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Can Climate Policy Enhance Sustainability?

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Summary

Implementing an effective climate policy is one of the main challenges for our future. Even though ambitious mitigation targets are necessarily costly, curbing GHG emissions can prevent future irreversible impacts of climate change on human kind and the environment. Climate policy is therefore crucial for present and future generations. Nonetheless, one may wonder whether the economic and social dimensions of future global development could be harmed by climate policy. This paper addresses this question by examining some recent developments in international climate policy and considering different levels of cooperation that may arise in light of the outcomes of the Conference of the Parties recently held in Doha. Then it explores whether the implementation of various climate policy scenarios would help enhancing sustainability or rather whether there is a trade-off between climate policy and economic development and/or social cohesion. This is done by using a new comprehensive indicator, the FEEM Sustainability Index (FEEM SI), which aggregates several economic, social, and environmental indicators. The FEEM SI index is built into a recursive-dynamic Computable General Equilibrium (CGE) model of the world economy, thus offering the possibility of projecting all indicators into the future, and therefore delivering a perspective assessment of sustainability under different future climate policy scenarios. We find that the environmental component of sustainability improves at the regional and world level thanks to the GHG emission reductions achieved through climate policy. However, the economic and social components are affected negatively yet marginally. Hence, overall sustainability increases in all scenarios. If the USA, Canada, Japan and Russia would not contribute to mitigating future GHG emissions, as envisioned in one of our scenarios, sustainability in these countries would decrease and the overall effectiveness of climate policy in enhancing global sustainability would be offset.

Keywords: Climate policy, Computable General Equilibrium (CGE) Models, Sustainability, Indicators

JEL Classification: Q54, Q56, C68

This paper is part of the research carried out by the Climate Change and Sustainable Development Programme of the Fondazione Eni Enrico Mattei. Comments and suggestions from Silvio Giove, Enrica De Cian and other colleagues at FEEM are gratefully acknowledged. The usual disclaimer applies.

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Abstract

Implementing an effective climate policy is one of the main challenges for our future. Even though ambitious mitigation targets are necessarily costly, curbing GHG emissions can prevent future irreversible impacts of climate change on human kind and the environment. Climate policy is therefore crucial for present and future generations. Nonetheless, one may wonder whether the economic and social dimensions of future global development could be harmed by climate policy. This paper addresses this question by examining some recent developments in international climate policy and considering different levels of cooperation that may arise in light of the outcomes of the Conference of the Parties recently held in Doha. Then it explores whether the implementation of various climate policy scenarios would help enhancing sustainability or rather whether there is a trade-off between climate policy and economic development and/or social cohesion. This is done by using a new comprehensive indicator, the FEEM Sustainability Index (FEEM SI), which aggregates several economic, social, and environmental indicators. The FEEM SI index is built into a recursive-dynamic Computable General Equilibrium (CGE) model of the world economy, thus offering the possibility of projecting all indicators into the future, and therefore delivering a perspective assessment of sustainability under different future climate policy scenarios. We find that the environmental component of sustainability improves at the regional and world level thanks to the GHG emission reductions achieved through climate policy. However, the economic and social components are affected negatively yet marginally. Hence, overall sustainability increases in all scenarios. If the USA, Canada, Japan and Russia would not contribute to mitigating future GHG emissions, as envisioned in one of our scenarios, sustainability in these countries would decrease and the overall effectiveness of climate policy in enhancing global sustainability would be offset.

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1. Introduction

Designing and implementing an effective climate policy is often controversial because of the economic costs it entails and because it requires efforts that may slacken future growth, particularly in developing countries. A wide set of pledges were proposed at the 15th United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP-15) held in Copenhagen in December 2009. One of the crucial outcomes of the Conference was indeed that several countries, both developed and developing, committed to specific quantified emission targets or actions. However, the two subsequent Conferences of the Parties, held respectively in Cancun and Durban, failed to include these targets within a legal framework capable of coordinating the collective mitigation efforts after the expiration of the first commitment period of the Kyoto Protocol. The recent Conference in Doha postponed a global agreement to control climate change to 2015.

The variety of policy options that would possibly emerge from the latest climate change negotiations inevitably suggests analysing various policy scenarios, and within these scenarios the possible impacts of different policy measures. Elzen et al. (2009), for example, propose three scenarios depicting low and high abatement targets, as well as a common effort from Annex I and Non-Annex I countries for 2020. Mitigation costs are estimated to be between 0.01 and 2.24% of GDP, this later figure in the high cost scenario, i.e. a global effort in which Annex I countries aim at a 30% reduction target with respect to 1990, while Non-Annex I countries aim at a 16% reduction target with respect to baseline emissions. Total annual abatement costs with global emission trading are below 1% of GDP for all countries analysed. In another study, Mattoo et al. (2009) perform an analysis of global abatement efforts by means of a Computable General Equilibrium (CGE) model, focusing on different manufacturing exports and outputs. The different scenarios relate to the adoption of emissions trading systems (ETS) and public transfers to developing countries. Their main findings are that manufacturing output and export would face a decline especially in countries with higher carbon intensity. For low carbon-intensive countries these effects would be lower, and for some countries they could even be beneficial. Moreover, including trading in emission rights and transfers may intensify the decline of production in the manufacturing industry. In this study, abatement costs are estimated to be between 1.3% and 1.7% of World output in 2020.

These are just two examples. There are indeed many other papers and contributions addressing the costs of reducing GHG emissions under various scenarios on climate policy and this paper does not aim at reviewing this large body of literature. This study rather proposes a medium term assessment of GHG reduction efforts using a different approach. Rather than considering only the economic costs of stabilising GHG concentrations, it addresses within an integrated framework (the ICES general equilibrium model) the economic, social and environmental impacts of climate policy. This integrated framework yields various economic, social and environmental indicators, which are then used to evaluate the implications of climate policy using a composite index - the FEEM Sustainability Index (FEEM SI). The FEEM SI, built into a recursive-dynamic general equilibrium model, aggregates current and future impacts of climate policy into a single indicator. By using FEEM SI it is therefore possible to analyse whether the implementation of climate policy would help enhancing sustainability or rather whether there is a trade-off between climate policy and economic development and/or social cohesion.

The remainder of the paper is structured as follows. The next section briefly describes the current climate policy context starting from the Copenhagen Accord until the recent outcome of the Doha Conference. Section 3 introduces the FEEM SI and ICES, the general equilibrium framework used in our policy assessment. Section 4 describes and analyses the proposed climate policy scenarios along with the main simulation results on the likely impacts of sustainability on climate policy. Finally, Section 5 provides some conclusions and directions for future research.

2. Climate policy after Doha

The adoption of the Kyoto Protocol under the UNFCCC was just a first step towards a global emission reduction agreement. The Kyoto Protocol committed most industrialised nations and some economies in transition (Annex I Parties) to reduce their overall GHG emissions by 5.2% below 1990 levels, in the period between 2008 and 2012. Although the target has been attained, the Protocol did not reach enough international consensus to achieve the abatement level necessary to sufficiently mitigate the future effects of climate change. Overwhelming scientific evidence, indeed, highlights that the Kyoto target is not sufficient to reduce the increasing anthropogenic emissions in the atmosphere. If governments do not take further action to stabilise GHG concentration in the atmosphere, the average temperature by the end of this century may increase with the best estimate at the lower end of 1.8°C and at the upper end of 4°C (IPCC, 2007). In addition, delaying the adoption of effective climate policies will allegedly lead to higher costs to achieve ambitious stabilisation targets (Bosetti *et al*., 2008).

The first round of the Kyoto Protocol commitment expired at the end of 2012, and the second round (2012-2020) just started with fewer adhering countries and the same emission reduction target. Therefore, climate policy proceeds along a highly unsatisfactory path, at least as far as major impacts of future climate change are concerned.

Although high expectations preceded the 15th UNFCCC Conference of the Parties (COP-15), held in Copenhagen in December 2009, countries failed to define a new international climate agreement to replace the commitments of the Kyoto Protocol. During the preparatory talks, disagreement among major countries emerged on a number of matters. On the one hand, developing countries asked for stronger legally binding commitments and additional support in financing technology transfers by Annex I Parties, emphasising the historical responsibility of the developed economies. On the other hand, developed countries demanded a reduction commitment by developing countries, especially by the major emitters, such as China and India. They also supported the increase of financial resources from the private sector and the establishment of carbon markets.

In this context, the debate concerning future mitigation actions represented one of the most problematic political questions, causing a deadlock, which repeatedly blocked the negotiations. At the end of COP-15, a vague political agreement was delivered: the “Copenhagen Accord”, which did not impose any global commitment or binding emissions reduction target. On the contrary, Parties established a bottom-up pledge-and-review process by demanding both developed and developing countries to submit their own mitigation actions to the UNFCCC secretariat. One of the most crucial outcomes of COP 15 is indeed that all major emitting nations submitted an emission reduction plan. All Annex I Parties submitted their emission reduction targets (see UNFCCC 2011a) along with 39 Non-Annex I countries (see UNFCCC 2011b). Crucially, China will endeavour to lower its carbon dioxide emissions per unit of GDP by 40-45% by 2020 compared to the 2005 level. Similarly, India proposed to reduce the emissions intensity of its GDP by 20-25% by 2020 in comparison with the 2005 level.

Little progress was made on this matter during the subsequent Conference of the Parties held in Cancun, Mexico, in 2010, which mainly incorporated the key points of the Copenhagen Accord into the official UNFCCC process. The 17th Conference of the Parties, which took place in Durban in 2011, and the subsequent 18th Conference in Doha, eventually established that a second Kyoto commitment period begins on January 1, 2013 and ends on December 31, 2017 or 2020. However, not all countries joined this effort. During the negotiation, Canada, Japan and Russia officially declared they did not intend to participate in a second commitment period, while the US confirmed that they would not join the Kyoto Protocol. Most importantly, the “Durban Package” launched a new Working Group on the Durban Platform for Enhanced

Action with the objective to develop a new legal instrument applicable to all Parties, to be adopted by 2015 and to come into force in 2020 (UNFCCC 2011c). This commitment was confirmed in Doha. With this compromise, countries actually postponed a collective emissions reduction to after 2020, leaving the next few years' action up to the voluntary commitments, which single countries will undertake.

This brief summary of climate negotiations will be useful to understand the climate policy scenarios that will be later proposed when assessing the role of climate policy in enhancing sustainability.

3. Sustainability in a general equilibrium framework

The concept of sustainable development comes from the Bruntland Commission, which in 1987 defined it as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). Many other definitions followed, as well as attempts to measure the progress in this respect. Sustainability is a complex and multi-faceted concept embodying environmental, as well as economic and social dimensions. A valid tool to measure sustainability is a set of indicators (Parris and Kates, 2003; Singh and Gupta, 2009), given their synthetic properties as well as their role in supporting policymaking and making public communication easier. The indicators' aggregation procedure is more controversial; however, it is worth noting that an index, built with a transparent aggregation methodology, which is complementary to its single components, can be very useful to summarise a wide range of information, thus facilitating policy design, assessment and implementation.

Within this framework, the FEEM Sustainability Index (FEEM SI) summarises the three main components of sustainability (economic, social and environmental), which in turn result from the aggregation of theme-specific indicators. Figure 1 illustrates the tree structure of the FEEM SI.

The FEEM SI (see Annex 2 for more details) builds on the recursive-dynamic general equilibrium model ICES-SI, which includes an enhanced GTAP-E static core (Burniaux and Troung, 2002) and several other new components of the energy sector (see Carraro et al. 2011). Therefore, all indicator values stem from a coherent framework. Given its general equilibrium structure, ICES SI provides an ideal platform to analyse future scenarios of the world economy. ICES SI yields results for 40 regions, representing major countries as well as macro regions, and 17 economic sectors in each region. Some exogenous assumptions, relying on international projections (IMF, 2010; World Bank, 2010; IEA, 2010), and the endogenous dynamics of the model, allows building a baseline scenario for the main economic, social and environmental variables of the model for the period 2004-2050.

While different models are commonly used for the evaluation of sustainability impacts (Cf. Klaassen and Miketa, 2003), CGE models are not, even though they can bring added value to this field: they are flexible since not only can they incorporate several key sustainability indicators in a single micro-consistent framework, but they also allow performing a trade-off analysis among different components of sustainability. This feature is especially useful in analysing the effects of a policy implementation on both compliant and non-compliant regions: an intervention on one dimension of sustainability in one country not only influences the other sustainability sphere in that country, but it also influences other counties that have not undertaken any policy reforms, through international spillovers (Cf. Böhringer and Löschel, 2006). The consistency of multi-sector and multi-country interactions can only be guaranteed in a general equilibrium framework.

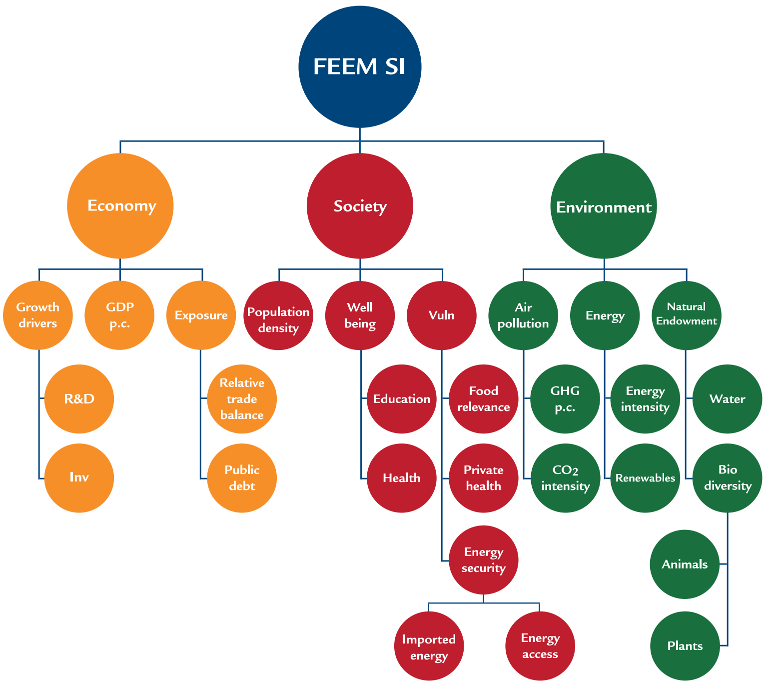

Figure 1: FEEM SI indicators' tree

Therefore, ICES SI is an ideal framework for the construction of a policy-oriented sustainability index. First, the large database on which the model is based makes it possible to calculate the index for all the world regions, and to create indicators using data relative to the different sectors. Second, the nature of the CGE model, in which all sectors and regions are interconnected, captures the trade-offs between different indicators. Finally, the model dynamic framework produces data relative to a growth path that can be used to calculate the index in the future, and under different policy assumptions. Therefore, our sustainability index is not retrospective, based on past data, as most other sustainability indexes. It is rather forward looking and it thus allows analysing how sustainability may change under different future policy scenarios.

4. Emissions abatement scenarios

Let us consider a set of four mitigation scenarios with the objective to assess the possible outcomes of autonomous and coordinated efforts to curb GHG emissions within a sustainability framework. In particular, the focus is on the possibility that all countries will fulfil the low and high emission reduction pledges they submitted under the Copenhagen Accord. These two scenarios take into account the implementation of a global emission trading market, excluding China and India, who pledged a reduction in the carbon intensity of GDP. In addition, another scenario, probably more realistic after Doha, combines the minimum efforts proposed under the Copenhagen Accord and the possibility to exchange emission permits only within the European Emission Trading System.

Finally, another post-Doha scenario reflects the fact that some countries will unlikely put ambitious mitigation policies into place. First, the United States remains firmly committed to their position to not join the Kyoto Protocol, because it does not include reduction targets for emerging economies. Moreover, president Obama's failure to endorse a comprehensive bill to reduce GHG emissions at the federal level during his first presidential mandate, added further uncertainties for the future of domestic climate policy in the US. Furthermore, Canada officially retreated from the Kyoto Protocol and consequently will not take part to the second commitment period.[1] During the last round of talks, Japan and Russia also confirmed they will not participate in the second committing period under the Protocol. It is worth noting that the decision to phase down nuclear power, undertaken by the Japanese government after the Fukushima disaster in 2011, would likely make future emission reduction more challenging without a large deployment of renewable energy technologies (Cf. IGES 2012). In light of these developments, this second post Doha scenario excludes the US, Canada, Japan and Russia from climate action until 2020, when the new agreement is expected to come into effect.

The four scenarios are briefly described below, bearing in mind that the proposed reductions for every region are with respect to 1990 CO_2 emissions only.[2]

1. ***Low pledges (global ITS) scenario:*** the low abatement pledges submitted as required in Copenhagen are effective for a set of leading regions, both from Annex I and Annex II (Table A1.1). The climate policy implementation envisions a global emission permits market excluding only China and India, which achieve their targets through a domestic carbon tax.
2. ***High pledges (global ITS) scenario:*** a selection of regions complies with the high Copenhagen pledges (Table A1.1) through a coordinated action (a global permit market), except China and India.
3. ***Low pledges (EU ETS) scenario:*** the low pledge scenario is depicted in a more realistic way, where only the European Union (EU27) is involved in a cooperative action and adopts an Emission Trading Scheme (ETS); all the other countries achieve their targets unilaterally with a domestic carbon tax.
4. ***Post-Doha scenario:*** considers the low Copenhagen pledges and the possible evolution after COP-18. In this scenario, four countries (Canada, USA, Japan and Russia) do not comply with their Copenhagen pledges. Again, EU27 achieve the low Copenhagen pledges using the ETS and the other countries through a carbon tax.

From the modelling point of view, the ITS and ETS systems only differ in terms of geographic extension; the ETS module in the ICES-SI model comprises efforts from all sectors in the economy to accomplish the selected target.

4.1. Targets and effective growth in the abatement scenarios

The most common way to assess the effect of different climate policies on CO_2 emissions levels is to compare the implications of the various policy scenarios with the main variables in a ***Baseline*** scenario. This latter scenario has been built in line with the IMF (2010) economic projections and does not include any intervention to control CO_2 accumulation in atmosphere.

In our Baseline scenario, global emissions almost double in 2020, compared to the 1990 reference level, with a growth of 94% (Table 1, first column. Table 1 shows results for the leading regions of Annex I and Non-Annex I and presents an aggregate value for the Rest of the World[3]). Table 1 also summarises the growth of CO2 emissions for each region according to their own pledge for the four climate policy scenarios described above, starting from 2010 until 2020.

[1] Statement by Minister Kent, Foyer of the House of Commons, December 12, 2011. Environment Canada, at www.ec.gc.ca/default.asp?lang=En&n=FFE36B6D-1&news=6B04014B-54FC-4739-B22C-F9CD9A840800 (retrieved on July 5, 2012)
[2] The analysis considers only CO_2 because it is the main GHG and is produced mainly due to fossil fuel combustion.
[3] Rest of the World includes all countries not joining in the Convention and few of those are part of it, but for modelling purposes are included in a macro-region

Table 1: CO_2 emissions growth and reduction targets with respect to 1990 in 2020 for the different abatement scenarios

Region	Baseline	Low pledges (global ITS)		High Pledges (global ITS)		Low pledges (EU ETS)		Post-Doha (EU ETS)	
	Effective Growth (%)	Target (%)	Effective Growth (%)	Target (%)	Effective Growth (%)	Target (%)	Effective Growth (%)	Target (%)	Effective Growth (%)
Annex I - Leading Regions									
Australia	62	13	10	-11	4	13	13	13	13
Canada	26	3	-6	3	-11	3	3	-	34
European Union	2	-20	-18	-30	-21	-20	-20	-20	-20
Switzerland	15	-20	3	-30	0	-20	-20	-20	-20
Japan	21	-25	-4	-25	-8	-25	-25	-	31
New Zealand	102	-10	56	-20	48	-10	-10	-10	-10
Norway	32	-30	20	-40	18	-30	-30	-30	-30
Russia	9	-15	-32	-25	-37	-15	-15	-	15
Turkey	123	-	191	-	202	-	191	-	145
USA	36	-3	-4	-3	-9	-3	-3	-	42
Non-Annex I - Leading Regions									
Brazil	279	142	201	131	187	142	142	142	142
China	376	375	375	336	334	375	375	375	376
India	367	354	357	325	327	354	357	354	356
Indonesia	335	222	211	222	197	222	222	222	222
Mexico	108	46	55	46	47	46	46	46	46
Korea (Republic of)	207	115	146	115	137	115	115	115	115
South Africa	83	20	-19	20	-26	20	20	20	20
Annex I	***21***	***-12***	***-11***	***-17***	***-15***	***-12***	***-10***	***-12***	***17***
Non-Annex I	***317***	***289***	***292***	***284***	***261***	***289***	***289***	***289***	***290***
Rest of the World	***115***	***-***	***155***	***-***	***163***	***-***	***155***	***-***	***127***
WORLD	***94***	***-***	***75***	***-***	***67***	***-***	***75***	***-***	***89***

In the ***Low pledges (global ITS)*** scenario, countries adopt their low pledges and use a global ITS of carbon permits to reach it. Many Annex I countries show higher emission growth with respect to their targets. Russia, Canada and South Africa, which face lower abatement costs, accomplish higher abatement and sell permits to other countries. The emission growth with respect to 1990 is +75%. In 2020, the overall outcome of this policy scenario is a contraction of carbon emissions of 10% compared to the baseline scenario, where Annex I countries contribute with -26% of CO_2 emissions and Non-Annex I with -6%. The Rest of the World increases by 18% their CO2 emissions, raising the issue of carbon leakage.

In the ***High pledges (global ITS)*** scenario, Australia, EU27, Switzerland, New Zealand, Norway, Russia, Brazil, China and India commit to more stringent pledges. This leads to a total additional abatement of 14% compared to 2020 in the baseline scenario (+67% with respect to 1990 levels), which translates into a -30% for Annex I, -13% for Non-Annex I and +22% for Rest of the World. Therefore, the introduced harsher targets determine a drop of emission levels, but the highest effort falls over the Annex I aggregate. In addition, the tighter restriction on CO_2 levels of Annex I countries generates a higher leakage effect in the Rest of the World.

In the ***Low pledges (EU ETS)*** scenario, world emissions levels coincide with those in the first scenario (Low pledges, global ITS) and the burden distribution among Annex I, Non-Annex I and Rest of the World only changes marginally. The discrepancy emerges when observing the effective emission growth with respect to 1990 across countries. In addition, the aggregate EU27 is no longer able to purchase emission permits from other countries and must comply with the -20% CO2 mitigation target with respect to 1990, instead of the observed -18% of the Low pledges, global ITS scenario (see Annex 3 for detailed results). In 2020, the biggest abatement effort among the EU27 countries is undertaken by Poland, Rest of EU, Finland and UK (respectively -35%, -40%, -24% and -22% with respect to the baseline scenario).

The latter scenario, ***Post-Doha (EU ETS)***, depicts a likely evolution of emissions abatement after COP-18, excluding Canada, Russia, USA and Japan from the set of countries achieving the Copenhagen pledges. As a result, at the global level, CO2 emission growth with respect to 1990 is close to the baseline one (+89%), the EU persists in achieving the -20% target with respect to 1990 levels, whereas the rest of Annex I countries increase their emissions (34% w.r.t 1990). The Non-Annex I aggregate presents similar results to the Low pledges (*EU ETS)* scenario (+29% w.r.t 1990) and the carbon leakage slightly decreases in the Rest of the World (17% w.r.t 1990).

The abatement efforts of leading regions of the UNFCCC and of the Rest of the World are summarised in Figure 2. The profile of the emission level is depicted in the background area and shows the reduction achieved by leading countries in the first three scenarios (Low and High pledges with ITS, Low pledges with EU ETS) and the increase to baseline levels in the Post-Doha one. In 1990, Annex I countries emit more than the Non-Annex I aggregate, although the situation is reversed in all policy scenarios for 2020. The Rest of the World emissions are negligible in 1990, but represent nearly 20% of the global CO_2 level in the 2020 baseline and tend to increase in all scenarios except the Post-Doha one. The bars in Figure 2 show the emission growth for the baseline and the four scenarios with respect to the 1990 level. The Rest of the World shows a leakage effect, which increases with more ambitious pledges.

The CO_2 emission price set within the ITS/ETS guarantees an optimal allocation of permits within all participating countries. In the ***Low pledges (global ITS)*** scenario the price is 89 US$ per Tons of CO_2 for all countries participating in the Kyoto Protocol (excluding China and India), while in the ***High pledges (global ITS)*** scenario it increases to 109 US$. When introducing the ETS for the sole European market and considering only the low pledges ***(Low pledges, EU ETS)***, the carbon price remains high (98 US$/T CO_2) given that now the aggregate EU27 has to autonomously achieve the -20% target without trading permits with other regions. In the ***Post-Doha*** scenario, the price decreases to 73 US$/T CO_2.

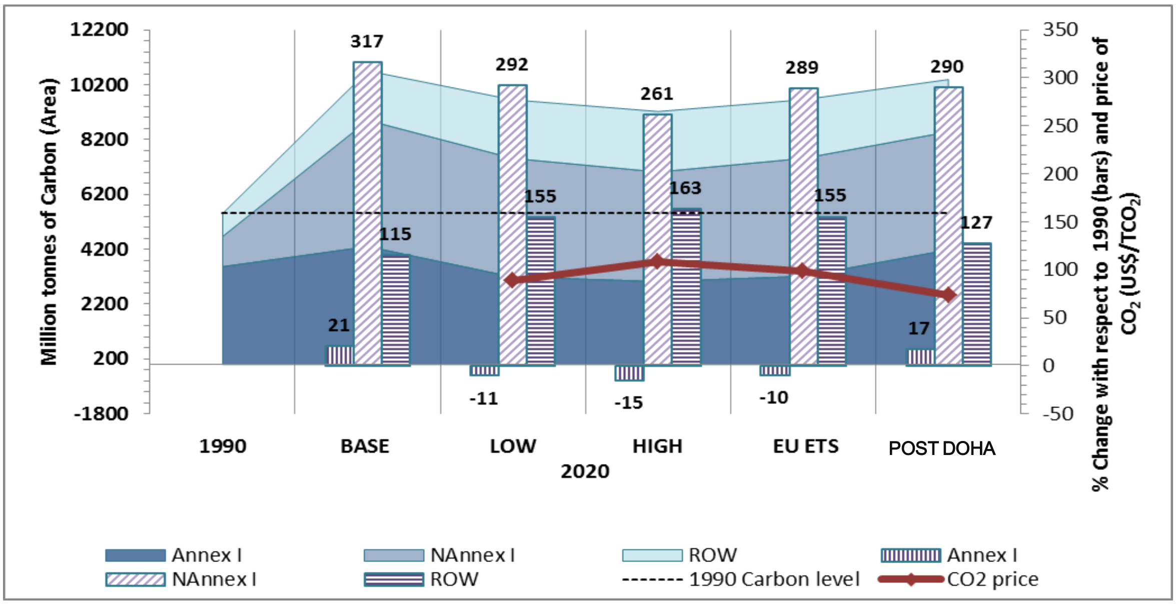

Figure 2: CO_2 emissions for different abatement scenarios in 2020

Implementing mitigation policies to reduce future emissions produces different effects on leading regions' economies and on the Rest of the World. Direct effects are the reduction in total emissions from the group of countries participating in the ETS. There is also a direct mitigation cost, reflected in the carbon price. As expected, this direct cost increases with the stringency of mitigation targets. Indirect effects result from competitive interactions of economic activities. This latter component can be measured through the variation of GDP in 2020 with respect to the baseline scenario. Figure 2 shows the GDP in US$ trillions (expressed in 2004 US$), which helps to assess the magnitude of climate policy cost. More detailed results can be found in Annex 3.

Let us therefore analyse the impact of each policy on GDP. As seen for the direct mitigation cost, the total cost is higher with high pledges. However, a more drastic change occurs when the emission allowances are restricted only to the European market (***Low pledges***, ***EU ETS*** scenario). Countries such as New Zealand, Japan, Norway, Korea, Mexico and Brazil pay the rigidity of the carbon tax instrument, while, in the ITS case, they were achieving their targets by purchasing permits and abating marginally. The ***Post-Doha*** scenario determines an increase of GDP for Japan, Canada, USA and Russia, since they have no pledges. The other economies experience a generalised GDP loss comparable to the high pledge scenario. The only exceptions are Turkey and the Rest of the World, which do not submit any pledges and benefit from a lower leakage effect in this scenario. Figure 3 shows that GHG mitigation is extremely costly for Russia: this result confirms its reluctance to commit to the second phase of the Kyoto Protocol. Observing the aggregates, we notice that the GDP loss in percentage change is higher for Non-Annex I countries than for Annex I.

The climate mitigation strategies analysed in the four scenarios determine an overall GDP loss between 0.4 and 0.8% of the 2020 world GDP.

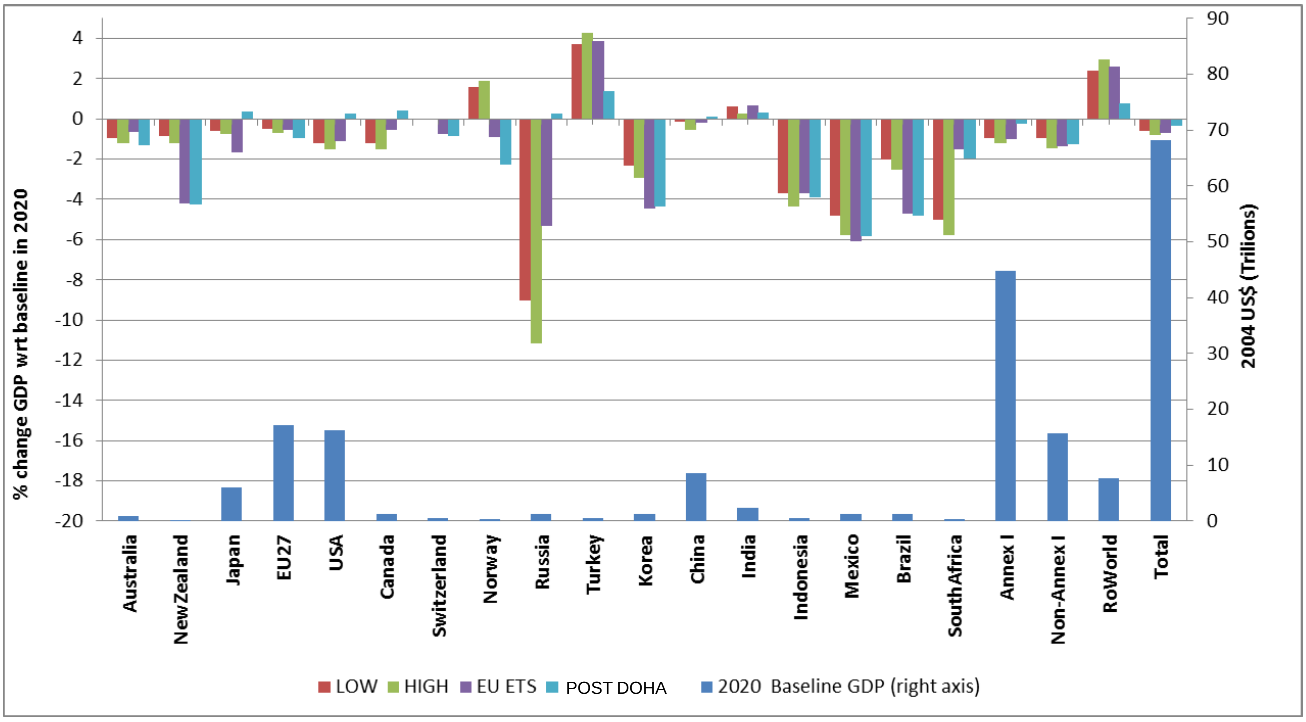

Figure 3: GDP in 2020 (baseline) and the indirect costs of different abatement efforts

4.2. *Sustainability under different climate mitigation policies*

Given the pervasive effects of mitigation policy, it is important to assess the implications of the four policy scenarios not only on GDP but more generally on sustainability. Focusing on sustainability implies considering the effects of climate policy on the economic, social and environmental variables included in the model. To perform this analysis, we use the FEEM Sustainability Indicator described in Section 2. All economic, social and environmental indicators composing the FEEM SI result from running the ICES-SI model developed at FEEM (see Carraro et al. 2011) for the ***baseline*** scenario and the four climate policy scenarios. The FEEM SI has been calculated for each region and for the world as an aggregate. Results are shown in Figure 3 and in Annex 4.

In the ***baseline*** scenario, the World's sustainability decreases until 2017 and then experiences a feeble growth due to the economic recovery coupled with a rise in environmental sustainability (carbon and energy intensity indicators). By contrast, all considered policy scenarios determine an improvement of sustainability with respect to the baseline scenario, which is negligible in the ***Post-Doha*** scenario and more consistent in the other three cases. The stricter the climate policy, the higher the sustainability achieved.

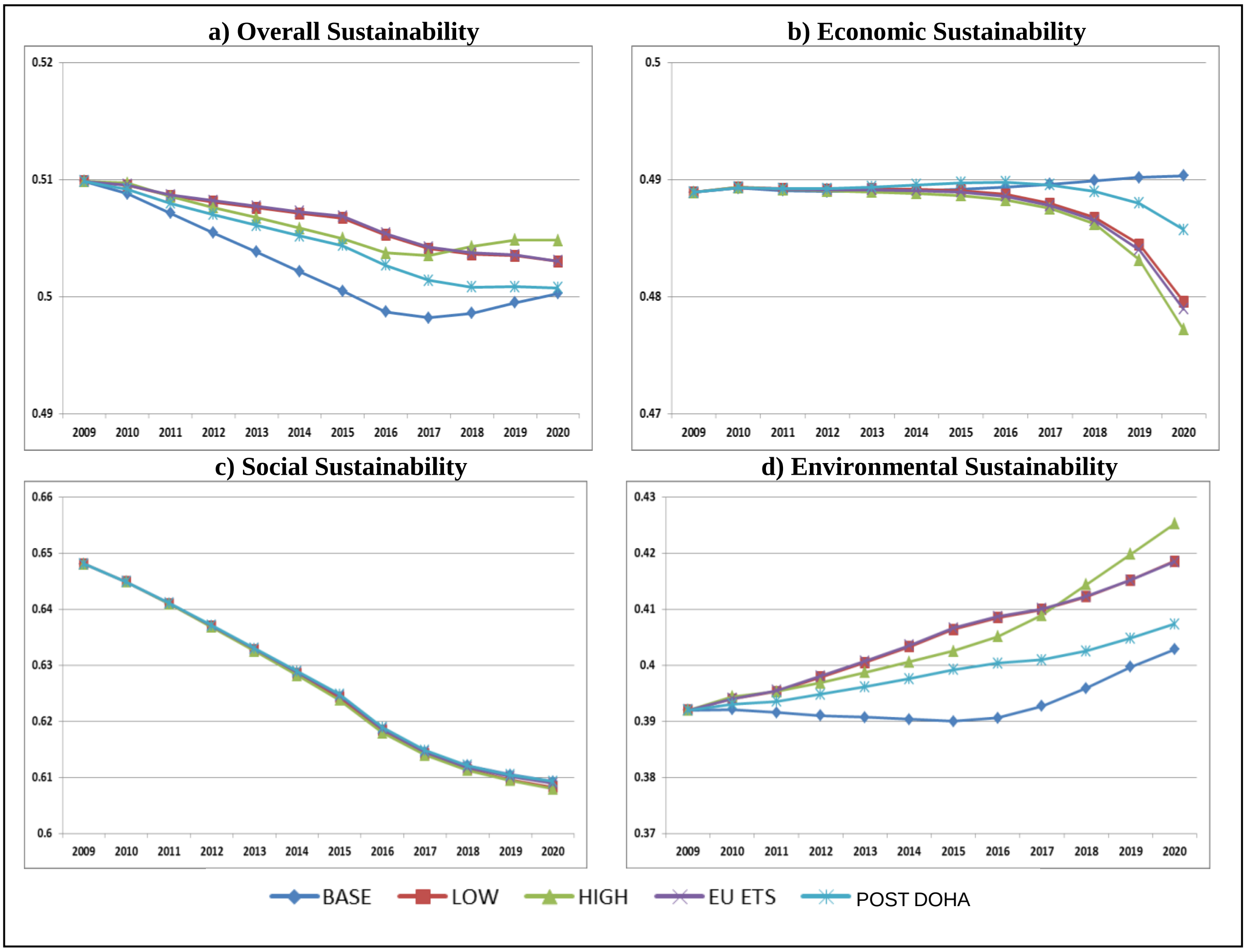

Figure 4: Changes in World Sustainability according to the FEEM SI

As shown in panel a) of Figure 4, the ***Low pledges (global ITS /EU ETS)*** scenarios envision a less drastic drop of sustainability, due to the improvement of environmental sustainability which balances the negative performance in the economic and social dimensions. At the World level, the direct cost of climate policy in terms of GDP is insignificant. However, a more ambitious climate policy determines a higher drop in the economic pillar of sustainability: in particular, public debts increase due to a reduction in governments' revenues driven by a domestic output reduction. The social pillar is also affected by climate policy due to the contraction of available resources for education and health expenditures. There is indeed a crowding out effect in public budgets when devoting resources to mitigation initiatives. The ***High pledges (EU ETS)*** scenario prospects the best outcome for sustainability, especially after 2017; in fact, whereas the economic and social pillars result only slightly lower compared to the low pledges scenarios, the benefits to the environmental dimension of sustainability are otherwise significant.

Computing the percentage changes with respect to the baseline scenario in 2020 of the FEEM SI and its main pillars under the four policy scenarios allows a better understanding of policy impacts. Figure 5 shows that the consistent increase in the environmental component more than offsets the decrease in the economic and social one, thus leading to an overall higher sustainability (with respect to the baseline scenario). It is worth noticing that more ambitious mitigation targets would lead to a more sustainable world in 2020. Let us also notice that the ***Post-Doha*** scenario shows a drastic contraction of the benefit for the environmental pillar and a related reduction of economic losses, which however determine an overall sustainability close to the baseline one.

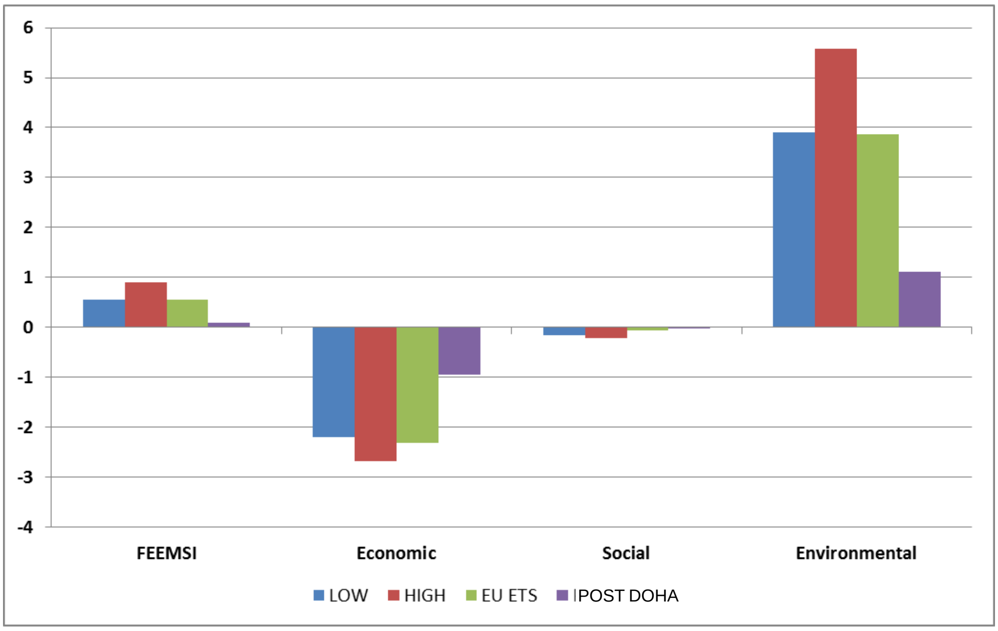

Figure 5: Percentage changes in the FEEM SI with respect to the baseline at 2020

Figure 6 shows detailed results for the four macro-regions considered in this analysis: European Union, Rest of Annex I (excluding EU27), Non-Annex I and Rest of the World. It only focuses on overall sustainability. Most of ***EU27*** countries see an improvement of their sustainability level between 1% and 2% (w.r.t the baseline). Poland and Rest of EU (RoEU) are the countries most positively affected by mitigation policy, achieving the highest emissions reduction among European countries at a low economic cost (they benefit from trading in the permit market). For Benelux and France the benefit on the environmental pillar is nearly offset by the economic and social losses.

It is also worth analysing the results for the ***Rest of Annex I***, which includes the four non-committing countries in the Post-Doha scenario. The lack of a mitigation policy implies a lower sustainability than in the *baseline* scenario for Japan, Russia and USA or the replication of the baseline results in the case of Canada. Turkey, belonging to Annex I, but with no pledge, is the only country in this bundle that reduces its sustainability level (again w.r.t the baseline) in all policy scenarios.

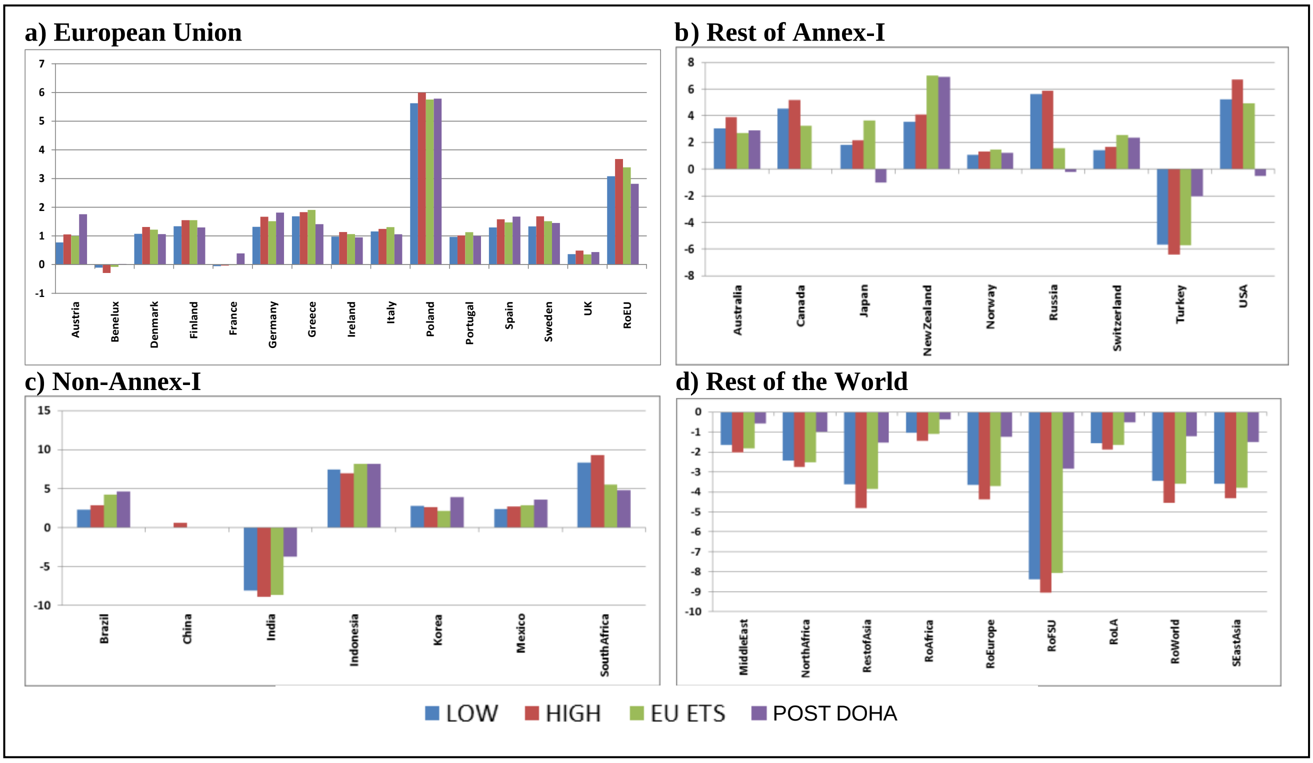

Figure 6: Percentage changes in the FEEM SI with respect to the baseline at 2020 by country

Regarding the ***Non-Annex I*** aggregate (panel c), India is the only country negatively affected by climate policy. As previously noticed, the target on emission intensity is not stringent for this country, therefore environmental sustainability benefits only marginally from the implementation of the four policy scenarios, compared with a worsening situation in the economic and social pillars. Most of the other Non-Annex I countries experience an improvement in their sustainability level (w.r.t the baseline) in the Post-Doha scenario, since they comply with the abatement targets, without purchasing emission reduction permits as in the ITS scenarios. Therefore, they enhance their improvement of environmental sustainability. China is excluded from this pattern because it results largely unaffected by mitigation interventions.

The ***Rest of the World*** regions (and Turkey) depict a clear image of the leakage effect characterising the countries without any climate policy. Regarding the components of sustainability, it is evident that environmental deterioration plays a major role. Overall, the Rest of the World countries see a stronger shrinking of their sustainability when the mitigation is more ambitious and the leakage is larger.

Finally, Figure 7 illustrates in detail changes in sustainability for USA, Canada, Japan and Russia, Italy and Turkey. The USA economic and social pillars result largely unaffected in all climate policy scenarios: while the GDP per capita indicator remains unchanged, the environmental sustainability increases up to 45% thanks to mitigation policies. Moreover, in the Post-Doha scenario overall and environmental sustainability in the USA drops below baseline levels.

For Canada and Russia, the phase out of mitigation pledges recreates the sustainability path of the baseline scenario: even if the economic pillar shows a recovery to baseline levels, the fall of environmental sustainability offsets all economic benefits. Japan loses more than the others countries in terms of overall sustainability, dragged by the drop of the environmental component of our sustainability indicator.

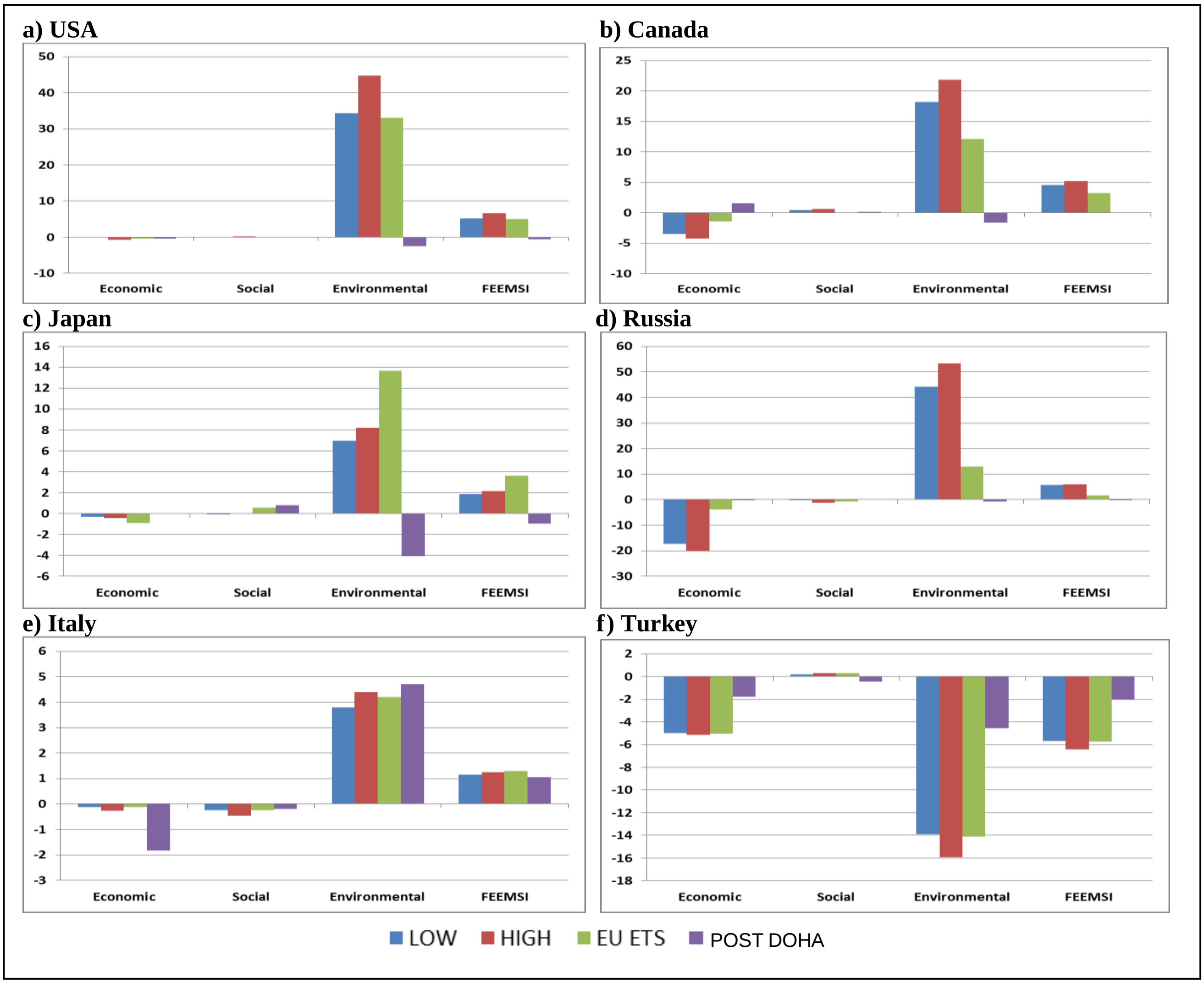

Figure 7: Percentage changes in the FEEM SI and its components with respect to the baseline in 2020 for selected countries

These results offer additional proof of the beneficial effect of emission control on countries' sustainability. The benefits are higher with stricter abatement targets. Interestingly, countries do not gain when they withdraw from their pledges. Even though the cost of climate policy is obviously lower, the negative performance of environmental indicators seems to be more relevant in terms of sustainability than the positive economic benefits, thus leading to a sustainability level worse than in the *baseline* scenario.

5. Conclusions

After the UNFCCC 18th Conference of Parties (COP-18), held in Doha, the future of negotiations for the achievement of an international agreement on climate change is more than ever uncertain. It is therefore important to further analyse the relevance of climate policy and its role in addressing climate-related environmental issues, possibly without harnessing economic growth and reducing social cohesion. This paper therefore used the sustainability concept to offer a different perspective on the impacts of possible future climate policy scenarios and the main challenges to come. The analysis focused indeed on a range of climate mitigation scenarios, inspired by the current state of climate negotiations, in order to highlight the impact of curbing GHG emissions on sustainability.

The tool used to assess the effects of climate policy on sustainability was the FEEM Sustainability Index (FEEM SI), which summarises the economic, social and environmental components of sustainability in a single indicator. Since the FEEM SI is built within a dynamic CGE model, it allows for scenario analysis, thus making it an ideal instrument for the analysis of different climate policies and of their impacts on future sustainability levels.

Our analysis illustrates that, notwithstanding the costs countries need to bear to meet their climate targets, sustainability is likely to increase after the implementation of mitigation measures. The environmental component is affected positively, both at the regional and world level, thanks to the adoption of climate policy. The economic and social components are less affected, even though negatively, and this loss rarely offsets the benefits. The more ambitious the pledges, the higher the performance of the environmental pillar and of overall sustainability.

The most interesting insight stems from the analysis of the Post-Doha scenario, envisioning the non-commitment of Canada, USA, Japan and Russia. The outcome of their inaction in mitigating CO_2 emissions is negative, at both the world and country levels. The four non-committing countries, which experience a benefit in both the High and the Low pledges scenarios, lose their gains in the Post-Doha scenario and have a sustainability performance close to the one in the baseline scenario. These findings confirms that a no climate policy strategy would be costly and that mitigation efforts, even if fragmented and unilateral, would contribute to increase sustainability.

Our results show how the cost of climate policy cannot be measured by GDP losses only. Climate policy has pervasive effects across different sectors and throughout the world by changing economic but also social and environmental variables. A careful assessment of climate policy requires the aggregation of these different effects into a single indicator that can help policymakers in adopting more informed decisions.

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Annex 1: Quantitative targets submitted to the UNFCCC Secretariat at the end of January, 2010

Table A1: Copenhagen-Cancun pledges with respect to 1990 emission levels

Country	Low pledges	High pledges
Annex I		
Australia[c]	13%	-11%
Canada[c]	2.52%	2.52%
European Union	-20%	-30%
Switzerland	-20%	-30%
Japan	-25%	-25%
New Zealand	-10%	-20%
Norway	-30%	-40%
Russia	-15%	-25%
USA[c]	-3%	-3%
Non-Annex I		
Brazil[a]	142.1%	131.5%
China[b]	40%	45%
India[b]	20%	25%
Indonesia[a]	221.6%	221.6%
Mexico[a]	45.9%	45.9%
Republic of Korea[a]	115.0%	115.0%
South Africa[a]	20.4%	20.4%

a) The original target expressed in CO_2 emission reduction (%) w.r.t 2020 BAU is converted to change w.r.t 1990 levels

b) The target is expressed in carbon intensity variation w.r.t. 2005 levels. Converting these figures into changes of CO_2 emissions w.r.t 1990 show results of 375.6% for China and 354.2% for India with the Low pledges, and respectively 336.0% and 325.8% with High pledges.

c) The original target in CO_2 emission reduction (%) w.r.t 2005 is converted in change w.r.t 1990 levels

Annex 2: The FEEM Sustainability Index (FEEM SI)

The FEEM SI was built using a comprehensive methodology divided into four different steps: (i) Indicators were initially selected following the main literature, which has been acknowledged internationally, such as the EU SDS indicator list and the indicators from the Commission on Sustainable Development of the United Nations. A set of possible indicators was carefully evaluated to choose the ones that best fit in the sustainability framework within the potentials of the general equilibrium framework of the ICES-SI model (Carraro et al., 2012).[4] Table A2.1 describes the indicators. In line with the theory of sustainability, the structure of the FEEM SI tree is composed of the three main pillars of sustainability, namely the economic, social and environmental pillars. For each of these dimensions, the FEEM SI tree covers the main areas of research on sustainability assessment: economic growth drivers, GDP per capita, economic exposure, population density, well-being, social vulnerability, energy, air quality and natural endowments.

(ii) The index is then calculated using the output of ICES-SI, which has been structured to calculate the desired indicators for each region and year. (iii) In order to achieve full comparability between indicators, we apply a normalisation procedure. This is done according to a policy target-based benchmarking methodology, where benchmarks have been derived from a wide policy review. (iv) Finally, indicators are aggregated within a single sustainability measure according to a non-linear aggregation function. The aggregation methodology for the FEEM SI introduces a very novel approach in this field. In fact, it enhances the importance of considering the interactions between indicators by attributing weights to the single indicators as well as to all possible combinations of indicators belonging to the same theme or sub-theme. Weights are then combined with a special weighted average based on the Choquet integral, which is a particularly well-suited tool used to deal with multi-attribute issues such as sustainability.[5]

Table A2: List of indicators for the FEEM SI

DIMENSION	NAME	EQUATION	LONG DESCRIPTION
Economic	R&D	R&D Expenditure / GDP (%)	This indicator assumes a positive relationship between investment in R&D and growth, by maintaining that increased investment in R&D can bring more R&D output that will eventually lead to more innovation and increased productivity
	Investment	Net Investment / Capital Stock (%)	Investment is one of the main drivers of economic sustainability, allowing for capital accumulation, which boosts economic growth. This indicator is weighted considering the country specific capital stock.
	GDP per capita	GDP PPP / population	It is a measure of the per capita value of all market goods and services produced within a country. GDP p.c. is the typical indicator used to define the average well-being in a country.
	Relative Trade Balance	Trade Balance / Market Openness	The Relative Trade Balance measures the degree of a country's exposure in the global commodities markets. It considers the net export value and weighs it with the country specific market openness (exports + imports). Relying relatively more upon exports is an indication of strong competitiveness.
	Public Debt	Government Debt / GDP (%)	Public Debt has an important role on the future perspective of a country's economy. It depends on current government choices on expenditure and taxation, and on previously accumulated debt.
Social	Population Density	Population / Country Surface	Population Density evaluates the population concentration in a specific country or macro-region (excluding uninhabitable areas). It represents the pressure on the available living space and resources for each individual.
	Education	Education Exp. / GDP (%)	Expenditure in Education constitutes an investment in human capital. The role of education in improving future economic conditions and enhancing mobility as well as gender equality is supported by several studies.

[4] A detailed description of the index is available on the FEEM SI website at www.feemsi.org.
[5] A sensitivity analysis can also be performed in order to verify the robustness of the aggregation methodology.

	Health	Total Health Exp. / GDP (%)	The generalised access to basic Health services is a major concern throughout the world. Monitoring the growth of expenditures in health by summing public and private expenditures allows measuring the degree of support on this issue.
	Food Relevance	Food Cons. / Private Exp. (%)	This indicator is used as a proxy for the poverty level. In fact, according to Engel's law, the higher the proportion of national income spent on food, the lower the level of a country's welfare.
	Energy Imported	Energy Imported / Energy Cons. (%)	This is an indicator of energy security. The higher the Energy Dependence from abroad, the higher the risks deriving from changes in energy prices and political instability in energy-rich countries.
	Energy Access	Population with Access to Electricity / Total Population (%)	Access to Energy is important with reference to living conditions and future prospectives of well-being. This indicator considers the share of population having access to electricity. It allows capturing the intra country aspect of energy security, being more focused on distribution of energy resources than on availability at the country level.
	Private Health	Private Health Exp. / Total Health Exp.(%)	Monitoring the balance between public and private contribution to the health sector is essential for sustainability because it determines the availability of primary service to the whole society. The higher the share of Private Health expenditure, the lower the ability of poorer people to access to the health care.
Environmental	GHG per capita	Kyoto GHGs Emissions / Population	The Greenhouse Gases are considered as described in the Annex I of the Kyoto Protocol. Emission per capita is a measure of the burden that the society imposes on climate and environment.
	CO_2 Intensity	CO_2 Emissions / Total Primary Energy Cons.	This indicator is fundamental to monitor the improvement of the environmental performance of production and consumption activities, the latter playing a major role in the release of Carbon Dioxide into the atmosphere.
	Energy Intensity	Total Primary Energy Supply / GDP PPP	This indicator aims to assess the evolution of energy use efficiency.
	Renewables	Renewable Cons. / Total Primary Energy Cons.(%)	The gradual reduction of fossil fuel use is an important step towards security and sustainability of energy systems. The higher the share of green energy, the higher the environmental performance of the energy sectors.
	Plants	Endangered Species / Total Species (%)	This indicator represents an alarm signal of the general worsening of habitats. It provides a comparable measure of endangered Plant species throughout the world, by considering the number of endangered species over the number of total known species present in that country.
	Animals	Endangered Species / Total Species (%)	As in the previous indicator, it also represents an alarm signal of the general worsening of habitats. It is calculated in the same way but focuses on animal biodiversity.
	Water	Water Use / Total Available Water (%)	Human pressure on water is an important indicator of resource pressure. It is estimated as water consumed in a country (for agriculture, industry and private uses) over the total renewable water resources available in that specific country.

Annex 3: Abatement by scenario: detail for Europe

Table A3: CO_2 Emissions growth in 2020 with respect to 1990 for four abatement scenarios: EU27

Region	***Low pledges (global ITS)***		***High pledges (global ITS)***		***Low pledges (EU ETS)***		***Post-Doha (EU ETS)***	
	Target (%)	***Effective Growth (%)***	***Target (%)***	***Effective Growth (%)***	***Target (%)***	***Effective Growth (%)***	***Target (%)***	***Effective Growth (%)***
EU27								
Austria	-20	12	-30	8	-20	9	-20	10
Benelux	-20	47	-30	42	-20	41	-20	41
Denmark	-20	-18	-30	-21	-20	-20	-20	-21
Finland	-20	-1	-30	-6	-20	-5	-20	-4
France	-20	-7	-30	-9	-20	-9	-20	-13
Germany	-20	-30	-30	-33	-20	-32	-20	-32
Greece	-20	3	-30	-1	-20	1	-20	1
Ireland	-20	10	-30	7	-20	8	-20	7
Italy	-20	-5	-30	-7	-20	-7	-20	-8
Poland	-20	-36	-30	-41	-20	-38	-20	-34
Portugal	-20	14	-30	11	-20	12	-20	8
Spain	-20	27	-30	23	-20	25	-20	23
Sweden	-20	-4	-30	-5	-20	-6	-20	-11
UK	-20	-27	-30	-29	-20	-28	-20	-28
RoEU	-20	-49	-30	-52	-20	-52	-20	-50

Annex 4: Detailed Results

Table A4: Percentage change in Overall Sustainability and its components with respect to baseline in 2020

Region	Low pledges (global ITS)				High pledges (global ITS)				Low pledges (EU ETS)				Post-Doha (EU ETS)			
	Eco	Soc	Env	FEEM SI	Eco	Soc	Env	FEEM SI	Eco	Soc	Env	FEEM SI	Eco	Soc	Env	FEEM SI
Australia	0.1	-0.3	17.7	3.1	0.8	-0.8	21.3	3.9	-0.1	-0.4	16.2	2.7	0.6	-0.3	15.3	2.9
Austria	0.0	0.0	2.2	0.8	0.1	-0.1	3.0	1.1	0.0	0.0	2.9	1.0	0.2	0.1	4.9	1.8
Benelux	-2.9	-1.6	5.7	-0.1	-3.6	-2.1	6.7	-0.3	-3.1	-1.7	6.2	-0.1	-2.8	-1.3	5.8	0.0
Brazil	1.7	-0.4	6.8	2.3	1.8	-0.5	8.2	2.8	-0.9	0.5	12.9	4.2	0.4	0.6	13.0	4.6
Canada	-3.4	0.4	18.2	4.5	-4.2	0.6	21.8	5.2	-1.4	0.0	12.1	3.2	1.6	0.2	-1.6	0.0
China	0.0	-0.5	0.7	0.0	-1.7	-0.3	7.5	0.6	0.0	-0.6	0.7	0.0	0.0	-0.1	0.1	0.0
Denmark	-0.2	0.2	4.1	1.1	-0.2	0.2	4.9	1.3	-0.2	0.2	4.7	1.2	-0.7	0.2	4.6	1.1
Finland	-3.6	0.2	8.1	1.3	-4.4	0.2	9.7	1.6	-3.9	0.3	9.1	1.5	-4.0	0.3	8.3	1.3
France	-0.9	-0.2	0.9	-0.1	-0.8	-0.4	1.1	0.0	-0.9	-0.2	1.0	0.0	-1.4	-0.2	2.6	0.4
Germany	-0.9	0.1	6.9	1.3	-0.8	0.0	8.3	1.7	-1.0	0.1	7.9	1.5	-0.7	0.1	8.4	1.8
Greece	-1.1	-1.3	6.8	1.7	-1.7	-2.0	8.1	1.8	-1.3	-1.3	7.6	1.9	-2.7	-1.4	7.5	1.4
India	-14.4	-4.8	0.7	-8.1	-17.1	-4.3	2.3	-8.9	-15.4	-5.2	0.6	-8.7	-6.7	-3.5	0.5	-3.8
Indonesia	3.0	1.0	12.7	7.5	-0.3	1.2	14.2	6.9	6.1	1.0	11.7	8.2	6.0	1.0	11.8	8.2
Ireland	1.2	-0.9	3.1	1.0	1.7	-1.2	3.5	1.1	1.4	-1.1	3.4	1.1	-0.2	-0.5	3.8	1.0
Italy	-0.1	-0.3	3.8	1.2	-0.3	-0.5	4.4	1.2	-0.1	-0.2	4.2	1.3	-1.8	-0.2	4.7	1.1
Japan	-0.3	0.0	7.0	1.8	-0.4	0.0	8.2	2.2	-0.9	0.5	13.7	3.6	0.0	0.8	-4.1	-1.0
Korea	-1.3	-0.6	17.1	2.8	-2.6	-0.6	19.8	2.6	-5.4	-0.1	25.3	2.1	-2.5	-0.1	25.5	3.9
Mexico	-0.3	-2.7	14.9	2.4	-0.9	-2.9	17.4	2.7	-1.2	-2.8	18.0	2.9	-0.1	-2.4	19.1	3.6
MiddleEast	0.0	-0.7	-6.2	-1.7	0.0	-0.7	-7.7	-2.0	0.0	-0.8	-6.7	-1.8	0.0	-0.2	-2.2	-0.6
NewZealand	-1.8	-0.1	15.4	3.6	-2.4	-0.2	18.1	4.1	-10.4	0.4	39.4	7.0	-10.5	0.4	39.0	6.9
NorthAfrica	-1.4	-0.6	-4.2	-2.4	-1.5	-0.5	-4.9	-2.8	-1.5	-0.6	-4.4	-2.5	-0.6	-0.6	-1.5	-1.0
Norway	1.8	-0.1	2.1	1.1	2.1	-0.1	2.6	1.3	-2.5	-0.3	8.8	1.5	-3.4	-0.3	8.8	1.2
Poland	-7.3	0.3	31.9	5.6	-7.5	-0.2	34.5	6.0	-8.3	0.5	33.2	5.8	-4.4	-0.3	30.1	5.8
Portugal	-0.5	-0.4	4.7	1.0	-0.4	-0.9	5.5	1.0	-0.5	-0.4	5.3	1.1	-1.8	-0.4	6.1	1.0
RestofAsia	-1.1	-1.4	-5.6	-3.6	-2.0	-2.0	-7.2	-4.8	-1.3	-1.5	-5.9	-3.9	-0.2	-1.5	-2.2	-1.5
RoAfrica	-1.7	-0.4	-1.0	-1.0	-2.6	-0.5	-1.2	-1.5	-1.7	-0.4	-1.0	-1.1	-0.6	-0.2	-0.3	-0.4
RoEU	-6.1	2.3	14.5	3.1	-6.4	2.1	16.6	3.7	-6.9	2.8	15.7	3.4	-4.6	1.8	12.7	2.8
RoEurope	1.0	-0.1	-8.8	-3.7	1.4	-0.1	-10.7	-4.4	1.0	0.0	-9.0	-3.7	0.2	-0.6	-2.5	-1.2
RoFSU	-13.2	-0.8	-20.3	-8.4	-13.3	-0.8	-23.4	-9.0	-13.2	-0.7	-19.0	-8.1	-5.0	-0.5	-5.5	-2.8
RoLA	0.1	-0.1	-3.6	-1.6	0.2	-0.1	-4.3	-1.9	0.2	-0.1	-3.8	-1.7	0.1	-0.1	-1.2	-0.5
RoWorld	1.0	-0.7	-8.3	-3.4	1.1	-0.8	-10.8	-4.5	0.8	-0.7	-8.5	-3.6	0.9	-0.7	-3.0	-1.2
Russia	-17.3	-0.4	44.1	5.6	-20.2	-1.2	53.4	5.9	-3.9	-0.8	12.9	1.6	-0.2	0.2	-0.7	-0.2
SEastAsia	0.4	-0.7	-7.7	-3.6	0.5	-1.0	-9.4	-4.3	0.5	-0.7	-8.2	-3.8	0.2	-0.6	-3.1	-1.5
SouthAfrica	-8.5	0.2	56.2	8.3	-12.4	1.1	64.9	9.3	-2.4	-0.8	35.2	5.5	-1.0	-0.9	29.5	4.8
Spain	-0.5	-0.5	5.9	1.3	-0.5	-0.7	7.2	1.6	-0.5	-0.5	6.6	1.5	-0.8	-0.4	7.4	1.7
Sweden	0.8	-0.3	3.8	1.3	1.3	-0.4	4.7	1.7	0.8	-0.3	4.4	1.5	-0.6	-0.2	5.3	1.4
Switzerland	-0.1	-0.5	4.7	1.4	0.0	-0.6	5.4	1.7	-0.8	-0.1	9.1	2.6	-0.8	0.1	8.1	2.4
Turkey	-5.0	0.2	-13.9	-5.7	-5.1	0.3	-15.9	-6.4	-5.0	0.3	-14.1	-5.7	-1.8	-0.5	-4.5	-2.0
UK	-1.0	0.0	2.4	0.4	-0.9	-0.2	2.9	0.5	-1.2	0.0	2.7	0.4	-1.7	-0.1	3.6	0.4
USA	-0.2	0.0	34.4	5.2	-0.7	0.1	44.7	6.7	-0.5	0.0	33.1	4.9	-0.4	0.0	-2.4	-0.5

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