the growing share of developing countries' emissions, the target A1 countries face tightens very rapidly, to almost zero emissions in only 30 years (right panel).

Figure 3 – Abatement and allocated emissions in the late participation scenario (2005-2070)

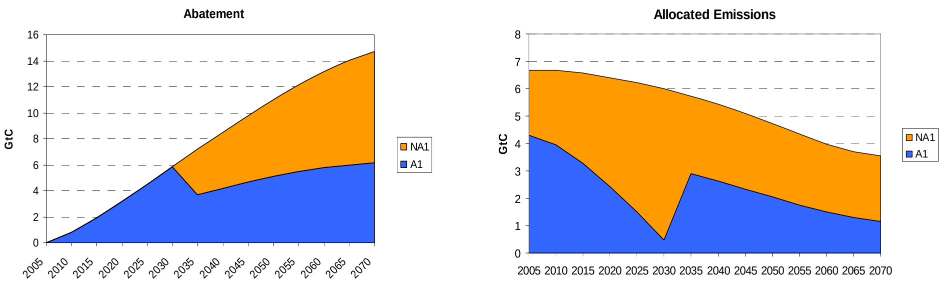


Figure 3 shows the increasing relevance of NA1 countries' emissions and the major consequences that their delay would have on the rest of the world. NA1 countries must join not later than 30 years from now, if A1 countries are not to face negative emission targets! However, as we will argue in the next sections, the situation could be improved, i.e. the delay period could be prolonged, if non-participatory countries are allowed to sell their emission reductions (with respect to their BaU emission paths) to A1 countries.

3. Climate policy scenarios

Let us provide a detailed analysis of the implications of different climate policy scenarios on the cost of climate policy, on actual GHG emissions and on energy investment strategies in different regions of the world. As we have said, in all policy scenarios world emissions are assumed to be constrained to follow a path consistent with stabilisation of CO2 concentrations at 450 ppm by 2100, or equivalently at a 3.5 W/m^2 radiative forcing including all GHG gases.[3] This global emission target is shared via a “contraction and convergence” allocation rule for A1 countries before 2035, and for all countries afterwards. In one scenario (see below), NA1 countries participate in the global carbon market without binding commitments before 2035, and in this period they are thus allocated their BaU emissions.[4] International carbon trading is modelled via an iterative algorithm that mimics a process of *tâtonnement* for a perfect market. We thus assume zero transaction costs, a hypothesis justified by the large volume of carbon trading.

Banking is permitted in order to allow participatory countries to vary their emissions in response to other countries’ delay in participation while respecting the global cap. We do not allow borrowing and speculative behaviour which is in line with the Kyoto protocol rules. Using WITCH, we compare the case of immediate participation versus a set of cases with delayed participation. These cases can be described as follows:

- **entry now**: all countries participate to the international climate agreement from the beginning.
- **entry 2035**: NA1 countries join the climate coalitions in 2035.[5] A1 countries bear all the mitigation effort before then, with the resulting target shown in Figure 3. We distinguish between two sub cases:
    - **w/out trade**: carbon trading is permitted only among participatory countries. And again we distinguish between two sub-cases:
        - in the first one, NA1 countries cannot anticipate that they will agree on a stabilization target from 2035 onward, Therefore, all their choice variables are fixed

[3] Choosing looser climate targets would make the analysis less interesting because of the higher possibility of moving emissions across the century.

[4] We also considered other burden sharing schemes such as “equal per capita” and “sovereignty” to explore a wide range of plausible allocations. We found that results are robust across schemes, and thus only the “contraction and convergence” case is presented here.

[5] Earlier and later participation dates were also analysed, with consistent results.

at the BAU levels from 2005 to 2035. We call this case **w/out trade myopic**.

  - in the second one, NA1 countries set their policy strategy from 2005 to 2035 taking into account that they will participate in a climate agreement aiming at stabilizing emissions at 450 ppm from 2035 onward. We call this case **w/out trade**.

- **with trade**: before 2035, NA1 can trade emission reductions from their baseline emission paths even though they do not participate to the climate policy agreement.

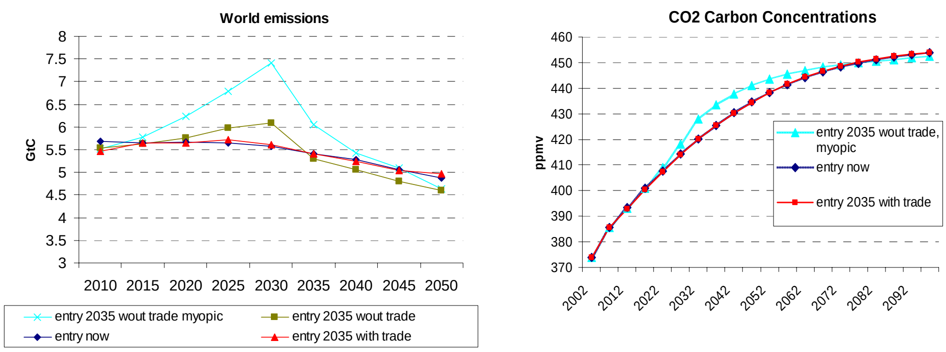
A final experiment is performed to analyse the case in which the timing of participation is uncertain. We assume that NA1 countries will join the climate coalition in 2035 with 50% probability and in 2050 with the residual probability. This **stochastic** case is implemented using the stochastic programming version of the WITCH model (see Bosetti and Tavoni, 2007 for a detailed description).

4. Implications of developing countries' delayed participation for global GHG emissions

We start by analysing the environmental implications of developing countries delaying their accession to a climate agreement. The left panel of Figure 4 shows fossil fuel emissions. Delayed participation with trade restricted to participatory countries induces higher global emissions before global accession. This means that lost abatement from NA1 countries is not totally compensated by A1 countries' extra effort, because of the very stringent target A1 countries are confronted with.

Even though the stringency of the overall target limits the postponement of abatement, up to 2 GtC/yr of abated emissions shift from the first period (before 2035) to the second one; i.e. they are added to the already large abatement effort that must be carried out in the second part of the century (not shown in the graphs). This postponed abatement is especially evident in the case in which NA1 countries do not anticipate their forthcoming climate obligation (*w/out trade myopic case*), and thus do not undertake measures to reduce emissions below their baselines. If instead they start reducing emissions before 2035 (because it is cost effective from their own unilateral and intertemporal viewpoint and not because they sign a climate agreement), extra emissions are significantly less (*w/out trade case*).

Figure 4: World emissions from fossil fuels and carbon concentrations



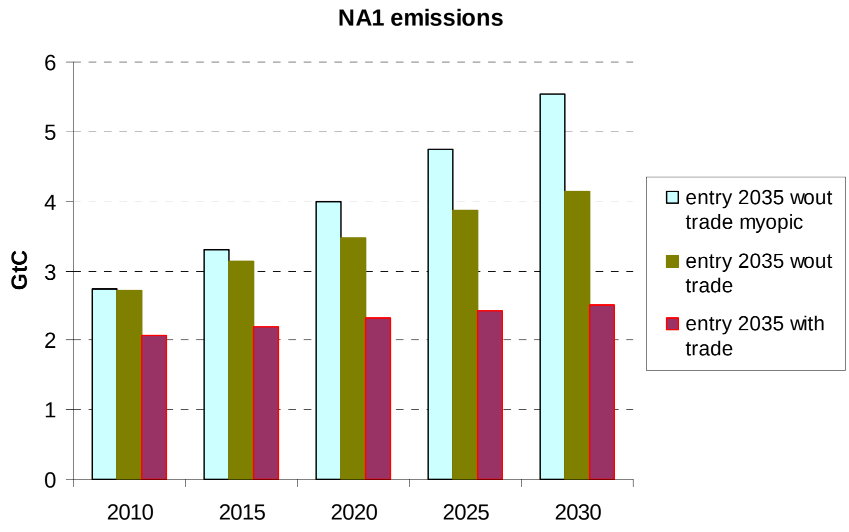
When NA1 countries are allowed to participate in the carbon market even before 2035 (*with trade case*), emissions are brought back to essentially the same levels as the immediate participation case. The negative environmental implications of delayed NA1-country participation is thus offset by the existence of a global carbon market (in which NA1 countries are allocated their BAU emission levels). This is confirmed in the right panel of Figure 4, which reports the evolution of atmospheric carbon concentrations over the century. Limiting trading induces an increase in concentrations from 2020 onwards. This has important implications also for the deployment of low carbon technologies, as explained in Section 6.

A closer inspection of NA1 countries' emissions reveals an interesting result. As already mentioned, the WITCH model features a game theoretical set up in which regions choose their investments strategically, by taking all other regions’ behaviour into account. When A1 countries participate in a climate agreement, they have an impact on global emissions which is ultimately taken into account by NA1 regions. This interaction occurs via different channels. First, a stringent climate policy lowers consumption and thus prices of exhaustible resources such as fossil fuels. Accordingly, countries not involved in a climate agreement have access to cheaper resources and have the incentive to increase their emissions with respect to the case in which there is no agreement. On the other hand, A1 countries’ commitment to a climate policy fosters technical change in low carbon technologies, thus decreasing their prices and making them economically attractive also in developing countries. Finally, given the perfect foresight nature of the model, A1 and NA1 countries foresee the eventual (after 2035) target and accordingly adjust their investment choices given the low capital turnover of energy investments.

Figure 5 shows how the two latter forces prevail in our setting. When NA1 countries are not allowed to trade emission permits, they nonetheless emit less than they would do in a BaU scenario (which is equivalent to the myopic case before 2035). The argument of inertia of investments especially motivates an anticipatory behaviour in developing countries, although this is significant only after 2020.

More decisive and immediate action to reduce emissions can be observed when NA1 countries are allowed to sell emission reductions from their baseline in the carbon market (see Figure 5 again). In this case, emissions grow at a much lower rate because NA1 countries benefit from selling allowances and A1 countries reduce emissions in NA 1 regions (because it is less costly).

Figure 5 – Comparison of NA1 countries' emissions across scenarios



5. Implications of developing countries' delayed participation on climate policy costs

Let us now turn to the economic implications of delayed NA1-country participation. Figure 6 shows the effects on international carbon prices. Prices increase very significantly without NA1 countries' participation, roughly three times compared to the full participation case, to over 1500$/tC (400 $/tCO2) just before NA1 countries join the coalition. This follows on from the fact that the A1 countries' target becomes very severe, as shown in Figure 3. In the myopic case, where NA1 countries do not anticipate their future emission reduction targets, prices remain higher even after they join the agreement, given the inefficient energy infrastructure that would have been built and that would make it harder for NA1 countries to reach their own target.

Granting non-participatory countries access to the carbon market brings international carbon prices down to the values that would emerge in the immediate participation case, as the carbon trading instrument tends to equalize marginal abatement costs across regions. Prices remain slightly higher in the first part of the century, and lower thereafter (not shown in Figure 6); this is a consequence of the banking option that allows the intertemporal transfer of carbon rights, which implies that the amount of emissions in each time period is not independent of the distribution of permits.[6] However, as the graph shows, this effect is very limited when compared to the effect of carbon trading restrictions.

Figure 6. Carbon prices across scenarios

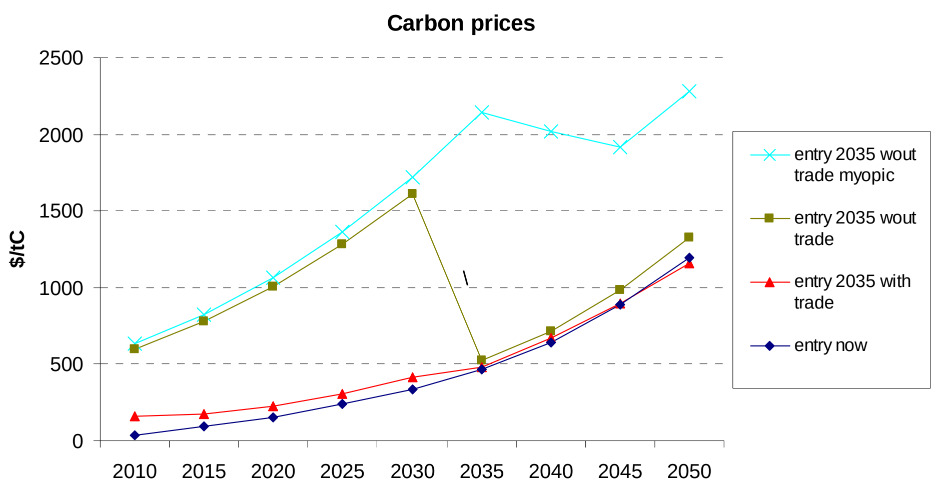


Table 1 shows the economic cost of achieving the 450 ppm target in the various policy scenarios. Costs are expressed as net present value of future world GDP losses using a 5% discount rate.

Table 1. Policy costs across scenarios

NPV GDP loss 2000-2100	WORLD	A1	NA1
Entry now	2.1 %	1.7 %	2.8 %
Entry 2035 w/out trade	2.8 % (+11 USDTln)	3.0 % (+12.6 USDTln)	2.5 % (-1.6 USDTln)
Entry 2035 w/out trade and myopic	3.7% (+24.6 USDTln)	3.1 % (+13.9 USDTln)	5.1 % (+10.7 USDTln)
Entry 2035 with trade	2 % (-0.9 USDTln)	2 % (+3 USDTln)	2 % (-3.9 USDTln)

[6] The analysis of the effect of banking on the implications of climate policy under different allocation schemes is contained in Bosetti, Carraro and Massetti (2008).

Achieving the 450 ppm stabilization target in the base case of immediate participation will imply a 2.1% loss of world GDP. Delaying NA1 countries' participation would negatively affect the cost of climate policy, by 2.8% and 3.7% depending on whether NA1 countries anticipate their future target or not. That is, we value the inefficiency of constraining "where-when" flexibilities in the range of 11-25 trillion 1995USD.

However, this extra cost cancels out when a global carbon market is introduced before 2035. Global costs are brought back to around 2%, and we actually observe slightly lower costs in this case. This derives from the fact that the very stringent target for A1 countries creates an incentive to make larger investments in energy-related R&D and in carbon-free technology, which then creates a positive intertemporal spillover effect.

Looking at the regional distribution of the policy costs, the contraction and convergence scheme in the full participation case entails higher economic losses for NA1 countries (2.8%) than for A1 countries (1.7%). If NA1 countries delay their participation, A1 countries face a notable increase in cost, to around 3% of GDP when NA1 countries are outside the global carbon market. This is equivalent to an extra economic loss for A1 countries of approximately 13 trillion USD; however, this cost could be significantly cut down (by 10 trillion) if NA1 countries were allowed to trade from their baseline emissions before 2035. NA1 countries face slightly lower costs (1.6 trillion) when they defer their involvement, but they are drastically higher (10 trillion) when they behave myopically by following their BaU emission path for 30 years, and subsequently commit to emissions reductions.

A carbon market in which all regions trade before 2035 has the implication of partitioning global policy costs into two equal portions: both A1 and NA1 countries would pay 2% of their GDP to achieve the climate target. A1 countries' transfers to NA1 countries increase by 3 trillion, but that avoids a 13.9 trillion loss to achieve the same climate objective by means of autarkic measures.

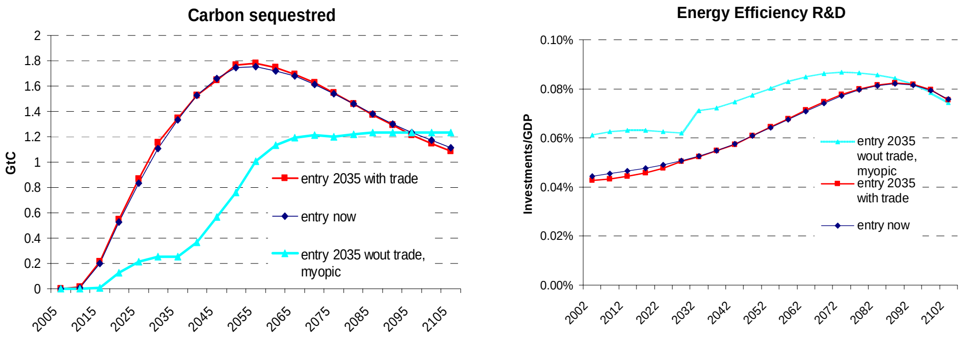
6. Implications of developing countries' delayed participation on energy technology

One might wonder about the implications of developing countries' delayed participation for the deployment of abatement technologies. Developing countries are believed to host a substantial number of cheap mitigation options which arise from high energy intensities and capital replacement as a result of rapidly expanding economies. On the other hand, developed countries possess a more-than-proportional share of the human capital and research infrastructure that are needed for the technological innovation that is often advocated as the key to the decoupling of mitigation and economy.

Figure 7 shows the penetration of two important abatement options in the energy sector: power generation with coal and CCS (left panel) and energy efficiency enhancing research and development (right panel).

Carbon capture and storage (CCS) is considered to be one of the crucial low carbon technologies, because it would allow the world to continue to use affordable fossil fuels and at the same time reduce carbon emissions. Therefore, it is expected to play an important role, especially in countries that heavily rely on coal for generating energy, such as China and India for example, which are among NA1 countries. Postponing their participation in a climate agreement along with excluding them from the carbon market would reduce the diffusion of CCS significantly, as reported in Figure 7 (see the *myopic case*).

Figure 7. Energy mitigation technologies



After NA1 countries join the coalition in 2035, CCS would revive; interestingly enough, however, both its growth rate and maximum penetration would be jeopardized throughout the whole century. The reason for this downscaling can be attributed to the fact that CCS does not completely offset carbon emissions. In line with the engineering literature, we assume that only 90% of carbon can be captured and injected, and that the remaining 10% is vented. This imperfect abatement rate is penalising if mitigation targets are very severe, in which case virtually carbon free technologies such as renewable energy and nuclear power are preferred. This is exactly what happens when NA1 countries delay their participation and cannot trade permits, and part of the abatement effort is shifted to the second half of the century[7].

A contrasting picture emerges when we look at investments in energy innovation (Figure 7, right). Delayed participation and no carbon trading results in higher investments in energy efficiency R&D, since A1 countries' tight emission target must be achieved through innovation measures, given the limited availability of mitigation options in currently used technologies. This more 'innovation-centred' investment behaviour persists even after NA1 countries join the coalition, because of the positive intertemporal spillover from R&D activity ("standing on shoulder") that is

[7] Improving the carbon capture rate (through dedicated investments) could alleviate this effect. On the other hand, potential leakage from the reservoirs (assumed to be zero in our simulations) would exacerbate it.

accounted for in our framework.[8] It's worth noting that allowing for a global carbon market even before 2035 implies the same path of technology adoption as in the case of immediate participation, in line with the findings of the previous section.

7. Effects of uncertainty on the timing of participation

As a final experiment, we move from a deterministic to a stochastic context by introducing uncertainty about the timing of NA1 countries' participation. The date of their participation in a binding climate agreement is clearly very indeterminate and the resulting uncertainty has important implications for short-term investment strategies and policy measures.

We employ a stochastic programming version of the WITCH model, framing the analysis on a scenario tree, solving for all scenarios simultaneously and accounting for non-anticipativity constraints (action has to be the same for different scenarios before the disclosure of uncertainty in 2035, while the optimal reaction to the information revealed when uncertainty is eliminated is allowed afterwards). This formulation enables us to devise the optimal strategy before uncertainty is disclosed, and identify potentially optimal hedging behaviour. It also enables us to determine the most suitable portfolio of mitigation technologies given the uncertainty about the timing of NA1-country participation.[9]

We assume the probability distribution of participation time for NA1 countries to be as follows: with 50% probability they will join the climate coalition in 2035, and with the remaining 50% probability they will do so in 2050. We analyse only the case in which NA1 countries are allowed to trade permits before 2035. If they are not - as shown in Section 2 - A1 countries alone would not be able to bear the whole mitigation effort after 2035 (unless we allow for the possibility of achieving negative emissions).

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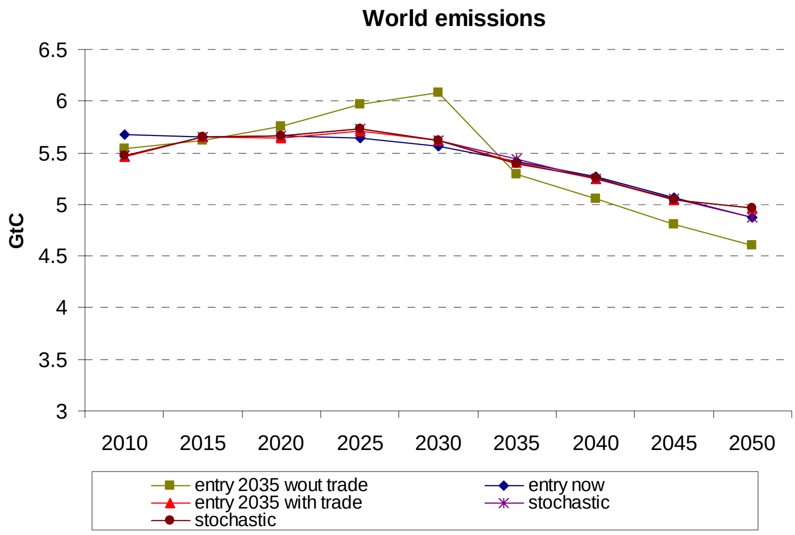
[8] Interregional spillovers are not modelled here, since they would have a limited impact on the results (see Bosetti et al. 2007a).

[9] The stochastic version of WITCH has already been used to analyse the effects of uncertainty about the effectiveness of energy R&D investments (see Bosetti and Tavoni, 2008).

Let us focus on the equilibrium strategy before uncertainty is resolved in 2035. Figure 8 shows global carbon emissions in the deterministic and stochastic cases. The stochastic path (in brown) is very similar to the deterministic one with participation of NA1 countries in 2035. The stochastic equilibrium strategy (the hedging strategy) overlaps the deterministic strategy when NA1 countries are supposed to sign a binding climate agreement in 2035, but allowed to trade from their BAU before 2035. Similarly, the global cost of climate policy and the adoption (timing and size of investments) of mitigation technologies in the stochastic case are very similar to the deterministic one if NA1 countries are allowed to trade from their BAU before 2035.[10] As long as a global carbon market is in place, uncertainty over NA1-country participation (which may occur in 2050 rather than in 2035) does not affect the optimal strategies of A1 countries.

Figure 8. Global emissions for deterministic and stochastic cases



However, if emissions in developing countries remain unabated for more than 30 years from now - either because they do not accept any binding commitment and/or because a global permit market is not established - then the 450 ppm stabilization target becomes unattainable.

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[10] These results are available upon request.

8. Conclusions

If the world is serious about fighting global warming, scientific evidence indicates that stringent stabilization of carbon concentrations is needed by the end of the century. Setting a 450 ppm CO2 only (550 all GHGs) target requires that emissions are severely reduced from their baseline level. More than a thousand fossil-fuel-generated GtC would need to be abated throughout the century with respect to our projected baseline, three times total industrial emissions released into the atmosphere since 1750. This will require a substantial change of today's use of energy in industrialised countries. Beyond 2050, per capita emissions will need to be lowered to 0.3 tC/cap per year. This represents today's per capita emissions in India, which is only $1/10^{th}$ and $1/15^{th}$ of average EU and US per capita emissions respectively.

Such a difficult task requires global participation in a cooperative effort to control GHG emissions, and it will not be possible without cooperation from developing countries. The timing of these countries' participation to an international climate agreement, however, is at present very uncertain and likely to be effective only years, if not decades, from now. This consideration is often used to support the argument that emission abatement restricted to developed countries would be ineffective, given the growing CO2 emissions of developing countries. Yet, when computing the economic cost of achieving a given stabilization target (as for example in the IPCC4AR 2007), model experiments have traditionally assumed perfect "when"/"where" flexibilities in allocating the global effort in time and space.

This paper has evaluated the cost of climate policy taking into account the possibility of delayed NA1-country participation to a binding climate agreement. Results show that a 30-year delay in NA1-country participation has a severe impact on global carbon emissions with significant implications for climate policy costs. Our estimate of the additional cost imposed by delayed NA1-country participation is between 10 and 25 trillion USD. This negative effect wanes when non-participatory countries are allowed to trade emission reductions from their BaU emissions. Therefore, the optimal solution would be to establish a global carbon market even without binding emissions targets for NA1 countries, a suggestion in line with the existing literature on international agreements (Cf. Weyant and Hill 1999).

Technology deployment is also affected by the time of participation to the carbon market. We find that delayed participation of NA1 countries to the carbon market would jeopardize the large scale diffusion of carbon capture and sequestration technologies. On the other hand, technology innovation via energy R&D would be positively affected because of the urgent need in developed countries. Finally, uncertainty about the time of participation of NA1 countries does not seem to modify the optimal abatement strategy in A1 countries and the cost of climate policy as long as a global carbon market is in place.

Although our results are robust to different assumptions on the rate and timing of participation, a number of further improvements to our analysis would be useful. First, we have not considered mitigation options in the agro-forestry sector. In a previous paper (Tavoni et al. 2007) we showed that they could contribute to reducing global costs of climate policy. Given the importance and the timing of avoided deforestation, including it in the analysis would likely reinforce the argument in favour of a global carbon market. Second, carbon trading could occur even in the absence of a global carbon market, for example via trade of carbon intensive or bio-energy goods. Such effects are probably secondary when compared to the large flows registered in the international carbon market, but could lead to important terms-of-trade effects (McKibbin *at al.*, 1999) as well as "secondary costs" associated with pre-existing distortions and market imperfections (Babiker *et al.*, 2004). These effects are not yet included in the model and will be the focus of further research.

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