The role of REDD in a Copenhagen Carbon Market

(Preliminary version – please do not cite)

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Abstract:

This paper analyses the impact of introducing REDD credits into a carbon market following the Copenhagen Accord. This is done by means of an extended recursive dynamic CGE model that incorporates avoided deforestation abatement cost curves from a partial equilibrium study, taking also into account land and timber effects resulting from avoided deforestation activities. Various policy scenarios considering different levels of restrictions to the use of REDD credits are analyzed. We conclude that REDD may significantly reduce carbon prices and policy costs. When no limits are imposed, the large number of REDD credits entering the carbon market allows the regions pertaining to the climate policy agreement to systematically emit above their targets. While it is economically sounding that abatement is shifted to lower abatement costs activities, these results confirm that policy design requires limits to the use of REDD credits along with the creation of long term incentives to promote a greener economy. On the other hand carbon prices are sufficiently high to guarantee substantial reductions in deforestation rates. Regions selling avoided deforestation credits without a binding emission reduction target may benefit from carbon leakage and be better off when the selling of REDD credits is not allowed.

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This paper is part of the research of the Sustainable Development Programme of the Fondazione Eni Enrico Mattei.

1. Introduction

Forests are a two edged sword in global climate policy. On the one hand, they are one of the major contributors to increasing average global temperatures, accounting for circa 17% of total annual carbon release (IPCC 2007). On the other, by keeping current forest stocks, increasing forest areas or changing timber management practices, forests may help to stabilize or even decrease current green house gases (GHG) concentrations. On top of this, many in the policy arena have suggested that forest could provide relatively low cost net carbon emissions reductions.

A fairly large number of studies have corroborated this claim in scientific grounds. Kindermann et al 2008, comparing results from three global forestry and land use models, offers a useful summary of these estimates. According to this study, the regions with lowest avoided deforestation costs could provide 2.8-4.7 of Gt of reduced CO_2 emissions during the 2005–2030 period at a 100$ per ton of CO_2. In another study, Sohngen and Mendelsohn 2003 linked the DICE model of Nordhaus and Boyer 2000 with a global forestry model, concluding that forests could cost effectively account for 30% of total carbon abatement across the century. Tavoni et al. 2007, using the World Induced Technological Change Hybrid model (WITCH) analyzed the impacts of adding forest based carbon sequestration opportunities on the costs of meeting a 550 ppmv CO_2 concentration target by 2100. The authors concluded that forests could generate policy cost savings of around 40% that could otherwise be used to finance an additional 0.25°C less warming by the end of the century. Using the same model, but considering only avoided deforestation, Bosetti et al. 2009 studied the role of forestry under a more stringent stabilization target (450 ppmv CO2). According to the authors, the use of Reducing Emissions from Deforestation and forest Degradation (REDD) credits in an international carbon market could decrease stabilization costs by 10-23%.

Given the major role played by forests in regulating climate, and its potential contribution on an optimal climate change policy portfolio, it is not surprising that they have since long been central in international climate negotiations. If it is true that questions like permanence, uncertainty or additionality have seriously constrained the inclusion of forests based carbon sequestration activities under the Kyoto Protocol, many have argued that the decisions concerning REDD were one of the few positive outcomes of Copenhagen. The accord explicitly recognized the “role of reducing emissions from forest deforestation and forest degradation and the need to enhance removals of greenhouse gas emissions by forests” (UNFCC, 2009) and paved the way for supporting

REDD policies in developing countries. The Conference of the Parties recently held in Cancun has reassured the political willingness to move forward with REDD.

In this paper we address the impacts of adding REDD into the portfolio of climate change mitigation options considering a policy exercise where all countries within the Copenhagen Accord have committed themselves to their announced high pledges. Two are the reasons why we chose the high pledge scenario: i) Since deforestation activities are concentrated in certain regions of the world, to foster the participation of these countries it is necessary to reach an international agreement with the rest of the world supporting REDD activities; and ii) Given the concerns about flooding the existing carbon markets, this possibility should be assessed in a scenario where the mitigation goals are more ambitious and therefore the underlying carbon price should be expected to be higher. In this way we would be focusing in a scenario that would offer a reasonable approach both for ambitious targets and the corresponding higher reward for the affected regions.

While REDD negotiations have considerably moved forward, the definition of the financial framework to be established is still a sensitive issue. While many countries consider the carbon market a better mechanism to guarantee necessary funding, others are apprehensive that REDD credits may eventually flood the market and therefore favour public financial support. In this study we analyze the role of REDD on climate policy by introducing REDD credits into a world carbon market. Taking into account these afore mentioned political concerns, different scenarios where limitations to the use of REDD are imposed. To this aim we use a recursively dynamic multiregional Computable General Equilibrium (CGE) model, the Intertemporal Computable Equilibrium System (ICES) model. As noted in the introduction, the number of available studies addressing the use of REDD in climate policy is fairly large, but few have been done under a computable general equilibrium framework. The use of such a framework is particularly useful in this context as its highly detailed sectoral disaggregation enables the analysis to coherently take into account energy, land and forest sectors interactions through market mechanisms. Such interactions are usually not represented in partial equilibrium studies, even if those sectors are now directly connected through a carbon price. We introduce direct and indirect effects occurring both on land and timber markets as a result of REDD credits by making use of data provided in the FAO Global Forestry Resources Assessment of 2005. Reductions in deforestation rates are endogenously calculated using a carbon market price signal, decreasing both the amount of land available to agricultural uses and the flow of wood entering timber markets in respect to what would occur in a business as usual scenario or a policy not accounting for REDD credits. Finally, standard analysis regarding carbon price, leakage, distributional impacts and policy costs is also performed.

The remainder of this paper is organized as follows. Section 2 describes the modelling framework used in the present study. Section 3 presents the scenarios and discusses the results. Section 4 concludes.

2. Modelling Framework

The modelling tool used for the analysis of the implication of REDD in the global economy is provided by the recursive-dynamic ICES, a CGE model based on the core structure of the Global Trade Analysis Project (GTAP) model and database version 6 (Dimaranan, 2006). Its production side is however that of the GTAP-E model (Burniaux and Truong, 2002). This in order to account for a more satisfactory representation of the energy and emission sides of economic systems. GTAP-E also includes carbon taxes and an Emission Trade (ET) module to simulate international carbon market which is key to our investigation. We updated that, originally restricted to emission reductions from fossil fuel use, to account for emission reductions from avoided deforestation and the trading of the corresponding carbon credits originated. The regional and sectoral detail of the model, its production tree and baseline assumptions are reported in appendix I.

The role of avoided deforestation has then been introduced through three different channels.

Firstly, a set of equations computing regional emission reductions from avoided deforestation in response to different carbon prices have been added to the model. Parameterization of these equations are derived from the IIASA Cluster model (Gusti et al. 2008) prepared for the Eliasch 2008 report.

Following Kindermann et al. 2008, we assume that avoided deforestation and the associated credits come only from the lowest-cost avoided deforestation opportunities areas: Africa, Central and South America and Southeast Asia. However, according to the deforestation rates obtained trough IIASA Cluster model (Gusti et al. 2008)) more than the 94% of total world deforestation activity took place in these areas (2000 data). We also assume that all these regions have already established institutional and governmental structures that would allow them to immediately enter the European trading scheme.

Those reductions are then subtracted from the total emissions originated by the model. The generated credits can be sold in the international carbon market and accrue national income of the sellers and decrease that of the buyers.

Secondly, changes in deforestation patterns fostered by the possibility to sell REDD credits into the carbon market affect agricultural, forestry and pasture land use, i.e. the regional land stocks. Indeed more forest remaining unharvested implies a lower amount of land available to agricultural and pasture activities. This lower availability is defined with respect to a baseline land availability under "business as usual deforestation rates". Both baseline regional land availability and its mitigation-policy driven change have been estimated starting from the IIASA cluster model. This provides baseline emissions from deforestation that we converted to (lost) forest hectares using UN FAO 2006. To calculate the amount of land entering large scale agriculture after deforestation we follow UN FAO 2001. According to this study circa 10% of deforestation in Africa was due to conversion to this type of land use, while for Latin America and Asia this numbers is equal to 46% and 30%, respectively. Then, the baseline land availability is endogenously corrected in response to (lower) deforestation under different carbon prices.

Thirdly, reduced deforestation resulting from different carbon prices also decreases the total amount of wood entering timber markets. To account for this fact, we follow a similar approach to the one described above. A business as usual timber supply is then endogenously modified accounting for the lower harvesting induced by the possibility to sell REDD credits. The relation between non harvested hectares and timber production from primary forest (cubic meters) has been estimated coupling data from UN FAO 2006 with Brown 2000 reporting information on timber extraction from primary and forest plantation.

By introducing these effects into the model we account for the most important factors when evaluating the role of avoided deforestation under climate policy framework and its resulting impacts on the economy.

3. Discussion of Results

3.1. Scenarios description

Our simulation builds on the comparison of four different scenarios. The first one, the no policy business as usual, is a 2020 dynamic benchmark obtained perturbing the calibration year equilibrium (2001) in order to replicate the regional GDP growth consistent with the A2 IPCC scenarios. The baseline also incorporates medium-term evolution of prices of major fossil fuels from EIA 2009. In the second scenario all countries commit themselves to the high pledges defined in the Copenhagen Accord (see table X) without using any REDD policy. A fully integrated carbon market in the form of an Emission Trading Scheme (ETS) is implemented only for countries targeting emission reductions. Accordingly, China and India, whose targets are defined in carbon intensity terms, pursue independent domestic policies consisting in the introduction of a carbon tax to comply with their pledges. In the third scenario, policy targets are defined as above, but with the additional possibility for Sub Saharan Africa (SSA thereafter), Central and South America (LACA thereafter) and Southeast Asia (EASIA thereafter) to enter the ETS selling REDD credits. Note that SSA can participate to the carbon market even without accepting a binding reduction quota, but only on the basis of proven reduction in “business as usual” deforestation activities. This option has been chosen as it should provide the highest incentive to REED countries to engage in avoided deforestation actions and allows us to isolate its role in the policy context. Finally, in the fourth type of scenario we assume different restrictions to the use of REDD credits.

A final remark regarding this evaluation process. In a recursive dynamic framework, such as the one used in this paper, it is not enough to impose a policy target for the final year of the policy but a yearly target must be defined for the all policy time horizon. In the present study this was done by means of a linear interpolation, beginning in 2010, that guarantees that by 2020 all regions comply with their respective targets

3.2 The role of REDD credits on a ETS carbon market

When policy is implemented without the possibility of using REDD credits, the carbon market price rises from 4.4\$/t CO_2 in 2010 to circa 77\$/t CO_2 in 2020, with a resulting cost for the involved countries as a whole equal to 0.87% of GDP compared to baseline.

While in absolute terms the USA and EU-27 are the regions bearing higher policy costs, Russia, South Africa and South Korea present higher relative losses in terms of GDP, 9%, 7% and 3% respectively. Interestingly enough, India and China observe higher GDP growth under policy (1 and 0.5% respectively), while Norway and Iceland are practically unaffected. Note that both China and India pursue domestic polices targeting carbon intensity (that still allows them increase in emissions) and face significantly lower carbon prices than the one observed inside the ETS market (7.5$/t CO_2 for China and 10$/t CO_2 for India in 2020). As a result, these two regions become more competitive as they benefit from a less stringent climate policy, increasing their production of carbon intensive commodities, the so-called leakage effect. Finally, taking advantage of the same effect, regions not taking part in Copenhagen also improve welfare when policy is introduced. In this case, commodities produced in countries without a climate policy become more competitive as they are not charged with environmental taxes. They are thus increasingly demanded, and increasingly produced. Consequently emissions outside the policy zone increase. Following the calculus methodology proposed in IPCC 2007 we obtain a carbon leakage of circa 9%, if considering only reductions within the regions exchanging credits in the ETS. If also China and India are considered in this calculus this number is equal to 7%.[1]

If REDD credits are allowed to be used in the carbon market without restrictions, climate policy cost is significantly reduced to 0.34% of GDP compared to baseline, while carbon price now starts from 2.5$/t CO_2 in 2010 to around 36$/t CO_2 in 2020. Despite this sharp reduction (around 53% in 2020), carbon price is still enough to trigger substantial amounts of avoided deforestation. In fact, even if in 2010 only 6% of business as usual deforestation is avoided, this number rapidly increases to 75% in 2020. The large number of REDD credits entering the carbon market allows the regions pertaining to the climate policy agreement to systematically emit above their targets. In 2009, the year just before policy starts, the aggregated level of emissions for all Copenhagen regions equals' 18 876 million tonnes of CO_2. Considering the announced targets, by 2020 total emissions must equal 14 305 million tonnes of CO_2. However, under the unrestricted REDD scenario, the total level of emissions reaches 17 141 million tonnes of CO_2 in that year, implying that the required remaining reduction of 2 836 million tonnes of CO_2 is provided by avoided

[1] We present his difference due to the divergence of targets between China and India (defined as carbon intensity) with respect to the remaining countries inside the Copenhagen Accord (quantitative emission reduction targets)

deforestation. While it is economically sounding that abatement is shifted to lower abatement costs activities, these results confirm that policy design do require the creation of long term incentives to promote a greener economy. In effect, the option of limiting the number of REDD credits allowed in the market has been widely proposed in the policy arena. We discuss this option in the next subsection.

REDD has been seldom appointed as a way of introducing developing regions into a global climate policy. In this context, it is particularly relevant to analyze how these areas of the world are affected under Copenhagen when the carbon market is opened to this type of credits. As expected, when policy does not include the possibility of selling REDD credits both EASIA and LACA are worst off if compared to the no policy baseline scenario.[2] However, when such possibility is made part of the considered climate policy, LACA actually observes, by 2020, the same GDP growth rate as in business as usual while EASIA reduces its policy costs but remains below BAU. SSA, on the other hand, by not having any emission reduction target under Copenhagen, but still being given the possibility to sell REDD credits, is diversely affected. In fact, SSA increase its GDP in the REED scenario compared to the no policy baseline scenario, meaning that benefits from selling REDD credits are larger than their direct and indirect costs. We recall that in our exercise the first are triggered by lower land available to agriculture/pasture and lower raw wood supply to the timber sector. Finally, SSA is also unambiguously better off if a carbon market is introduced without the possibility to use REDD credits. While this last result may seem counter-intuitive, the explanation behind it is actually straightforward since it is directly related with carbon leakage. For SSA, the loss of competitiveness of countries inside Copenhagen outweighs gains from selling REED, but to a more competitive policy region. This is a typical example of indirect effects - on GDP through competitiveness - being larger than direct effects - on GDP through revenues from sold credits. This could constitute in one of the reasons for REDD regions not to be interested with the reduction of deforestations, signalling to policy makers the necessity of additional mechanisms or incentives that could be coupled to the REDD initiatives.

3.3 Introducing limits to the use of REDD credits

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[2] Note that while only Brazil and Mexico have committed themselves under Copenhagen, the target in this exercise is imposed to the aggregated LACA region. The same is true for EASIA and Indonesia. As a consequence, to the extent that only Brazil, Mexico and Indonesia emissions are targeted, one could expect leakage to occur in other countries inside these areas. Such an effect, however, is not possible to capture here.

In the unrestricted scenario a fairly large number of REDD credits enter the market. Considering the all policy time horizon, these amount to 17205 million tonnes of CO_2. A number almost 4 times bigger than the total required policy emission reductions by 2020. In fact, considering the level of aggregate emissions in 2009, compliance with the high pledges announced in Copenhagen requires a total reduction of only 4371 million tonnes of CO_2. In order to prevent such a flooding into the carbon market, it has been often proposed the imposition of restrictions to the use of this type of these credits. Such a policy can be justified as a way to control the carbon price decrease and maintain a sufficient dynamic stimulus to the development of additional environmental friendly and energy saving technologies, but also as an incentive for early participation of REDD countries in global climate policy.

In the present analysis, REDD restrictions are defined in terms of the emission reduction efforts required under policy. A restriction of 100% implies that during the whole time policy horizon the total amount of REDD credits allowed to enter the market cannot be superior than the required reduction stated in the Copenhagen Accord, i.e. 4371 million tonnes of CO_2. Accordingly, for a restriction of 25% this last figure is equal to 1092 million tonnes of CO_2. With this in mind we have considered 4 restriction levels, 25%, 50%, 75% and 100%

We observe that, for the restrictions here considered, the carbon price decrease is significantly reduced. By 2020, for a restriction equal to 25% carbon price drops only by 2% in 2020 while this number equals 9% if the level of restriction is 100%. As expected, including REDD credits restrictions still generates policy costs savings, but to a much lower extent if compared to the unrestricted scenario. For the 25% restriction scenario, policy costs equal 0.85% in terms of GDP, while for the 100% restriction scenario GDP is reduced in 0.77% by 2020. Finally, a heavy restriction in the use of REDD credits also undermines the use of such a policy as a way to significantly reduce deforestation rates. For the 100% restriction scenario, avoided deforestation amounts to 6% of 2010 business as usual deforestation, rising only to 11% in 2020.

In light of the discussion made in the previous subsection, we conclude that EASIA and LACA are increasingly worse off as the restriction to REDD credits is more stringent. Accordingly, while such a policy aiming to control for carbon price decreases may create a more favourable economic environment to the development of cleaner technologies, on the other hand it may prevent countries with higher deforestation rates from entering into a global climate policy agreement.

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4. Concluding Remarks

In this study we have used ICES, a dynamic recursive computable general equilibrium model to analyze the impacts of linking REDD and a global carbon market under the Copenhagen Accord. In order to do this we started by analyzing a climate policy where the use of such credits is not allowed. Under this scenario, Russia, South Africa and South Korea are the regions bearing higher relative losses in terms of GDP. We observe that all regions inside ETS suffer from the introduction of this climate policy, while China and India are actually better off. This is due to the fact that they pursue a domestic climate policy, as their target is defined in terms of carbon intensity, and as a result they face lower carbon prices. This makes carbon intense commodities produced in these regions relatively more competitive. The same happens to all regions outside the accord, as they benefit from the so-called carbon leakage effect.

The introduction of REDD credits into the carbon market significantly reduces carbon prices and, consequently, policy costs. The regions that benefit the most from this option are also the ones that were most affected under the previous scenarios (Russia, South Africa and South Korea). Interestingly enough we observe that the Latin America and Caribbean region under this scenario grows as much as in as in business as usual, confirming that REDD may indeed provide policy makers a tool to include this regions of the world in a broader climate change accord. As noted, China and India were better off under a world with climate change policy than in a no policy scenario. However, when REDD credits enter the market, this gain is significantly reduced: whilst India still grows above BAU rates, China observes the same growth rate under both scenarios. REDD may therefore be seen as a potential tool to prevent carbon leakage.

Finally, it is also interesting to notice what happens to the Sub-Saharan Africa region, that is now allowed to sell REDD credits even if not participating in the emission reduction efforts. In fact, when the selling of these credits is possible, this region actually experiences lower growth in comparison to a climate policy scenario where such an option is not given. Indeed, it is under this last scenario that SSA is unambiguously better off. This last result is explained by carbon leakage. For SSA, the loss of competitiveness of countries inside Copenhagen (when REDD credits are available for regions inside Copenhagen requiring lower reduction efforts) outweighs gains from selling REED, but to a more competitive policy region. This particular outcome could also be used to understand what could be the position of countries which did not present any pledge to adhering to a climate policy strategy but are allowed to sell REDD credits. The main conclusion would be that in order to involve these regions some additional incentives should be offered to overcome the net loss due to a reduced leakage effect. This point could also be considered for regions inside LACA and EASIA with no pledge in the Accord. Moreover, introducing REDD credits in the carbon market is sufficient to generate substantial amounts of avoided deforestation (75% of 2020 business as usual deforestation is avoided).

When restrictions to the use of REDD credits are imposed, the carbon price decrease is significantly reduced and, as a result, there are also policy cost savings. The same occurs to the corresponding amount of avoided deforestation activities (the slackest restriction case here considered would generate only a 11% reduction of business as usual deforestation in 2020). While East Asia and the Latin America and Caribbean region are worse off in a scenario where REDD restriction are active, it is under this scenario that Sub Saharan Africa experiences the highest growth rates. This seems to be due to the fact that the reduction on carbon leakage resulting from the introduction of REDD credits in the market is actually compensated by the selling of REDD credits revenues.

Tables and Figures

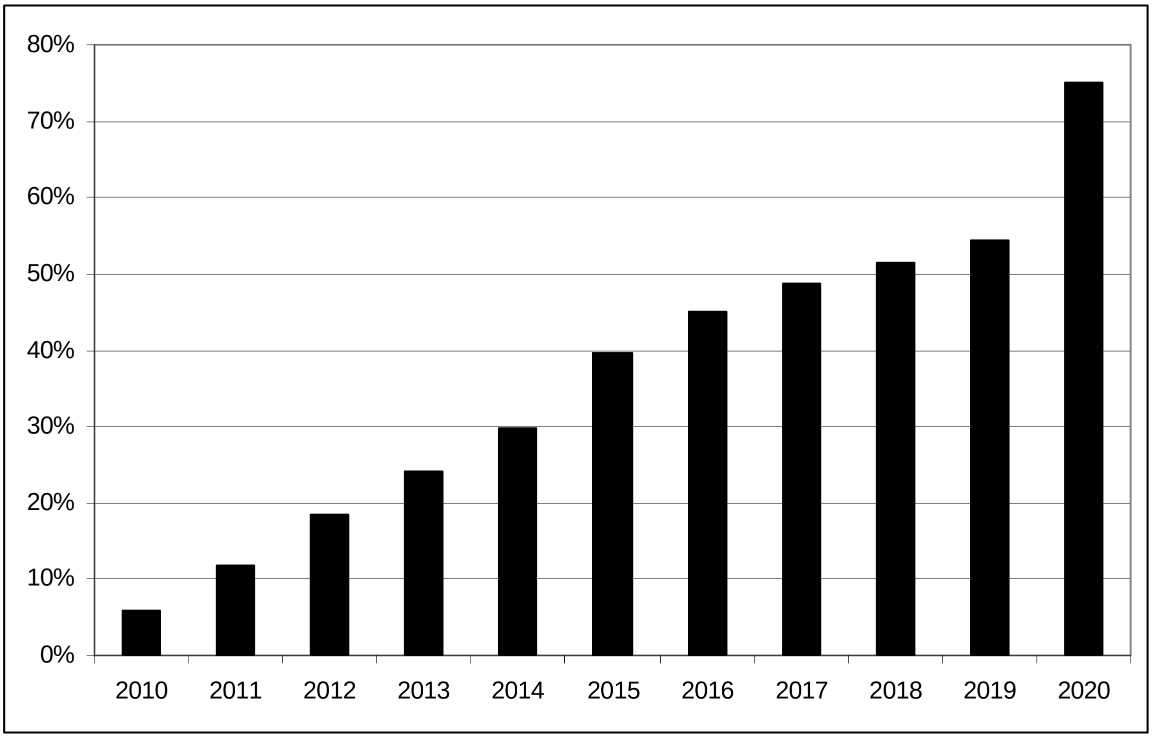
Table 1. CO_2 Price

		mited access to REDD credits in the ETS market (defined as a % of required emission reductions)				
	Without REDD	25%	50%	75%	100%	**unlimited REDD**
		1092 $MTCO_2$	2186 $MTCO_2$	3278 $MTCO_2$	4371 $MTCO_2$	17205 $MTCO_2$
CO2 Price $/t	76.7	74.9	73.1	71.4	69.7	36.2
% reduction wrt policy without REDD		-2%	-5%	-7%	-9%	-53%

Table 2. GDP % w.r.t 2020 B.A.U

		Limited access to REDD credits in the ETS market (defined as a % of required emission reductions)				
	Without REDD	25%	50%	75%	100%	**unlimited REDD**
Australia	-2.0%	-1.91%	-1.86%	-1.81%	-1.76%	-0.84%
NewZealand	-1.4%	-1.36%	-1.32%	-1.28%	-1.24%	-0.60%
China	0.5%	0.46%	0.43%	0.41%	0.38%	0.00%
Japan	-0.6%	-0.57%	-0.55%	-0.54%	-0.52%	-0.21%
SouthKorea	-2.7%	-2.63%	-2.56%	-2.48%	-2.41%	-1.24%
India	1.0%	0.96%	0.93%	0.90%	0.87%	0.39%
Canada	-1.3%	-1.28%	-1.24%	-1.20%	-1.16%	-0.47%
USA	-1.1%	-1.07%	-1.04%	-1.01%	-0.99%	-0.48%
EU27	-0.7%	-0.62%	-0.60%	-0.58%	-0.55%	-0.15%
Russia	-9.0%	-8.75%	-8.51%	-8.28%	-8.05%	-3.98%
SouthAfrica	-6.8%	-6.61%	-6.46%	-6.31%	-6.17%	-3.27%
NORICE	0.2%	0.17%	0.17%	0.17%	0.16%	0.20%
EASIA	-2.1%	-2.05%	-1.99%	-1.93%	-1.88%	-0.98%
LACA	-0.8%	-0.76%	-0.72%	-0.68%	-0.64%	0.00%
SSA	2.1%	2.15%	2.16%	2.17%	2.17%	1.39%
ROW	2.5%	2.48%	2.41%	2.35%	2.28%	1.38%

Figure 1. Percentage of BAU avoided deforestation under unlimited use of REDD credits



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Annex I: ICES technical appendix

ICES is a recursive-dynamic CGE model for the world economy.

The regional and sectoral detail of the model used for this study are represented in Table A1.

Table A1. Regional and sectoral disaggregation of the ICES model

Region	***Sectors***	
Australia	Rice	Non-Market Services
New Zealand	Wheat	
China	Other Cereal	
Japan	Vegetable Fruits	
South Korea	Animals	
India	Forestry	
Canada	Fishing	
USA	Coal	
EU27	Oil	
Russia	Gas	
South Africa	Oil Products	
NORICE *	Electricity	
EASIA *	Water	
LACA *	EnergyIntensive	
SSA *	Other industries	
ROW *	Market Services	

**NORICE: Norway and Iceland; EASIA: East Asia; LACA: Latin America and the Caribbean; SSA Sub-Saharan Africa; ROW: Rest of the World*

ICES solves recursively a sequence of static equilibria linked by endogenous investment determining the growth of capital stock from 2004 to 2050. For the present study the model is run in a simplified version where endogenous investment decision drives 2001-2020 growth in just one time leap.

GDP growth rates for the region modelled replicate those of the IPCC A2 scenario and are reported in table A2.

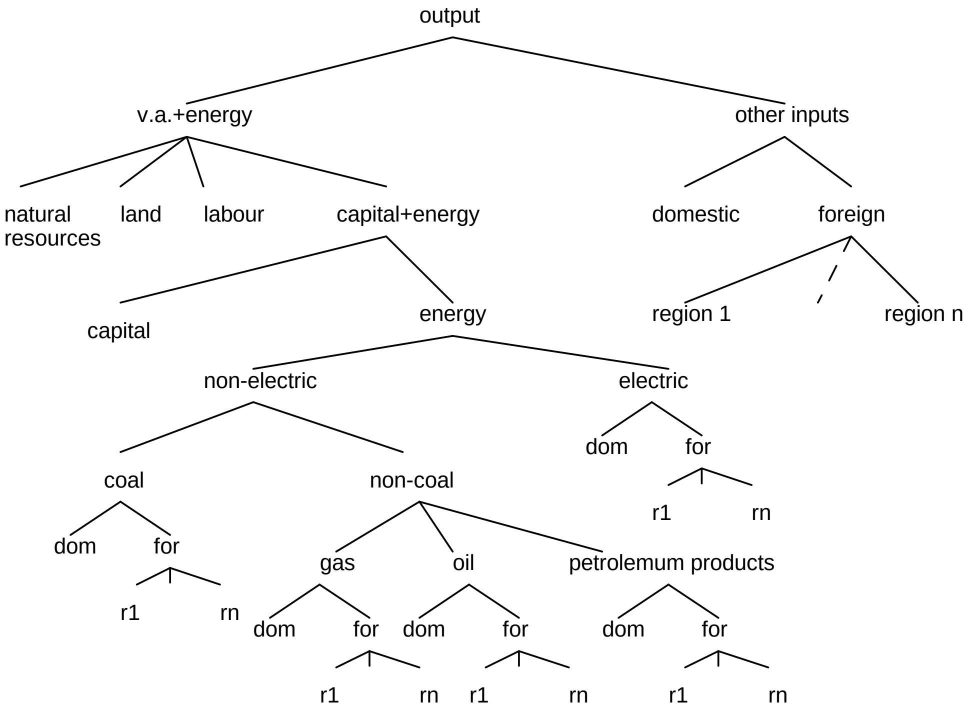
Table A2. GDP growth rates for the BAU (% 2001-2020)

Region	***GDP growth***
Australia	52.4
NewZealand	59.2
China	222.7
Japan	35.5
SouthKorea	46.8
India	142.9
Canada	54.1
USA	57.9
EU27	42.7
Russia	95.9
SouthAfrica	37.4
NORICE	30.4
EASIA	177.1
LACA	92.5
SSA	122.9

ROW	120.9

Industries are modelled through a representative firm. minimizing costs while taking prices as given. In turn. output prices are given by average production costs. The production functions are specified via a series of nested CES functions. Domestic and foreign inputs are not perfect substitutes. according to the so-called "Armington" assumption. The production tree is reported in Figure A1.

Figure A1. Nested tree structure for industrial production processes of the ICES model



A representative consumer in each region receives income. defined as the service value of national primary factors (natural resources. land. labour. capital. see Figure A2). Capital and labour are perfectly mobile domestically but immobile internationally. Land and natural resources. on the other hand. are industry-specific.

This income is used to finance three classes of expenditure: aggregate household consumption. public consumption and savings. The expenditure shares are generally fixed. which amounts to saying that the top-level utility function has a Cobb-Douglas specification.

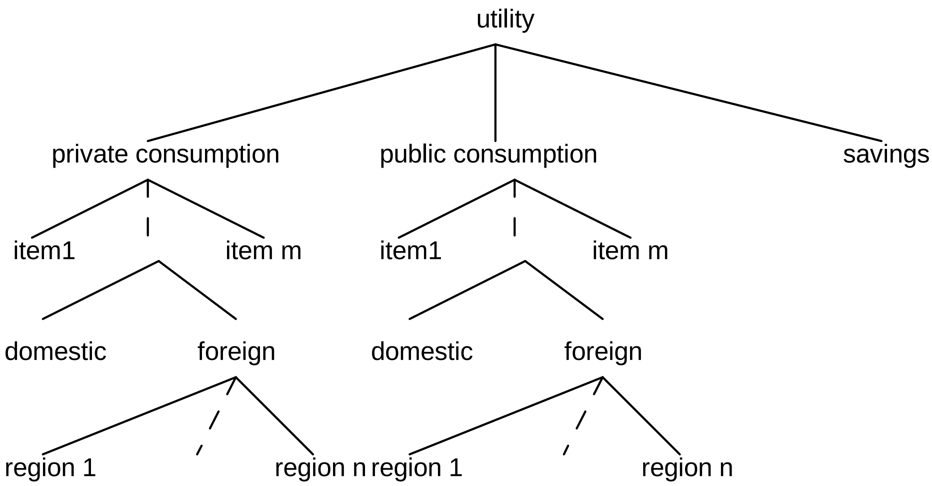
Public consumption is split in a series of alternative consumption items. again according to a Cobb-Douglas specification. However. almost all expenditure is actually concentrated in one specific industry: Non-market Services.

Private consumption is analogously split in a series of alternative composite Armington aggregates. However. the functional specification used at this level is the Constant Difference in Elasticities form: a non-homothetic function. which is used to account for possible differences in income elasticities for the various consumption goods.

Investment is internationally mobile: savings from all regions are pooled and then investment is allocated so as to achieve equality of expected rates of return to capital.

In this way. savings and investments are equalized at the world. but not at the regional level. Because of accounting identities. any financial imbalance mirrors a trade deficit or surplus in each region.

Figure A2. Nested tree structure for final demand of the ICES model



Annex II: Copenhagen Targets

Table 1: Proposed targets

Country	High Pledges
Annex I - *with respect to 1990 emission levels*	
Australia	1% to -11%
Canada	2.52%
European Union	-30%
Iceland	-30%
Japan	-25%
New Zealand	-20%
Norway	-40%
Russia	-25%
USA	-3%
Non-Annex I	
Brazil	39% reduction against baseline by 2020
China[a]	carbon intensity reduction: 45% with respect to 2005
India[b]	carbon intensity reduction: 25% with respect to 2005
Indonesia	26% emission reduction against baseline
Mexico	30% emission reduction against baseline
Republic of Korea	Emission reduction: 30% against baseline
South Africa	- Emission reduction: 30% against baseline