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COSTS, REVENUES, AND EFFECTIVENESS OF THE COPENHAGEN ACCORD EMISSION PLEDGES FOR 2020

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JEL classifications: F53, H23, H87, Q54, Q58
Keywords: Climate change, Computable general equilibrium model, Copenhagen accord, Greenhouse gas mitigation

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ABSTRACT

Tackling the problem of global climate change requires a high level of international cooperation. Many countries have pledged targets or actions to reduce greenhouse gas emissions in the Appendices to the Copenhagen Accord. This analysis examines the costs and effectiveness of these pledges, using the OECD's ENV-Linkages computable general equilibrium model. Several scenarios are analysed to evaluate the impacts of the range of pledges, the use of offsets, and linking emission trading systems. The results show that while the emission targets currently pledged by a wide range of countries under the Accord are an important and welcome start to a global solution, the pledges are not ambitious enough to put us on a pathway to limit average global temperature increase to below 2°C. This paper also analyses the economic impacts of the pledges, and estimates the costs of action at around 0.3% of GDP for both Annex I and non-Annex I countries and 0.5-0.6% of global real income (not taking into consideration the economic benefits from avoided damages from climate change). Furthermore, the analysis reveals that the potential for increased fiscal revenue or proceeds are substantial and for the Annex I group of countries can exceed 1% of GDP (or 400 billion USD) if mitigation actions are achieved through market instruments such as carbon taxes or cap-and-trade emission schemes with auctioned emission allowances.

JEL classifications: F53, H23, H87, Q54, Q58

Keywords: Climate change, Computable general equilibrium model, Copenhagen accord, Greenhouse gas mitigation

RÉSUME

Pour parer au changement climatique planétaire, une coopération internationale poussée s'impose. Beaucoup de pays se sont engagés à réaliser des objectifs ou à mettre en œuvre des actions de réduction des émissions de gaz à effet de serre dans les appendices à l'Accord de Copenhague. La présente analyse vise à examiner les coûts et l'efficacité de ces engagements au moyen du modèle d'équilibre général calculable ENV-Linkages de l'OCDE. Elle porte sur plusieurs scénarios, de manière à évaluer les incidences qu'entraînent les divers engagements pris, l'utilisation de formules de compensation, ainsi que les liens entre les systèmes d'échange de droits d'émission. Les résultats montrent que si les objectifs d'émission actuellement annoncés par un large éventail de pays dans le cadre de l'Accord sont un premier pas important et fort apprécié dans le sens d'une solution mondiale, les engagements ne sont pas suffisamment ambitieux pour nous placer sur une trajectoire permettant de maintenir l'élévation moyenne de la température du globe au-dessous de 2°C. Ce document concerne aussi les répercussions économiques des engagements, les coûts de l'action étant estimés à 0.3 % environ du PIB, que les pays soient visés ou non à l'Annexe I, et à 0.5-0.6 % du revenu réel mondial (compte non tenu des avantages économiques liés aux atteintes évitées du changement climatique). Par ailleurs, l'analyse fait ressortir des perspectives non négligeables d'augmentation des recettes budgétaires qui, pour les pays de l'Annexe I, pourraient représenter plus de 1 % du PIB (400 milliards USD) si les mesures d'atténuation passent par des instruments de type marché tels que les taxes carbone ou les systèmes de plafonnement et d'échange dans lesquels des quotas d'émission sont attribués par voie d'enchères.

Classification JEL : F53, H23, H87, Q54, Q58

Mots clés : changement climatique, modèle d'équilibre général calculable, Accord de Copenhague, atténuation des émissions de gaz à effet de serre

FOREWORD

This report presents the OECD analysis on the costs and effectiveness of the global greenhouse gas emission reduction targets and actions for 2020. It builds directly upon the preliminary work on this topic, presented in the OECD book "The economics of climate change mitigation: policies and options for global action beyond 2012". The present report uses an updated version of the modelling tool ENV-Linkages to assess the collective targets and actions as pledged in the Appendices of the Copenhagen Accord.

This report has been authored by Rob Dellink, Gregory Briner and Christa Clapp of the OECD Environment Directorate. It was reviewed by Delegates of the Working Party on Global and Structural Policies and the Working Party on National Environmental Policies at their meeting in May 2010. The authors are also grateful to Jean-Marc Burniaux, Jan Corfee-Morlot, Helen Mountford and Cuauhtemoc Rebolledo-Gómez of the OECD for valuable input and feedback.

This document does not necessarily represent the view of either the OECD or its member countries. It is published under the responsibility of the Secretary General.

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EXECUTIVE SUMMARY

At the Copenhagen Conference of Parties (COP-15) of the UN Framework Convention on Climate Change (UNFCCC) in December 2009, the international community assembled under the UNFCCC took note of the Copenhagen Accord, a political agreement on climate change. The Accord recognises the scientific view that the increase in average global temperature should be below 2°C. The Accord also invited all Parties to the UNFCCC to submit pledges for targets or actions to reduce their greenhouse gas (GHG) emissions. As of June 2010, almost all Annex I countries have pledged quantified economy-wide emissions targets for 2020 in Appendix I of the Copenhagen Accord; in addition, 37 non-Annex I countries have pledged mitigation actions in Appendix II.

This paper analyses the economic and environmental consequences of implementing these pledges, using the OECD's dynamic general equilibrium model ENV-Linkages. To reflect the range of actions that countries have pledged, the pledges have been translated into two scenarios where Emission Trading Schemes are implemented to achieve the pledged targets or actions. The "Low & Fragmented" scenario corresponds to all countries meeting the lower end of their pledged ranges, while the "High & Linked" scenario corresponds to all countries meeting the higher end. Furthermore, the High & Linked scenario assumes that Annex I countries harmonize their carbon markets to allow trading of emission permits. The Low & Fragmented scenario does not include linking of Annex I carbon markets, as it resembles a more fragmented world. Many countries have not yet declared to what extent they want to allow offsets as part of their pledge. In both cases, by default the assumption is made that 20% of the required emission reductions in Annex I countries can be fulfilled through the use of international offsets.

The analysis shows that a sizable gap remains between pledged Annex I targets and the trajectory suggested by the IPCC for attaining the long-term target of maximum 2°C temperature increase. For non-Annex I countries, the transition towards low-carbon development also needs to be stronger to meet the IPCC trajectory. The expected emission growth in the baseline with no additional climate action is so large, that even a sizable reduction from BAU does not lead to a stabilisation of global emissions at current levels. Even though ambitious stabilisation targets could still be achievable in the longer run, far more significant efforts may be needed after 2020, which are likely to come at a higher cost than if a more gradual pathway to 2°C was chosen today. Note that the assessment does not consider emissions associated with land-use, land-use change and forestry (LULUCF); an assessment that includes these emissions and the related mitigation actions would likely result in lower costs, unless there are restrictions on accounting for these emissions and actions in an international framework.

GDP and income impacts vary across countries, depending not only on the stringency of their pledge, but also on the availability of low-cost domestic mitigation options. For the group of Annex I countries, on average both scenarios lead to a GDP loss of approximately 0.3% from baseline levels, and a reduction in household real income of 0.5%. The output of energy-intensive industries in the Annex I countries declines less than 1% from baseline levels in 2020 for both scenarios. For the group of non-Annex I countries, expected GDP impacts and real income losses are slightly larger in the High & Linked scenario. In addition, in both scenarios Brazil faces relatively high costs of implementing its pledge unless it receives substantial international financing for its mitigation actions.

Global economic costs are quite similar to the Annex I results. While at the global level the additional costs are relatively minor despite the increased ambition level of the combined pledges, for a few regions implementing the higher end of the pledge range implies substantially higher costs. Fossil fuel suppliers, such as Russia, suffer from the falling fuel prices on the world market, as international mitigation policies induce lower demand for fossil fuels and hence lower prices. In contrast, there are a number of regions that have lower costs in the High & Linked scenario, including Canada, Japan and the United States. The main reason is that the High & Linked scenario allows permit trading between Annex I countries. As the damages from climate change, and hence the benefits from mitigation action, are not included in the analysis, these numbers represent only the cost of action.

Although these costs are certainly not negligible, they should be viewed in context: these losses are small compared to the substantial growth in projected GDP in the baseline, and the costs of inaction are likely to be substantially higher. International financial transfers can be used to redistribute the costs across regions, but it remains unclear how such transfers will be implemented in a future agreement.

Introducing a carbon pricing instrument to meet these pledges could also create a major source of income for governments, if they either auction permits, or implement a carbon tax. For the Annex I group of countries, these could amount to over 1% of GDP in 2020, *i.e.* more than 400 billion USD. Domestic fiscal revenues could be especially high in countries that either have a very stringent policy without linking to other carbon markets, or that can exploit relatively cheap domestic reduction options and sell these on the international carbon market.

The analysis shows that linking carbon markets can reduce costs across the Annex I region. In principle, linking carbon markets does not matter for the environmental effectiveness of the policies, as the same targets and actions are implemented. The availability of offsets also plays a crucial role in keeping the costs of climate policies low, as cheaper mitigation options in developing countries can lower the price of reducing a tonne of GHG emissions in the offset market. A higher level of offsets leads to smaller impacts on GDP and income, but also to lower fiscal revenues.

While it is promising that many countries are willing to commit to ambitious mitigation action, in line with other assessments, this OECD analysis shows that current pledges in the Copenhagen Accord are not likely sufficient for attaining the long-term goal of limiting average global temperature increases to 2°C. While not cheap, the costs of these pledges are limited compared to expected economic growth. Furthermore, climate policies provide important environmental benefits and have the potential to generate sizeable fiscal revenues. Ambitious global action to mitigate greenhouse gas emissions is thus not only necessary, but economically rational.

1. Introduction

Tackling the problem of global climate change requires a high level of international cooperation. Broad based participation is needed, involving not only developed, but also developing countries. Given the magnitude of emission cuts required to stabilise GHG concentrations at an ambitious level, climate change mitigation should be undertaken in a cost-effective manner.

At the fifteenth session of the Conference of Parties (COP-15) to the UN Framework Convention on Climate Change (UNFCCC) in Copenhagen in December 2009, the international community assembled in the UNFCCC took note of the Copenhagen Accord, a political agreement on climate change. To date, more than 120 countries plus the European Union have associated themselves with the Accord – ranging from major emitters such as the United States and China, to smaller countries that are vulnerable to climate change impacts, such as the Maldives. The Accord recognises the scientific view that the increase in average global temperature should be limited to 2°C. The Accord also invited all Parties to the UNFCCC to submit pledges for targets or actions to reduce their greenhouse gas (GHG) emissions.

The analysis presented in this paper shows that while the emission targets and actions currently pledged by a wide range of countries in accordance with the Accord are an important and welcome start to a global solution, the pledges are not ambitious enough to put us on a pathway to limit average global temperature increase to below 2°C. The pledges do reverse the trend of growing emissions by 2020; however there remains a sizable gap between pledges and the trajectory outlined by the IPCC for a 2°C pathway (see Figure 1).

This paper focuses on the economic impacts of the pledges, and explores the potential for increased fiscal revenue or proceeds if mitigation actions are achieved through market instruments such as carbon taxes or cap-and-trade emission schemes with auctioned emission allowances. For this analysis, the OECD's dynamic general equilibrium model ENV-Linkages is used (see Annex 1).

2. Brief description of the simulation scenarios

Some interpretation of the pledges in the Appendices of the Copenhagen Accord is necessary in order to analyse the potential environmental and economic impacts. For example, some pledges are provided in the form of a range, which is dependent on the action or financing of other countries. In addition, many pledges do not indicate to what extent they may be realised through the use of offsets. For the purposes of this analysis, two pledge scenarios are modelled, with sensitivity analysis undertaken on offset use and linking of emission trading systems. These scenarios and the underlying assumptions are described in this section.

2.1 Overview of the targets and actions that have been submitted to the Copenhagen Accord

As of June 2010, almost all Annex I countries have pledged quantified economy-wide emissions targets for 2020 in Appendix I of the Copenhagen Accord; in addition, 37 non-Annex I countries have pledged mitigation actions in Appendix II.

Table 1 shows how these pledges are translated into simulation scenarios for the purposes of this model-based analysis. In order to estimate costs and effectiveness in a consistent manner, all Annex I emission reduction targets are translated into reductions from the same base year 1990 and all non-Annex I mitigation actions, including the emission intensity targets of China and India, are expressed in emission reductions from Business-as-Usual (BAU) in 2020. For countries that have not submitted a pledge, the assumption is made that emissions remain at the BAU baseline level.

Table 1. Translation of Copenhagen Accord pledged targets and actions into simulation scenarios

Region	Declared country targets and actions	Low & Fragmented scenario[1]	High & Linked scenario[1]
Australia & New Zealand	Australia -5% to -25% from 2000; New Zealand -10% to -20% from 1990	+10.5% from 1990 (20% offsets)	-11.5% from 1990 (20% offsets)
Canada	-17% from 2005 domestic reductions; max. 10% credits from CDM	+3% from 1990 (10% offsets)	+3% from 1990 (10% offsets)
EU27 & EFTA	EU27, Liechtenstein and Switzerland -20% to -30% from 1990; Norway -30% to -40% from 1990; Iceland -30% from 1990; Monaco -30% from 1990	-20% from 1990 (20% offsets)	-30% from 1990 (20% offsets)
Japan	-25% from 1990	-25% from 1990 (20% offsets)	-25% from 1990 (20% offsets)
Russia	-15% to -25% from 1990	-15% from 1990 (no offsets)	-25% from 1990 (20% offsets)
United States	-17% from 2005	-3.5% from 1990 (20% offsets)	-3.5% from 1990 (20% offsets)
Non-EU Eastern Europe	Ukraine -20% from 1990; Belarus -5% to -10% from 1990; Croatia -5% from 1990	-16% from 1990 (20% offsets)	-16.5% from 1990 (20% offsets)
Brazil	-36% to -39% from BAU	-36% from BAU	-39% from BAU
China	Carbon intensity -40% to -45% from 2005	-0.2% from BAU	-8.5% from BAU
India	Carbon intensity -20% to -25% from 2005	+45% from BAU	+36% from BAU
Oil Exporting countries & Middle East[2]	Indonesia -26% from BAU; Israel -20% from BAU	-8.5% from BAU	-8.5% from BAU
Rest of the World	Korea -30% from BAU; Mexico -30% from BAU; South Africa -34% from BAU; many other pledges (incl. Costa Rica, Maldives, Marshall Islands)	-6% from BAU	-6% from BAU

1. All emission reductions are excluding LULUCF. The 20% limit on offsets in most Annex I regions is in line with the assumption in OECD (2009). All emissions are based on IEA and US-EPA data.

2. The region includes Middle East, Algeria, Libya, Egypt, Indonesia and Venezuela.

2.2 Formulating scenarios to simulate the targets and actions

In the model all countries are grouped into 12 regions and emissions from land use, land use change and forestry are excluded. Several countries have submitted a range of targets or actions, with various conditions attached (see the UNFCCC website for details); for instance, some developing countries have announced that these actions are dependent on international financing. These conditions have not been taken into consideration in this analysis. The "Low & Fragmented" scenario corresponds to all countries meeting the lower end of their pledged ranges, while the "High & Linked" scenario corresponds to all countries meeting the higher end. Furthermore, the High & Linked scenario assumes that Annex I countries harmonize their carbon markets to allow trading of emission permits, while the Low & Fragmented scenario does not include linking of Annex I carbon markets.

Due to the limited information available on what offset policies might be in the future, this analysis requires ad-hoc assumptions regarding the level of offsets. Many countries have not yet declared to what extent they want to allow offsets as part of their pledge. A value of 20% of the required emission reductions is used for Annex I countries, with two exceptions. First, Canada has previously informally indicated it would limit companies to buy offsets to a maximum 10%. Secondly, for Russia, the Low & Fragmented scenario assumes no offsets, as the domestic target is not binding and thus there is no demand for offsets. These assumptions imply an offset market in 2020 of around 1 billion USD; in line with projected values from other studies (Baron et al., 2009). The impact of this default assumption is investigated below.

The OECD's ENV-Linkages model[1] is used to assess the impacts of these pledges. ENV-Linkages simulates the economic impacts of these climate policies for the period 2005-2050, using regionally and sectorally disaggregated economic activity and associated GHG emissions. Emissions to and sinks from land-use, land-use change and forestry (LULUCF), and their related mitigation options are, while important, not represented in the model. The model is based on a so-called dynamic computable general equilibrium approach, which analyses implications of policy impulses on supply and demand of commodities and production factors under economic equilibrium conditions.

The model's baseline follows a Business-as-Usual (BAU) projection that reflects a situation without implementation of new climate policies. Compared to the analysis in OECD (2009), this baseline has been updated to reflect the effects of the financial crisis. While the crisis has a noticeable effect on production and emissions for at least the coming decade, the baseline still projects a trend of growing economic activity and increasing emissions until 2050. Based on recent trends and projections for economic variables by the OECD and for energy by the International Energy Agency (IEA, 2008), global GHG emissions are projected to increase from 2005 levels by around 30% by 2020 and nearly double by 2050 and beyond. Global Gross Domestic Product (GDP) is also projected to grow strongly (50% by 2020), primarily due to convergence across regions (cf. Duval and de la Maisonneuve, 2010).

The model simulates stylised carbon market policies: Emission Trading Schemes (ETS) with full auctioning are assumed to be implemented in all countries that pledged targets or actions, starting in 2013 and gradually building up until 2020. The instrument of auctioned emission permits was used as it ensures a cost-effective allocation is achieved, i.e. the targets are met at least cost, and thus serves as an appropriate benchmark against which to evaluate other potential policy instruments. Offset supply is based on competition between developing countries, ensuring the cheapest options are used first. Offset demand is limited to a ceiling for all Annex I countries (see above). Transaction costs in the carbon market are not taken into account.

3. Results of the simulations

Implementing the targets and pledges will have impacts not only on emission levels, but also on GDP and household income levels. The environmental and cost-effectiveness of the modelled scenarios are described below.

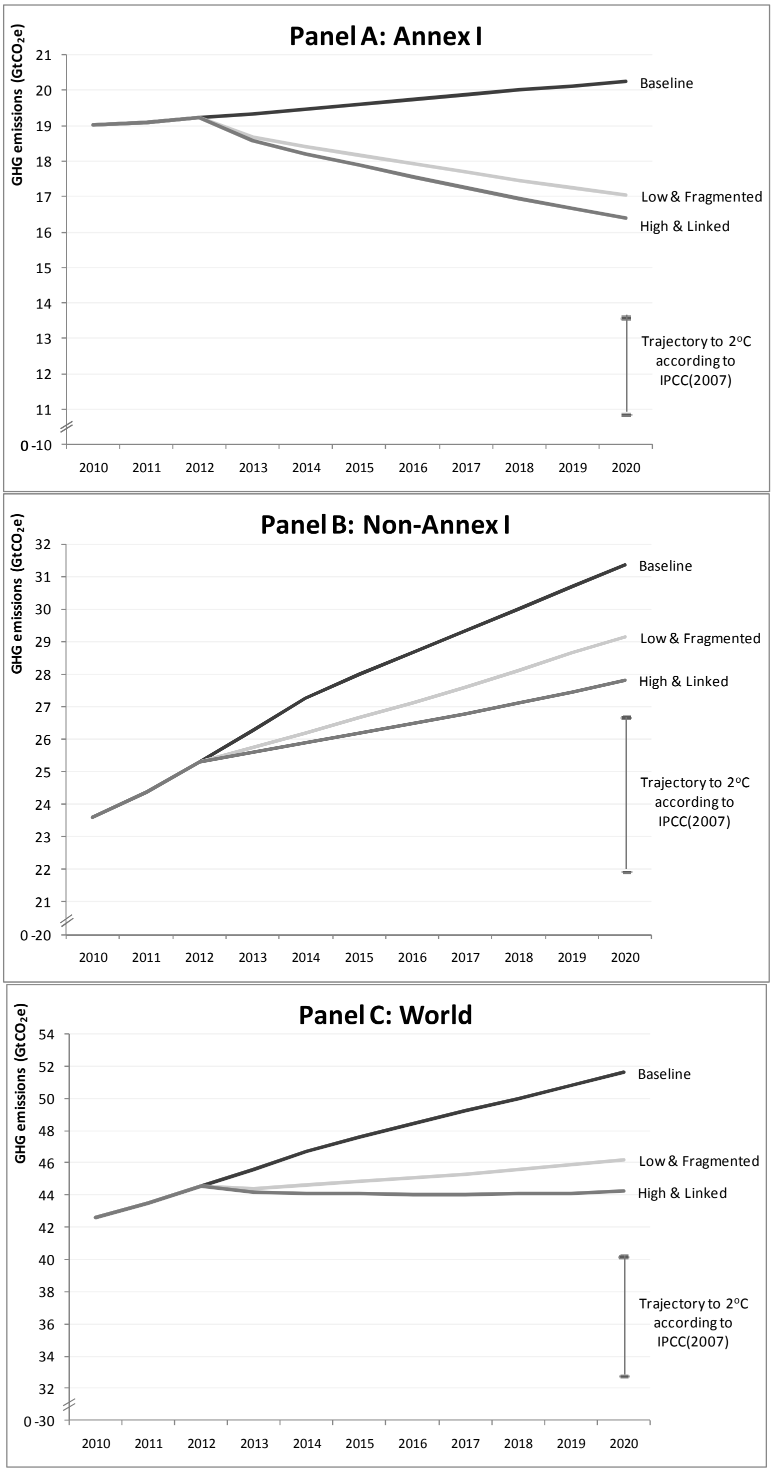
3.1 Environmental effectiveness of the collective targets and actions for 2020

According to the IPCC's Fourth Assessment Report (IPCC, 2007), a trajectory of 25% to 40% reduction from 1990 levels by 2020 for Annex I countries, combined with substantial deviation from baseline (interpreted as 15% to 30% below BAU) by major developing and emerging economies, would be consistent with a pathway to stabilisation of atmospheric concentration of greenhouse gases at around 450 parts per million (ppm) CO_2-equivalent. This GHG concentration level is associated with a medium

[1] As described in OECD (2009) and Annex 1.

likelihood (i.e. a chance of at least 50%) of limiting global average temperature increase to below 2°C, which is the long-term target for climate policies stated in the Copenhagen Accord.

Figure 1. The gap between pledged targets and the trajectory towards the long term goal of limiting global temperature increases to 2 C.



Source: OECD ENV-Linkages model

Figure 1 shows that the pledges by Annex I regions do reverse the trend of growing Annex I emissions, but a sizable gap between pledged targets and the trajectory suggested by the IPCC remains.[2] For non-Annex I countries, the transition towards low-carbon development also needs to be stronger to meet the IPCC trajectory. The expected emission growth in the baseline with no additional climate action is so large, that even a sizable reduction from BAU does not lead to a stabilisation of emissions in non-Annex I. The higher end of the pledges by Annex I countries amount to -17% in emissions from 1990; for non-Annex I to -7% in emissions from BAU in 2020. As the combined pledges for both groups of countries fall short of the pathway identified by the IPCC, the chance of exceeding temperature increases of 2°C is high. Even though ambitious stabilisation targets would still be achievable in the longer run, far more significant efforts may be needed after 2020, likely at a higher cost than if a more gradual pathway to 2°C was chosen today.

Although the combined pledges do not put emissions on the desired long-term pathway, these efforts do represent a significant break from current trends. If current trends would continue unabated, by 2020 global emissions would reach levels that are more than 30% above 2005 levels. If, however, all countries take on their most ambitious pledges as in the High & Linked scenario, global emission reductions in 2020 amount to 7.4 $GtCO_2e$. This leads to emission levels that are projected to be 14.5% below BAU levels in 2020, or equivalently around 13% above 2005 levels. This implies that in this scenario global emissions are stabilising from 2013 onwards. In contrast, the low pledges amount to global reductions in 2020 of 10.5% (5.5 $GtCO_2e$) from BAU, leading to global emission levels in 2020 that are 18% above 2005 levels.

3.2 Economic impacts of the collective targets and actions for 2020

While the environmental benefits of these emission reductions cannot be quantified within the modelling framework, the analysis sheds light on the economic impacts of implementing these pledges. For both scenarios, Figure 2 shows how these mitigation policies affect Gross Domestic Product (GDP) levels, equivalent variation in real income, potential fiscal revenues and output of the energy-intensive industries in the different regions, respectively; more detailed results of the simulations are given in Annex 2. As the damages from climate change, and hence the benefits from mitigation action, are not included in the analysis, these numbers represent the cost of action. GDP impacts (panel A) and real income impacts (panel B) vary across countries, depending not only on the stringency of their pledge, but also on the availability of low-cost domestic mitigation options. For the group of Annex I countries, on average both scenarios lead to a GDP loss of approximately 0.3% from baseline levels, and a reduction in household real income of 0.5%. Expected GDP impacts and real income losses are larger in the High & Linked scenario, even though this scenario assumes Annex I countries link their carbon markets.[3] At the global level, the additional costs are relatively minor despite the increased ambition level of the combined pledges, but for a few regions the higher end of the pledges implies substantially higher costs. Fossil fuel suppliers, such as Russia, suffer from the falling fuel prices on the world market, as international mitigation policies induce lower demand for fossil fuels and hence lower prices. The GDP impact in Russia is further affected by the stricter domestic policies in the High & Linked scenario (-25% emission reduction versus -15% emission reduction in the Low & Fragmented scenario). Furthermore, note that exported emission permits do not contribute directly to GDP, as this is measured in real terms, i.e. at the baseline prices. As the baseline contains no climate policies, the baseline price for emission permits is zero. The real income measure is not affected by this feature, as it based on the permit prices with climate policy.

In contrast, there are a number of regions that have lower costs in the High & Linked scenario, including Canada, Japan and the United States. The main reason is that the High & Linked scenario allows

[2] The emissions peak in 2012 for Annex I countries is artificial, as the stylised model simulation assumes all countries start implementing their policies in 2013.

[3] The impact of the assumption on linking Annex I carbon markets is investigated in detail in the Annex.

permit trading between Annex I countries. The domestic mitigation costs in Japan are relatively high, and therefore Japan in particular can limit its costs by linking their carbon market to those of the other Annex I countries. Moreover, Japan as well as Canada and the US do not have increased mitigation efforts above and beyond their Low & Fragmented scenario.

Figure 2. Costs and potential revenues in 2020

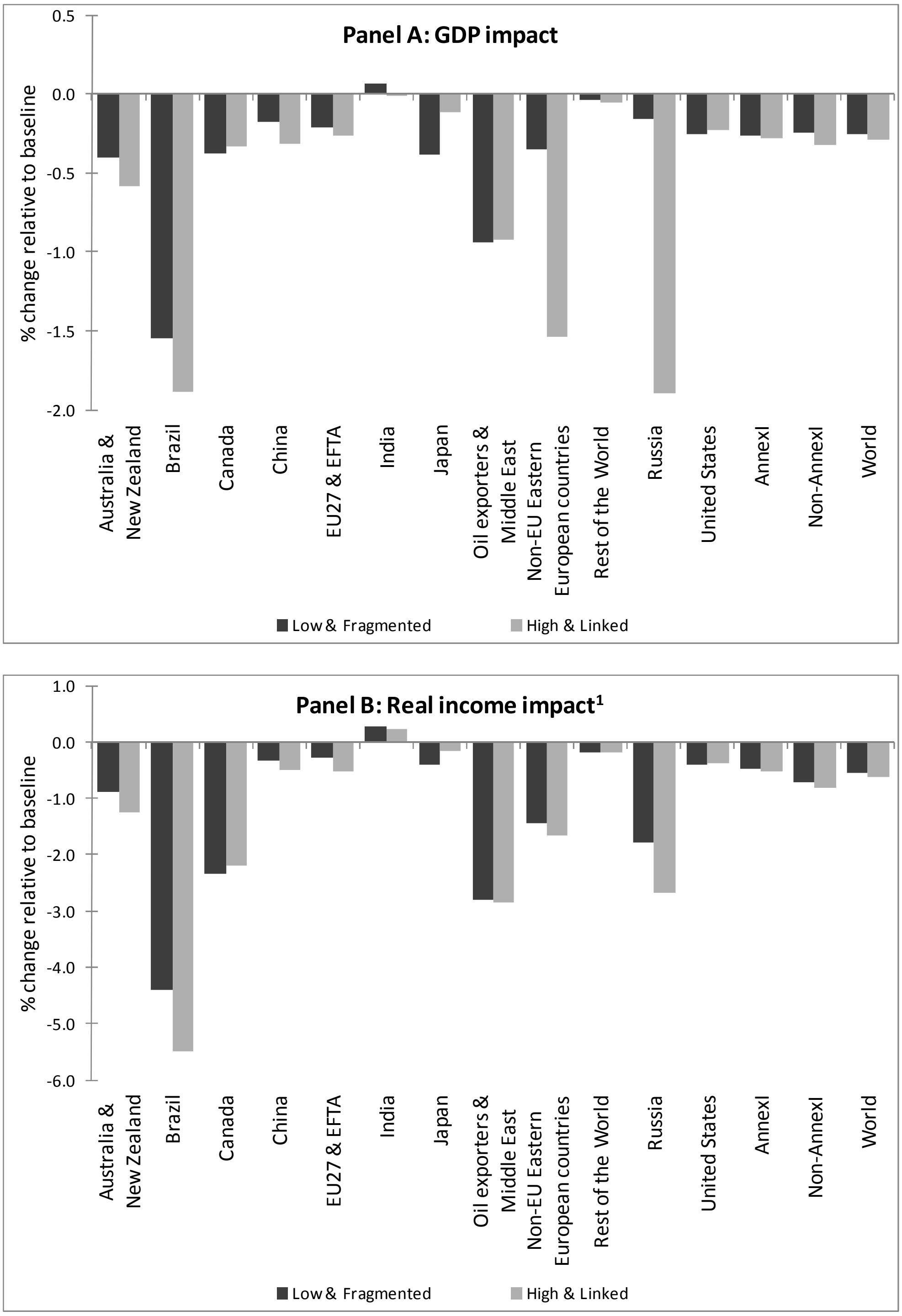
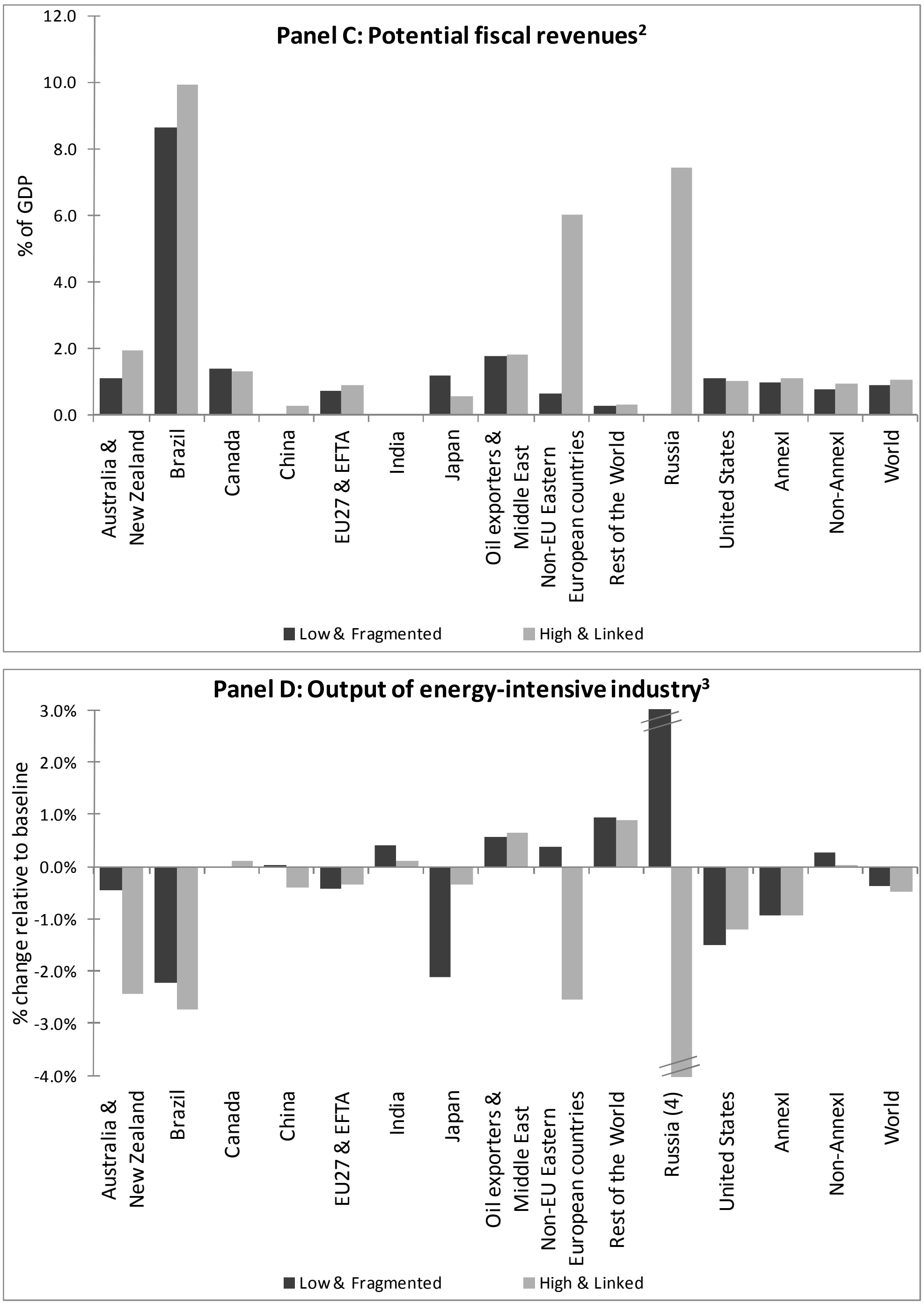


Figure 2. Costs and potential revenues in 2020 (continued)



1. Hicksian "equivalent real income variation" defined as the change in real income (in percentage) necessary to ensure the same level of utility to consumers as in the baseline projection.

2. Potential revenues or proceeds, based on implementation through carbon tax or full auctioning of permits.

3. Energy-intensive industries include chemicals, metallurgic, other metal, iron and steel, paper and mineral products.

4. Note that in Russia these sectors are projected to be very small in 2020 and hence percentage changes can be erratic.

Source: OECD ENV-Linkages model

The intensity target declared by India is evaluated in the model analysis as being less strict than the autonomous development projected in the baseline. The country can therefore benefit from providing offset credits and increase its GDP levels, albeit not much. In the High & Linked scenario, this increase fades, because the Annex I countries can limit costs by linking their carbon markets. For China, the lower end of their pledge translates into an allowed emission level that is very close to the baseline projection, but the cap does imply a small economic cost.

Finally, although these costs are certainly not negligible, they should be viewed in context: these losses are small compared to the substantial growth in projected GDP in the baseline. For the global economy, the annual costs of 0.3% of global GDP in the High & Linked scenario represent a reduction in the average annual GDP growth rate from 2.76% in the baseline to 2.74%. Even in Brazil, where the economic costs are estimated to be highest at 1.9% of GDP, the average annual GDP growth rate remains above 3% in all scenarios.

More importantly, implementing these pledges can have substantial benefits in terms of avoided climate impacts. The costs of inaction are likely to be substantially higher than the costs of action (cf. Stern, 2007). However, the ENV-Linkages model is not able to estimate the expected economic or social benefits of climate policy action, or the costs of inaction.

Panel C of Figure 2 shows the other side of the same coin: introducing carbon pricing can involve the creation of a major source of income for governments, if they either auction permits, or implement a carbon tax. For the Annex I group of countries, these could amount to over 1% of GDP in 2020, *i.e.* more than 400 billion USD. Domestic fiscal revenues could be especially high in countries that either have a very stringent policy without linking to other carbon markets (the case of Brazil in our assessment), or that can exploit relatively cheap reduction options and sell these on the international carbon market. By assumption, this latter effect is only present in the High & Linked scenario. Revenues from carbon taxes or proceeds generated from auctioned permits in developed countries can be used to offset more distortive forms of taxation, or, given the urgent need to reduce government deficits following the crisis, revenues could be used for fiscal consolidation. They could also be used to help meet the international financial commitments to support of climate adaptation and mitigation efforts in developing countries. In emerging economies, such revenues could be sources of finance for other pressing priorities, such as education, health care and poverty alleviation.

The final panel D of Figure 2 shows how the energy-intensive industries are affected by the climate policies. The Low & Fragmented scenario leads to a reduction in output of these sectors by almost 1% for Annex I, versus a 0.3% increase in non-Annex I. These output losses do not exceed 2.5% in any region, implying that the competitiveness impacts of these policies are limited, although for specific subsectors the losses may be more pronounced. In the High & Linked scenario, two opposite effects in the Annex I region cancel each other out: on the one hand the higher pledges negatively impact domestic energy-intensive industries, but on the other hand linking will reduce the worst negative impacts on energy-intensive industries as the highest-cost measures are avoided. The former effect dominates for the combined region of Australia and New Zealand, while the latter effect is especially important in Japan. Both the non-EU Eastern European economies and Russia are characterised by relatively inefficient heavy industries. Thus, when it is possible to sell permits on the international market, i.e. in the linked scenario, these industries will reform and reduce domestic production, and earn income from selling more permits to others. This option is not available to them in the Low & Fragmented scenario.

4. Sensitivity analysis

The results of this assessment are in part dependent on the assumptions regarding linking. Linking can be realised in two ways, either in an indirect manner by allowing the use of a common pool of offsets to meet the national pledges in different ETSs, or through direct linking of ETSs. The sensitivity of results to the assumptions on both manners of linking is examined in this section. Furthermore, in Section 4.3 the results are compared to a series of simulations where the Annex I countries implement pledges unilaterally.

4.1 The role of direct linking of Annex I carbon markets

In the Low & Fragmented scenario presented above (Figures 1 and 2), Annex I countries are assumed not to link their ETSs, reflecting the emergence of a fragmented international carbon market. Thus, apart from a limited availability of offsets, all emission reductions have to be achieved domestically. To disentangle the impact of the linking assumption from the range in emission reduction targets, panels A and B of Figure 3 presents the results for the same lower end of the pledges, but with linked ETSs in all Annex I regions, i.e. a Low & Linked scenario. This alternative shows that linking can reduce costs across the Annex I region, primarily as Russia is able to sell permits at a relatively low price. The lower end of the pledge made by Russia (-15% in emissions from 1990) is, according to the ENV-Linkage model simulations, not binding; as shown in Table A1 in the Annex, Russia can increase its emissions slightly above BAU levels. In the setting with linking, shown in Figure 3, this implies that some "hot air" is sold on the international market. Whether this will be allowed in reality is a subject of debate.

Similarly, a High & Fragmented scenario is investigated in panels C and D of Figure 3, where the linking assumption is dropped from the corresponding High & Linked scenario. As expected, both costs and fiscal revenues are higher for countries that want to buy permits on the Annex I market. Revenues are substantially lower for the potential sellers (Non-EU Eastern Europe and Russia). In principle, linking carbon markets does not matter for the environmental effectiveness of the policies, as the same targets and actions are implemented.

Figure 3. Varying the assumption on linking of Annex I carbon markets

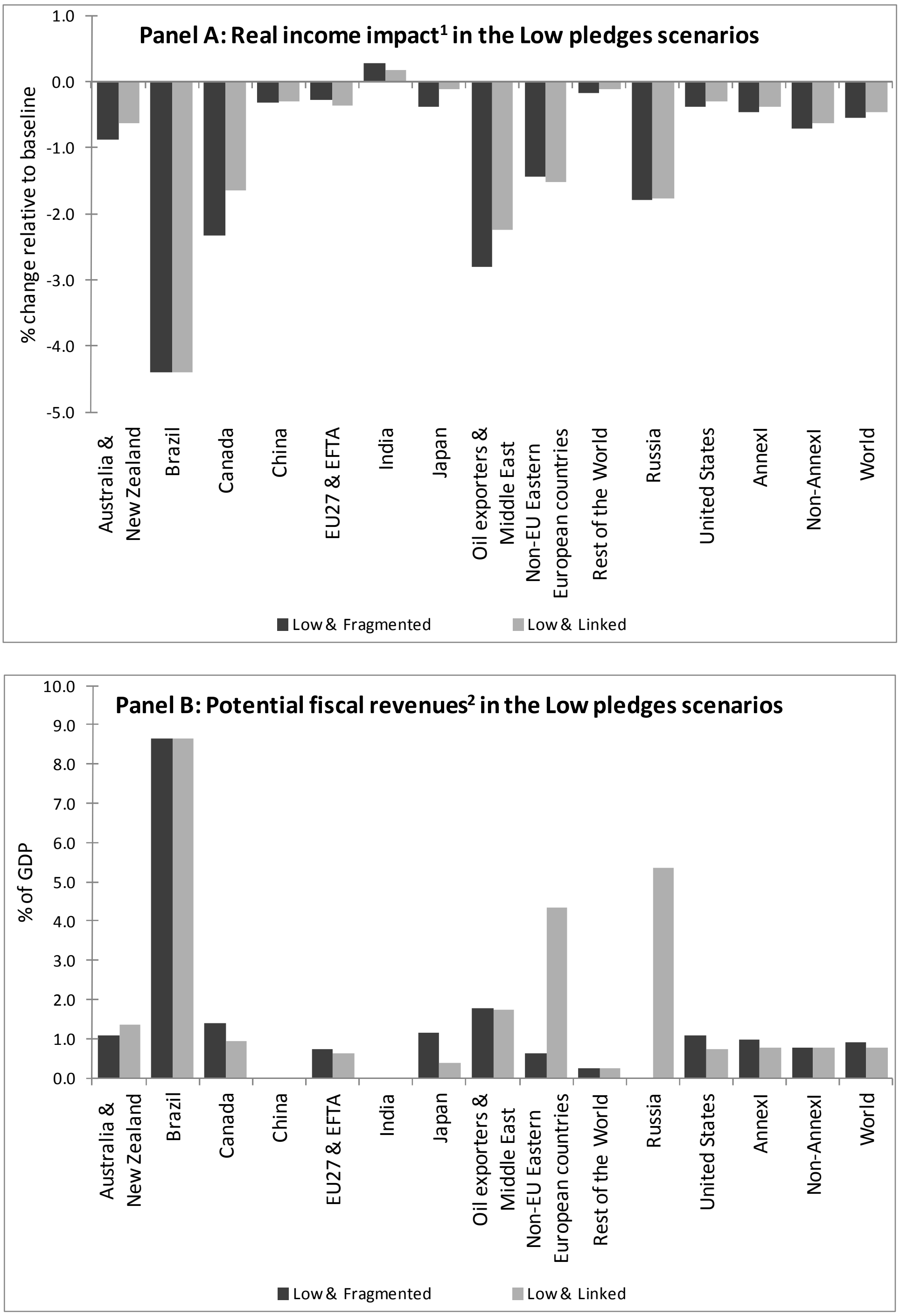
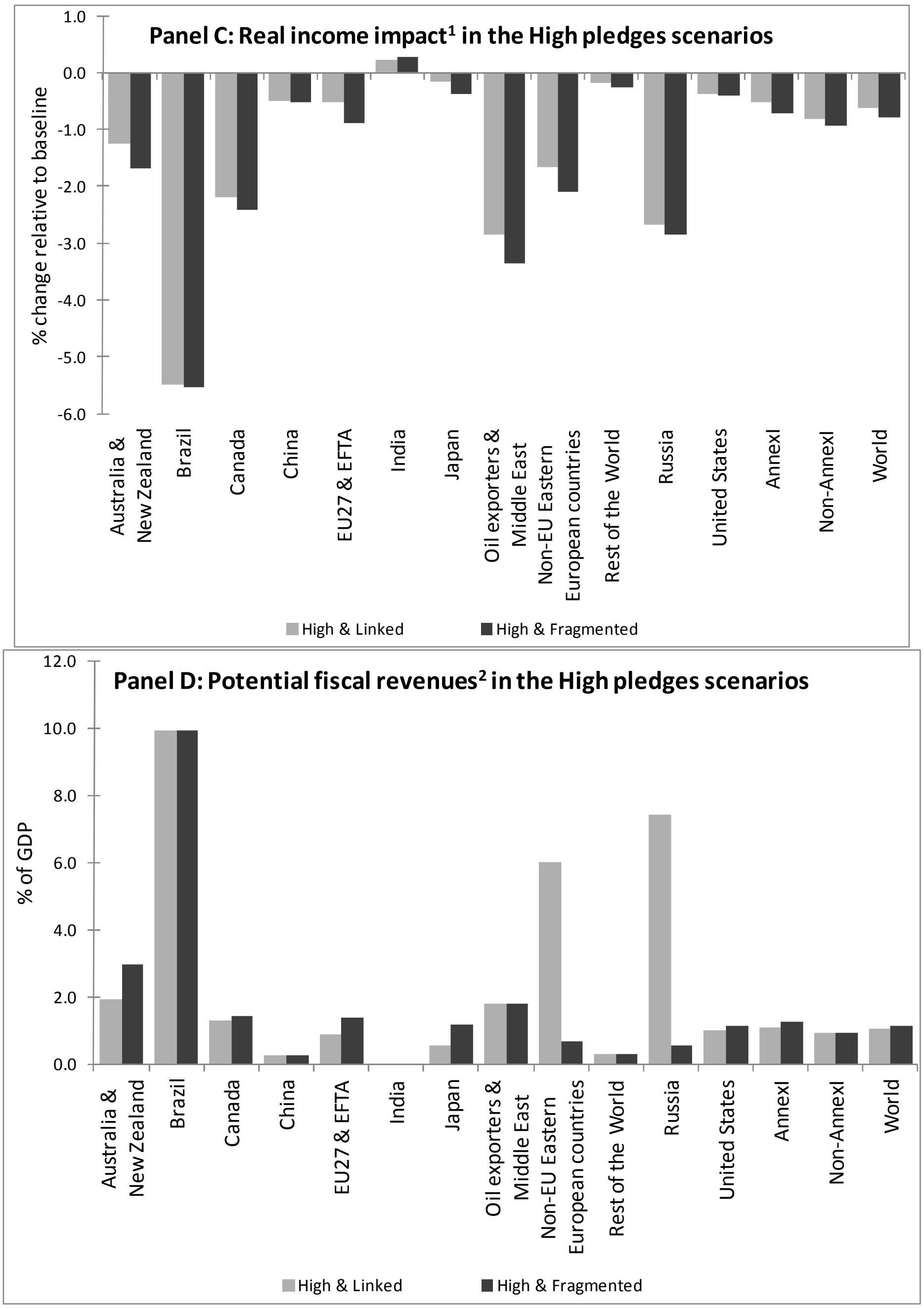


Figure 3. Varying the assumption on linking of Annex I carbon markets (continued)



1. Hicksian "equivalent real income variation" defined as the change in real income (in percentage) necessary to ensure the same level of utility to consumers as in the baseline projection.

2. Potential revenues or proceeds, based on implementation through carbon tax or full auctioning of permits.

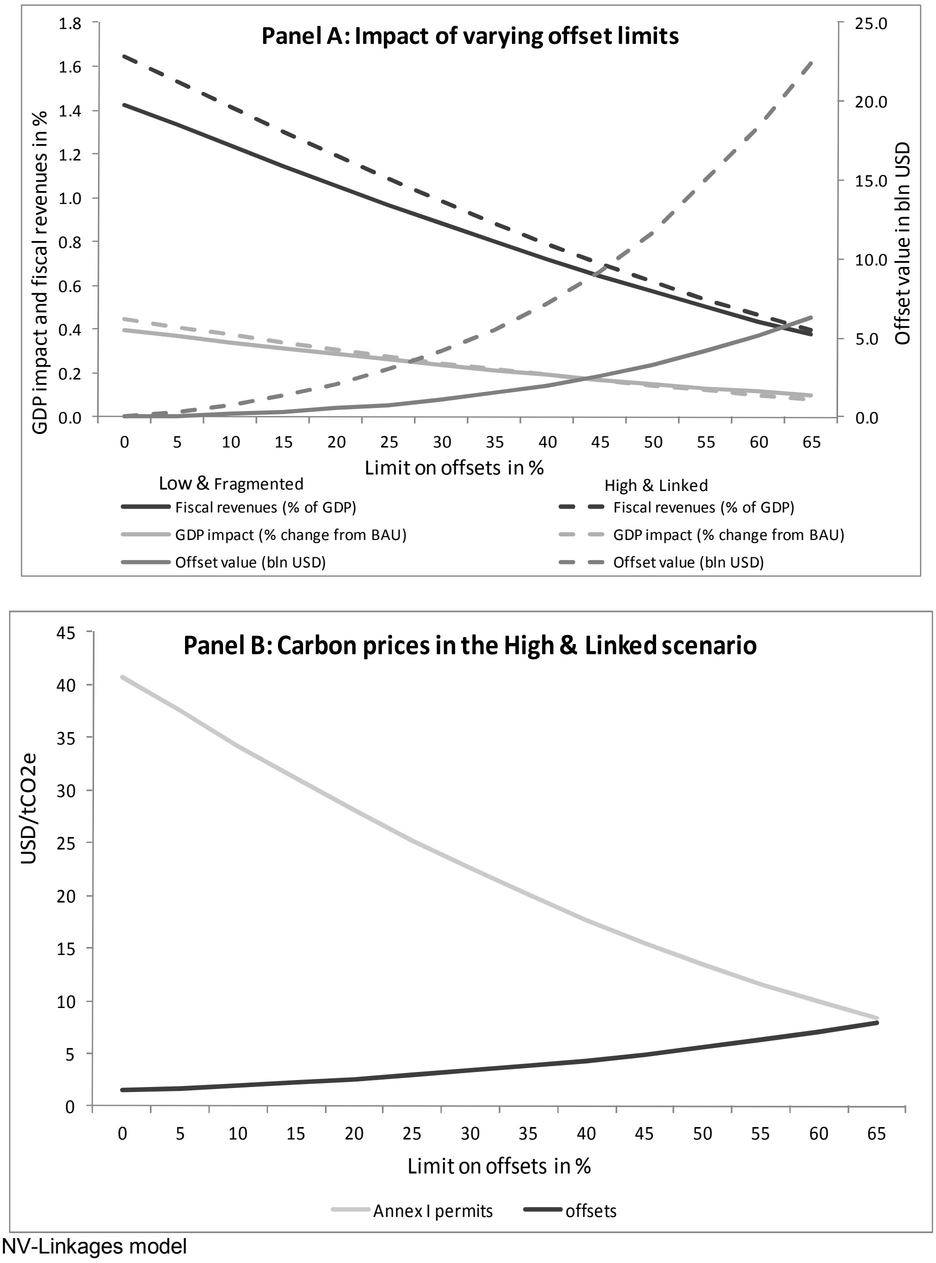
Source: OECD ENV-Linkages model

4.2 The role of the assumptions on offsets

The availability of offsets plays a crucial role in keeping the costs of climate policies low, as cheaper mitigation options in developing countries can lower the price of reducing a tonne of GHG emissions in the offset market. In the Low & Fragmented scenario, the offset market reaches a value of around 0.8 billion

USD annually (representing 850 $MtCO_2e$), whereas in the High & Linked scenario this increases to 3 billion USD (representing 1050 $MtCO_2e$). In comparison, Baron et al. (2009) estimate the annual demand for offsets until 2020 at around 1 $GtCO_2e$. The total carbon market value is around 500 billion USD in the Low & Fragmented scenario, and around 580 billion USD in the High & Linked scenario. Despite domestic action in China, it still dominates the offset market: in the High & Linked scenario it accounts for two-thirds of all offset supply, representing almost 700 $MtCO_2e$, with India also providing substantial amounts (300 $MtCO_2e$).

Figure 4. The impact of different offset limits in Annex I in 2020



Source: OECD ENV-Linkages model

The default ceiling of 20% of the target for offset demand by Annex I countries is based on an ad-hoc assessment. Changing the limit on offsets significantly affects the results; more offsets imply lower mitigation costs in Annex I countries and globally. At the same time, fiscal revenues are affected by the lower share of domestic reductions and lower carbon prices. The higher the level of offsets, the further carbon prices in Annex I and non-Annex I converge. In Figure 4, these impacts of the limit on offsets are represented graphically.[4] When the market for offsets is not constrained, *i.e.* at the right end of Panel A in Figure 3, it can reach a size of 6 billion USD in the Low & Fragmented scenario, and increase to more than 20 billion USD in the High & Linked scenario. The large difference between these two estimates is dominated by the 3 times higher price for offsets in the High & Linked scenario.

4.3 Decomposing the effect of the domestic pledges

The total costs of jointly implementing the Copenhagen pledges are represented in the ENV-Linkages model through the simultaneous implementation of all pledges. The interlinkages between the different world regions, not least through international trade in fossil fuels, imply that the impacts of other countries' pledges may be as important for the total costs in a country as purely domestic effects. Especially the oil-exporting regions, such as the OPEC countries and Russia, will feel the impact that international mitigation action has on the world market for fossil fuels through reduced revenues from exporting oil. Because the global general equilibrium framework specialises in modelling international trade relations, one of the major attributes of this OECD assessment is the comprehensive analysis of the economic impacts of simultaneous implementation of the pledges. The model results include various indicators for the costs of action that incorporate indirect effects (such as impacts on GDP and equivalent variation in income), as well as the potential for fiscal revenue.

A decomposition analysis can be carried out to identify what role the pledges of other countries play in the total costs presented above. To this end, a series of scenarios is run where one of the Annex I regions implements its pledge unilaterally, without caps on emissions in the other regions (but offsets are still assumed to be available). The effects of these simulations can be compared to the results from the (multilateral) Low & Fragmented and High & Linked scenarios discussed in Section 3. It should be stressed that the results of the unilateral pledges cannot be aggregated across regions, as they derive from individual simulations.

For most countries, including Canada and Russia, the real income impact from a unilateral implementation of a pledge is smaller than the impact in the multilateral base scenarios, as international demand for fossil fuels is not reduced in the unilateral cases. In the case of Russia, these international relations that result in reduced fossil fuel demand fully explain the income loss in the Low & Fragmented scenario, and most of the losses in the High & Linked scenario (the income change for the unilateral implementation is -0.2% from baseline, versus -2.7% in the multilateral High & Linked scenario). Furthermore, in the unilateral setting the country can still import energy-intensive goods at relatively low prices and this reduces consumption impacts.

However, a unilateral implementation of the pledge has a negative impact on the competitive position of domestic energy-intensive industry. On average, the output loss for energy-intensive industries increases from 1% (Low & Fragmented scenario) to 1.6% (unilateral low pledges) when the lower pledges are implemented, and from 1% (High & Linked scenario) to 2.1% (unilateral high pledges) for the higher pledges. This competitiveness effect dominates for relatively open economies that depend a lot on international trade, such as Japan and the European Union, and leads to a real income impact in these countries that is higher in the unilateral case than in the base scenarios.

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[4] When varying the offset limit, the ad-hoc assumption is made that offsets in Canada increase proportionally with the default value and thus are always half of the default value.

5. Discussion

This assessment provides information on the environmental and cost-effectiveness of the pledges in the Appendix of the Copenhagen Accord. It contributes to the literature by assessing the impacts on GDP, real income, and potential fiscal revenue, as well as exploring the sensitivity to offset and linking assumptions. Several other assessments of the pledges have been published, each with their own underlying assumptions and tools. This section explores how this analysis compares with other studies, including a discussion of the key underlying assumptions and limitations.

5.1 Comparison to other assessments

Many other organisations have assessed the potential environmental impact of the Copenhagen Accord. In terms of environmental impacts, this OECD assessment is broadly in line with other model assessments (den Elzen et al, 2010; Houser, 2010; Project Catalyst, 2010; Rogelj et al, 2010; Stern et al 2010; UNEP, 2010; UNFCCC, 2010). Although each assessment shows some variation on underlying interpretation of the targets and baseline, they all agree that even the most optimistic interpretation of the Copenhagen pledges implies that the joint targets and actions are not ambitious enough to put global emissions on the recommended pathway to limit average global temperature increase to 2 degrees Celsius.

The Climate Action Tracker[5] assesses the range of reductions for Annex I regions to be between -12% and -19% from 1990 levels. Rogelj et al. (2010) estimate 2020 emission levels to be between 10 and 20% above “today’s levels”. UNEP (2010) presents an overview from several different modelling studies, and stresses that each individual modelling study has an uncertainty of around 2 $GtCO_2e$ in their assessment. The major conclusion from the UNEP study is that “there is a low confidence that the two degree limit will be met under current commitments/mitigation actions”.

Fewer pledge assessments report potential economic impacts of the emission pledges. Most assessments are made on a national basis, focusing on a single country or region. It is also more difficult to compare across those studies that do report costs, because some studies report only direct costs from the implementation of a national pledge, some include net costs from the trading of emission allowances in the carbon market, and some – such as ENV-Linkages – include full direct and indirect impacts on GDP and real income levels. Studies using a bottom-up approach show direct or resource costs, but do not take into account additional costs of national emission reduction targets that occur through international trade flows. For example, the carbon prices reported in EC (2010) are not directly comparable to those reported from ENV-Linkages; although on average the order of magnitude is similar, some regions show quite different results.

One notable exception to the partial cost assessments is the study by McKibben et al. (2010), which is based on the G-Cubed general equilibrium model, thus capturing more complete GDP impacts. However McKibben (2010) assumes no trading of emission allowances between countries, and no offsets, so each country must meet its target domestically. This results in much higher GDP impacts than those shown in this OECD assessment, strengthening our earlier conclusion that direct or indirect linking of carbon markets is a main driver to keep costs of action as low as possible.

Another factor adding to the complexity on comparing economic impacts is the assumption regarding financial transfers. The emission reduction targets included in this OECD analysis do not account for additional reductions in non-Annex I countries that could be realised if international financing were made available. This assumption results in higher economic impacts in developing countries than would occur if financial transfers from Annex I parties to non-Annex I parties were assumed. In comparison, the den

[5] www.climateactiontracker.org

Elzen (2010) assessment assumes financial transfers covering 50% of non-Annex I mitigation costs.[6] In particular, our analysis shows that the ambitious pledge put forward by Brazil has a large impact on their domestic economy if no international transfers are available[7]. Direct financial transfers between governments can compensate for these impacts. Additional simulations with the ENV-Linkages model show that 50% international financing of mitigation action in non-Annex I countries can halve the GDP impact in Brazil and bring their real income loss down by three-quarters.

5.2 Limitations of the analysis

As mentioned above, the ENV-Linkages model does not explicitly model emissions associated with land-use, land-use change and forestry (LULUCF). A version of the model that includes LULUCF is currently under development; preliminary analysis reported in OECD (2009) suggests that there may be a large potential for relatively cheap mitigation action in this sector. To the extent that the pledged targets incorporate LULUCF emissions and mitigation actions, an assessment that includes these emissions and actions would likely result in lower costs, unless there are restrictions on accounting for these emissions and actions in an international framework.

In addition, this analysis does not account for surplus assigned amount units (AAUs) from previous commitment periods in the EU-ETS. The impact of potential surplus AAUs (e.g. from Russia) depends in part on the assumptions regarding use of the units across accounting periods. The existence of surplus AAUs in the post-2012 period would effectively allow for higher emissions in that period than would occur otherwise (see den Elzen, 2010, for further discussion). The non-binding target for Russia in the Low & Fragmented scenario does imply that Russia has some scope to sell permits without undertaking additional mitigation actions.

6. Final remarks

While it is promising that many countries are willing to commit to ambitious mitigation action, the pledged targets of Annex I countries and actions of non-annex I countries as submitted in accordance with the Copenhagen Accord are insufficient when compared to the emission reductions suggested by the IPCC to keep global temperature change limited to 2°C.

Ambitious global action to mitigate greenhouse gas emissions is not only necessary, but also economically rational. While not cheap, the costs of these pledges are limited compared to expected economic growth, and substantially less than most estimates of the costs of inaction (e.g. the Stern Review). Furthermore, provisions to limit the economic impact of climate change mitigation include the use of market-based instruments - such as carbon taxes or emissions trading schemes with auctioning of the permits, flexible mechanisms such as offsets, and linking of emission trading systems.

Climate policies are not only about costs, however. They also provide important environmental benefits and have the potential to generate fiscal revenues that are sizable, when market instruments are used. This is especially attractive in current times of large budget deficits. Furthermore, ambitious climate policies are an essential part of a broader green growth strategy that aims at a strong, fair and clean global economy.

[6] The GDP impacts shown in den Elzen (2010) are also lower than in our assessment due to the full international impacts on GDP that the ENV-Linkages model captures.

[7] Remember also that our analysis does not include LULUCF emissions and thus scales the associated mitigation potential and pledge accordingly.

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ANNEX 1. DESCRIPTION OF THE ENV-LINKAGES MODEL

The OECD ENV-Linkages model is a recursive dynamic neo-classical general equilibrium model. It is the successor to the OECD GREEN model for environmental studies (Burniaux, et al. 1992; Burniaux, 2000). The model is documented in Burniaux and Chateau (2008). Previous works using ENV-Linkages extensively include two books: OECD (2008) and OECD (2009).

ENV-Linkages is a global economic model built primarily on a database of national economies. In the version of the model used here, the world economy is divided in 12 countries/regions, each with 25 economic sectors (Tables A1 and A2), including five different technologies to produce electricity. The core of the static equilibrium is formed by the set of Social Account Matrices (SAMs) that described how economic sectors are linked; these are based on the GTAP database (currently using version 6.2). A fuller description of the database can be found at Dimaranan (2006). Many key parameters are set on the basis of information drawn from various empirical studies and data sources (see Burniaux and Chateau, 2008).

Table A1. ENV-Linkages model sectors

1) Rice	14) Food Products
2) Other crops	15) Other Mining
3) Livestock	16) Non-ferrous metals
4) Forestry	17) Iron & steel
5) Fisheries	18) Chemicals
6) Crude Oil	19) Fabricated Metal Products
7) Gas extraction and distribution	20) Paper & Paper Products
8) Fossil Fuel Based Electricity	21) Non-Metallic Minerals
9) Hydro and Geothermal electricity	22) Other Manufacturing
10) Nuclear Power	23) Transport services
11) Solar& Wind electricity	24) Services
12) Renewable combustibles and waste electricity	25) Construction & Dwellings
13) Petroleum & coal products	26) Coal

Table A2. ENV-Linkages model regions

ENV-Linkages regions	GTAP countries/regions
1) Australia & New Zealand	Australia, New Zealand
2) Japan	Japan
3) Canada	Canada
4) United States	United States
5) European Union 27 & EFTA	Austria, Belgium, Denmark, Finland, Greece, Ireland, Luxembourg, Netherlands, Portugal, Sweden, France, Germany, United Kingdom, Italy, Spain, Switzerland, Rest of EFTA, Czech Republic, Slovakia, Hungary, Poland, Romania, Bulgaria, Cyprus, Malta, Slovenia, Estonia, Latvia, Lithuania
6) Brazil	Brazil
7) China	China, Hong Kong
8) India	India
9) Russia	Russian Federation
10) Oil-exporting countries & Middle East	Indonesia, Venezuela, Rest of Middle East, Islamic Republic of Iran, Rest of North Africa, Nigeria
11) Non-EU Eastern European countries	Croatia, Rest of Former Soviet Union
12) Rest of the world	Korea, Taiwan, Malaysia, Philippines, Singapore, Thailand, Viet Nam, Rest of East Asia, Rest of Southeast Asia, Cambodia, Rest of Oceania, Bangladesh, Sri Lanka, Rest of South Asia, Pakistan, Mexico, Rest of North America, Central America, Rest of Free Trade Area of Americas, Rest of the Caribbean, Colombia, Peru, Bolivia, Ecuador, Argentina, Chile, Uruguay, Rest of South America, Paraguay, Turkey, Rest of Europe, Albania, Morocco, Tunisia, Egypt, Botswana, Rest of South African Customs Union, Malawi, Mozambique, Tanzania, Zambia, Zimbabwe, Rest of Southern African Development Community, Mauritius, Madagascar, Uganda, Rest of Sub-Saharan Africa, Senegal, South Africa.

All production in ENV-Linkages is assumed to operate under cost minimisation with an assumption of perfect markets and constant returns to scale technology. The production technology is specified as nested Constant Elasticity of Substitution (CES) production functions in a branching hierarchy. Each sector uses intermediate inputs – including energy inputs - and primary factors (labour, capital, land and natural resources). For each good or service, output is produced by different production streams which are differentiated by capital vintage (old and new). The substitution possibilities among production factors are assumed to be higher with the *new* than with the *old* capital vintages — technology has a putty/semi-putty specification. Capital accumulation is modelled according to the traditional Solow/Swan neo-classical growth model.

The energy bundle is of particular interest for analysis of climate change issues. Energy is a composite of fossil fuels and electricity. In turn, fossil fuel is a composite of coal and a bundle of the "other fossil fuels". At the lowest nest, the composite "other fossil fuels" commodity consists of crude oil, refined oil products and natural gas. The value of the substitution elasticities are chosen as to imply a higher degree of substitution among the other fuels than with electricity and coal.

World trade is based on a set of regional bilateral flows. Allocation of trade between partners responds to changes in relative prices between regions. The basic assumption is that imports originating from different regions are imperfect substitutes (Armington specification). Each region runs a fixed current-account surplus (or deficit).

The ENV-Linkages model has a simple recursive-dynamic structure, where households base their decisions on static expectations concerning prices and quantities. Household consumption demand and savings are implemented through an "Extended Linear Expenditure System". Since consumers are not represented with forward-looking behavior, some care needs to be exercised in studying policies that consumers may reasonably be expected to anticipate – either the policy itself or its consequences. In each period, investment net-of-economic depreciation is equal to the sum of government savings, consumer savings and net capital flows from abroad.

The government in each region collects various kinds of taxes in order to finance government expenditures. Aggregate government expenditures are linked to real GDP. Assuming fixed public savings (or deficits), the government budget is balanced through the adjustment of the income tax on consumer income.

CO_2 emissions from combustion of energy are directly linked to the use of different fuels in production. Other GHG emissions are linked to output in a way similar to Hyman *et al.* (2002). The following non-CO_2 emission sources are considered: *i)* methane from rice cultivation, livestock production (enteric fermentation and manure management), coal mining, crude oil extraction, natural gas and services (landfills); *ii)* nitrous oxide from crops (nitrogenous fertilizers), livestock (manure management), chemicals (non-combustion industrial processes) and services (landfills); *iii)* industrial gases (SF6, PFC's and HFC's) from chemicals industry (foams, adipic acid, solvents), aluminum, magnesium and semi-conductors production.

For studying the impacts of climate change policy, four types of instruments have been developed: 1) GHG taxes, global or specific by sectors, gases or emission sources; 2) tradable emission permits (with flexibility between regions and sectors); 3) offsets (including a stylised version of the Clean Development Mechanism); and 4) regulatory policy. Taxes and tradable permits are applied directly to GHG emissions. Offsets are driven by an exogenous limit on demand for offset credits and competition between potential suppliers. Regulatory policy has been introduced in the model through quantity constraints (Burniaux, et al. 2008).

Market goods equilibria imply that, on the one side, the total production of any good or service is equal to the demand addressed to domestic producers plus exports; and, on the other side, the total demand is allocated between the demands (both final and intermediary) addressed to domestic producers and the import demand. The general equilibrium framework ensures that a unique set of relative prices emerges such that demand equals supply in all markets simultaneously (i.e. across all regions, commodities, and factors of production). All prices are expressed relatively to the numéraire of the price system that is chosen as the index of OECD manufacturing exports prices. Implementation of a policy in the model leads to a new equilibration process and thus a new set of equilibrium prices and quantities to compare with the original equilibrium.

The process of calibration of the ENV-Linkages model is broken down into three stages (cf. Burniaux and Chateau, 2008). First, a number of parameters are calibrated, given some elasticity values, on base-year (2001) values of variables. Second, the 2001 database is updated to 2005 by simulating the model dynamically to match historical trends over the period 2001-2005; thus all variables are expressed in 2005 real USD. Third, the baseline projection until 2050 is based on convergence assumptions about labour productivity and other socio-economic drivers (demographic trends, future trends in energy prices and energy efficiency gains), as further described in Duval and De la Maisonneuve (2010). The baseline has been adjusted to incorporate the effects of the economic crisis of 2008-2009. In addition, the baseline assumes no new climate policies, but does include other government policies for instance on energy policy as included in the energy projections of the IEA (2009).[8] It thus provides a benchmark against which policy scenarios aimed at achieving emission cuts can be assessed.

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[8] The baseline simulation also contains the assumption that the EU Emission Trading System is implemented over the period 2006-2012, assuming a permits price that will rise gradually from 5 to 25 constant $US in 2012.

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ANNEX 2. AUXILIARY RESULTS OF THE MODEL SIMULATIONS

In this Annex, some additional model simulation results are presented in order to provide more insight in the main results as presented above. Tables A4 and A5 present more detailed results of the two modelling scenarios, while Tables A6 and A7 show the results for alternative assumptions on linking.

Table A4. Low & Fragmented scenario: lower end of the pledges, 20% offsets, without linking, year 2020

Region	Carbon price (USD/tCO_2)	Fiscal revenues (% of GDP)	% deviation from BAU 2020		GHG emissions deviation		
			GDP	Household equivalent real income[1]	$MtCO_2$ eq.	% relative to BAU2020	Target[2] % relative to base year
Australia & New Zealand	13.4	1.1	-0.4	-0.9	-163	-19.7	10.5
Brazil	97.0	8.6	-1.5	-4.4	-468	-36.0	-19.2
Canada	27.7	1.4	-0.4	-2.3	-197	-24.1	3.0
China	0.9	0.0	-0.2	-0.3	-978	-7.0	88.0
EU27 & EFTA	20.5	0.7	-0.2	-0.3	-970	-17.3	-20.0
India	0.9	0.0	0.1	0.3	-135	-3.9	56.6
Japan	59.7	1.2	-0.4	-0.4	-355	-25.6	-25.0
Oil exporting countries	8.6	1.8	-0.9	-2.8	-343	-8.5	25.4
Non-EU Eastern Europe	2.2	0.6	-0.3	-1.4	-104	-8.4	-16.0
Rest of the World	0.9	0.3	0.0	-0.2	-296	-3.5	19.9
Russia	0.0	0.0	-0.2	-1.8	12	0.5	-19.3
United States	27.9	1.1	-0.2	-0.4	-1,435	-18.0	-3.5
Annex I		1.0	-0.3	-0.5	-3,213	-15.9	-12.7
Non-Annex I		0.8	-0.2	-0.7	-2,220	-7.1	47.7
World		**0.9**	**-0.3**	**-0.5**	**-5,433**	**-10.5**	**17.9**

1. Hicksian "equivalent real income variation" defined as the change in real income (in percentage) necessary to ensure the same level of utility to consumers as in the baseline projection.

2. Due to data availability constraints, the base year is 1990 for Annex I regions and 2005 for non-Annex I regions (Brazil, China, India, Oil exporting countries, and Rest of the world). Global deviation is based on 2005 data for all regions. Targets are calculated as emission deviation before Annex I trading and with offset credits attributed to Annex I donor region.

Table A5. High & Linked scenario: higher end of the pledges, 20% offsets, with Annex I linking, year 2020

Region	Carbon price (USD/tCO_2)	Fiscal revenues (% of GDP)	% deviation from BAU 2020		GHG emissions deviation		
			GDP	Household equivalent real income[1]	$MtCO_2$ eq.	% relative to BAU2020	Target[2] % relative to base year
Australia & New Zealand	25.3	1.9	-0.6	-1.2	-211	-25.5	-11.5
Brazil	115.9	9.9	-1.9	-5.5	-508	-39.0	-23.0
Canada	25.3	1.3	-0.3	-2.2	-185	-22.7	3.0
China	3.0	0.3	-0.3	-0.5	-1,895	-13.5	73.1
EU27 & EFTA	25.3	0.9	-0.3	-0.5	-1,054	-18.8	-30.0
India	3.0	0.0	0.0	0.2	-259	-7.5	57.0
Japan	25.3	0.6	-0.1	-0.2	-208	-15.0	-25.0
Oil exporting countries	8.6	1.8	-0.9	-2.8	-343	-8.5	25.4
Non-EU Eastern Europe	25.3	6.0	-1.5	-1.7	-307	-24.7	-16.5
Rest of the World	3.0	0.3	-0.1	-0.2	-547	-6.4	19.9
Russia	25.3	7.4	-1.9	-2.7	-525	-22.0	-25.0
United States	25.3	1.0	-0.2	-0.4	-1,364	-17.1	-3.5
Annex I		1.1	-0.3	-0.5	-3,855	-19.0	-17.3
Non-Annex I		0.9	-0.3	-0.8	-3,551	-11.3	42.1
World		**1.0**	**-0.3**	**-0.6**	**-7,406**	**-14.3**	**12.8**

1. Hicksian “equivalent real income variation” defined as the change in real income (in percentage) necessary to ensure the same level of utility to consumers as in the baseline projection.

2. Due to data availability constraints, the base year is 1990 for Annex I regions and 2005 for non-Annex I regions (Brazil, China, India, Oil exporting countries, and Rest of the world). Global deviation is based on 2005 data for all regions. Targets are calculated as emission deviation before Annex I trading and with offset credits attributed to Annex I donor region.

Table A6. Low & Linked scenario: lower end of the pledges, 20% offsets, with Annex I linking, year 2020

Region	Carbon price (USD/tCO_2)	Fiscal revenues (% of GDP)	% deviation from BAU 2020		GHG emissions deviation		
			GDP	Household equivalent real income[1]	$MtCO_2$ eq.	% relative to BAU2020	Target[2] % relative to base year
Australia & New Zealand	17.5	1.4	-0.4	-0.6	-187	-22.5	10.5
Brazil	96.7	8.6	-1.6	-4.4	-468	-36.0	-19.2
Canada	17.5	0.9	-0.2	-1.6	-150	-18.4	3.0
China	1.2	0.0	-0.2	-0.3	-1,011	-7.2	88.0
EU27 & EFTA	17.5	0.6	-0.2	-0.4	-887	-15.8	-20.0
India	1.2	0.0	0.0	0.2	-130	-3.7	56.6
Japan	17.5	0.4	-0.1	-0.1	-171	-12.3	-25.0
Oil exporting countries	8.5	1.8	-0.8	-2.3	-343	-8.5	25.4
Non-EU Eastern Europe	17.5	4.4	-1.1	-1.5	-260	-21.0	-16.0
Rest of the World	1.2	0.3	0.0	-0.1	-273	-3.2	19.9
Russia	17.5	5.3	-1.3	-1.8	-437	-18.4	-19.3
United States	17.5	0.7	-0.2	-0.3	-1,116	-14.0	-3.5
Annex I		0.8	-0.2	-0.4	-3,208	-15.8	-12.7
Non-Annex I		0.8	-0.2	-0.6	-2,224	-7.1	47.7
World		**0.8**	**-0.2**	**-0.5**	**-5,433**	**-10.5**	**17.9**

1. Hicksian "equivalent real income variation" defined as the change in real income (in percentage) necessary to ensure the same level of utility to consumers as in the baseline projection.

2. Due to data availability constraints, the base year is 1990 for Annex I regions and 2005 for non-Annex I regions (Brazil, China, India, Oil exporting countries, and Rest of the world). Global deviation is based on 2005 data for all regions. Targets are calculated as emission deviation before Annex I trading and with offset credits attributed to Annex I donor region.

Table A7. High & Fragmented scenario: higher end of the pledges, 20% offsets, without linking, year 2020

Region	Carbon price (USD/tCO_2)	Fiscal revenues (% of GDP)	% deviation from BAU 2020		GHG emissions deviation		
			GDP	Household equivalent real income[1]	$MtCO_2$ eq.	% relative to BAU2020	Target[2] % relative to base year
Australia & New Zealand	42.0	3.0	-0.9	-1.7	-254	-30.7	-11.5
Brazil	116.3	9.9	-1.9	-5.5	-508	-39.0	-23.0
Canada	28.3	1.4	-0.4	-2.4	-197	-24.1	3.0
China	2.8	0.3	-0.3	-0.5	-1,885	-13.4	73.1
EU27 & EFTA	42.4	1.4	-0.5	-0.9	-1,391	-24.9	-30.0
India	2.8	0.0	0.0	0.3	-261	-7.5	57.0
Japan	60.5	1.2	-0.4	-0.4	-355	-25.6	-25.0
Oil exporting countries	8.8	1.8	-1.1	-3.4	-343	-8.5	25.4
Non-EU Eastern Europe	2.4	0.7	-0.5	-2.1	-109	-8.8	-16.5
Rest of the World	2.8	0.3	-0.1	-0.2	-552	-6.5	19.9
Russia	1.6	0.6	-0.4	-2.9	-113	-4.7	-25.0
United States	28.5	1.1	-0.2	-0.4	-1,435	-18.0	-3.5
Annex I		1.3	-0.4	-0.7	-3,855	-19.0	-17.3
Non-Annex I		0.9	-0.3	-0.9	-3,548	-11.3	42.1
World		**1.1**	**-0.4**	**-0.8**	**-7,403**	**-14.3**	**12.8**

1. Hicksian “equivalent real income variation” defined as the change in real income (in percentage) necessary to ensure the same level of utility to consumers as in the baseline projection.

2. Due to data availability constraints, the base year is 1990 for Annex I regions and 2005 for non-Annex I regions (Brazil, China, India, Oil exporting countries, and Rest of the world). Global deviation is based on 2005 data for all regions. Targets are calculated as emission deviation before Annex I trading and with offset credits attributed to Annex I donor region.