REDD in the Carbon Market: A general equilibrium analysis (Preliminary Version – please do not cite)

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Abstract

Deforestation is a major source of CO_2 emissions, accounting for around 17% of total annual anthropogenic carbon release. While the costs estimates of reducing deforestation rates considerably vary depending on model assumptions, it is widely accepted that emissions reductions from avoided deforestation consist of a relatively low cost mitigation option. Halting deforestation is therefore not only a major ecological challenge but also a great opportunity to cost effectively reduce climate change negative impacts.

In this paper we analyze the impact of introducing avoided deforestation credits into the European carbon market using a multiregional Computable General Equilibrium model – the ICES model (Inter-temporal Computable Equilibrium System). Taking into account political concerns over a possible "flooding" of REDD credits, various limits to the number of REDD allowances entering the carbon market are considered. Finally, unlike previous studies, we account for both direct and indirect effects occurring on land and timber markets resulting from lower deforestation rates.

We conclude that avoided deforestation notably reduce climate change policy costs. Unlimted availbility of REDD credits reduce European policy costs in approximately 83.24%, while limiting the use of these credits to 20% ot total european emissions reductions decreases costs in 23.01%. Given the relatively small scale of the european carbon market, avoided deforestation credits may drastically reduce carbon prices. Policy makers may, however, effectively control for this imposing limits to avoided deforestation credits use. In addition, avoided deforestation has the additional positive effect of reducing carbon leakage of an isolated European climate change policy. Finally, land price changes resulting from lower deforestation rates are found to be relatively more important in Sub Saharan Africa regions.

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1 Introduction

Tropical deforestation is a major source of CO_2 emissions and the main cause of biodiversity loss. According to the fourth IPPC report deforestation accounts for around 17% of total annual atmospheric carbon release (IPCC 2009). Given the rising concern of potential dangerous risks accruing from high level of atmospheric greenhouse gases (GHGs) concentrations, a large number of economic studies have analyzed the costs of avoiding deforestation. While estimates considerably vary depending on modelling assumptions, it is widely accepted the emissions reductions from avoided deforestation consist of a relatively low cost mitigation option. Halting deforestation is therefore not only a major ecological challenge but also a great opportunity to cost effectively reduce climate change negative impacts.

A recent study has compared the cost estimates of reducing carbon emissions trough deforestation resulting from three different global forestry and land-use models (Kindermann et al 2008). According to their analysis while costs differ by regions, the lowest-cost avoided deforestation opportunities are found in Africa, Central and South America and Southeast Asia. Together these regions could provide 2.8-4.7 of Gt of CO_2 during the 2005–2030 period at a 100$ per ton of CO_2.

A second branch of literature using integrated assessment models to assess the potential of deforestation and other forest/land use change mitigations suggest that forestry could cost effectively account for 30% of overall abatement across the century (Sohngen and Mendelsohn, 2003; Tavoni et al., 2007). While Sohngen and Mendelsohn (2003) linked a global forestry model with the DICE model of Nordhaus and Boyer (2000), Tavoni et al. (2007) used the World Induced Technological Change Hybrid model to analyse the impacts of introducing forestry mitigation opportunities on the costs of meeting a 550 ppmv CO_2 concentration target. According to this last study, forest activities generates policy cost savings of around 40% that could be used to finance an additional 0.25°C less warming by the end of the century. Both studies, however, considered not only opportunities from avoided deforestation but also included afforestation, reforestation and forest management. More recently, Bosetti et al. (2009) analyzed the role of forestry under a more stringent stabilization target considering only avoided deforestation opportunities. More importantly, in contrast to the two previous analyses, their analysis do not focus on the economically efficient pattern of mitigation but explicitly model a potential emission trade markets based on national emissions reduction commitments. Finally, they also include the possibility to "bank" emissions allowances. In line with previous studies, the authors also conclude that Reduced Emissions from Deforestation and Degradation (REDD) may provide policy makers a strong climate mitigation policy instrument. Forest emissions considerably decrease and total costs of the stabilization policy are lowered by a 10-23%, depending on the considered set of avoided deforestation supply curves. Alternatively, REDD could enable a reduction of 20ppmv of CO_2 equivalent concentration without policy costs increase.

Other studies have also examined the role of avoided deforestation credits in a global carbon market. A recent report, Eliasch (2008), has analyzed the impact of introducing forestry credits into the European Union emissions trading scheme. Forestry credits, however, are not restricted to avoided deforestation emission reductions but also include reforestation and afforestation activities. The study concludes that the EU carbon market price would be similar during Phase III whether Member States committed to a 20 per cent emissions cut with a 30 % supplementarity[1] limit or committed to a 30 per cent emissions cut with a 50 % supplementarity limit. More generally, forestry credits would reduce carbon prices by 4-41% depending on supplementarity limits and the EU emission reduction target level. Finally, forest credits lower the costs of reducing emissions to 50% of 1990 levels by 2050 in around 25-50% in the year 2030 and by 20-40% in 2050.

Dixon et al. (2008) using a numerical multi-country, two-sector partial equilibrium model of the global carbon market concluded that international permit price would be reduced by 45% when, in addition to CDM, unlimited carbon credits from avoided deforestation are made available. Moreover, policy compliance costs decrease by more than one third. Their analysis assessed the impacts of climate policies in a single period market ending in 2020 considering a post Kyoto 2012-2020 scenario where emission reduction targets were based on public announcements.

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[1] the proportion of abatement effort that can be met from non-Annex I country credits

In this paper we address the role REDD may play in the European carbon market using a multiregional Computable General Equilibrium (CGE) model – the ICES model (Inter-temporal Computable Equilibrium System). Such an investigation may shed new light on questions as carbon leakage, the distributional aspects resulting from a climate policy or incentives to participate in a carbon trading system when reduction emissions from avoided deforestation are considered. Unlike previous studies addressing the potential introduction of REDD credits in carbon markets we account for direct and indirect effects occurring both on land and timber markets. We introduce this using data provided by 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. While most studies on carbon markets and avoided deforestation do not take into account this effect, it represents a cost to countries providing REDD credits and may, therefore, influence incentives to participate in a carbon trading system.

The paper is structured as follows. Section 2 and 3 presents data and modelling framework. Section 4 discusses results and section 5 concludes the paper.

2 Data and modelling framework

2.1 Forestry Data

In this study we use a set of estimates of global potential for reducing emission reduction from deforestation derived from the IIASA model cluster (Gusti et al. 2008) prepared for the Eliasch (2008) report. Following Kindermann et al. 2008 we focus our analysis on the lowest-cost avoided deforestation opportunities areas: Africa, Central and South America and Southeast Asia. Moreover, we assume that all regions with high potential for selling avoided deforestation credits have already established institutional and governmental structures that would allow them to immediately enter the European trading scheme. Finally, we adjust our business-as-usual scenario to be consistent with land use change baseline estimates derived from this study.

2.2 Modelling framework

For the analysis of the implication of REDD in the global economy we rely on a dynamic CGE model based on the Global Trade Analysis Project (GTAP) database version 6 and core model (Hertel, 1996): ICES (Intertemporal Computable Equilibrium System). The model develops a recursive-dynamic growth engine where a sequence of static equilibria are linked by the process of capital accumulation driven by endogenous investment decisions and some exogenous assumptions. The specification of the supply side of the model follows Burniaux and Truong (2002), which increase the detail in the description of energy production and it also includes carbon taxes and an Emission Trade Scheme (ETS) module for analyzing climate policy implications. The model runs from 2001 to 2050 in one year time steps and the detail for the baseline scenario are described in annex I.

3 Modelling REDD in ICES

Like in every scheme where activities are interlinked and one action may have different repercussions in the rest of the system, reducing emissions form deforestation will affect directly and indirectly many economic activities. In the case of a CGE model like ICES it is more important to identify the sector which will be directly affected by the avoided deforestation activities and then rely on its structure to elucidate the indirect effects. Following this line of reasoning, direct effects of REDD are related to i) Emission abatement thanks to reducing deforestation, ii) Land uses effects on agriculture, iii) Land use effects on forestry, and iv) Effects on the economy of compensating REDD activities through the inclusion of credits in the existing carbon markets as an additional source of abatement.

3.1 Introducing land and timber effects

Regarding REDD emission abatement we used data from IIASA related to marginal cost curves from avoided deforestation to link the price signal given by either a carbon market or a carbon tax and find its corresponding abatement through reducing deforestation. This allow us to have information about the amount of CO_2 that would not be released into the atmosphere and consequently calculate total CO_2 emissions net of avoided deforestation, and also the amount of REDD credits that could be negotiated in international carbon markets.

Reducing emissions from deforestation brings about trade offs not only with timber production but also with agricultural output since deforested land could be used for agriculture. To model the effect of competition in land use we take into account the share of agricultural land coming from deforestation, so we have two land endowment types related to: a) a new stock of agricultural land coming from deforestation, and b) the stock of land previously devoted to agriculture. With this distinction it is possible to set exogenously the behaviour of these two land types and, moreover, correct endogenously the evolution of agricultural land coming from deforestation using a carbon price signal. To do this we translate the tonnes of CO_2 not emitted because of the reduced deforestation into the land endowment not used because it would not be available any more for agriculture, and calculate the net stock of deforested land freed for agriculture.

For the case of land use effect on forestry activities, we opt for a similar approach as agriculture. Timber can be produced either in managed forests plantations or just by exploiting primary forests through deforestation. For this reason we consider two types of sources for timber and establish their share for the initial year using IIASA data (IIASA reference). Consequently we can set exogenously the behaviour of forest plantations and primary forest, and then calculate the net contribution of deforested primary forest for timber production. Actual timber production is the result of timber harvested in plantations and from the net production of deforestation.

3.2 REDD credits in carbon markets

Given that REDD is an initiative aimed at fostering efforts to reduce forest exploitation, particularly in developing countries, and that there should be a compensation for such effort, we think that an international Emission Trading Scheme (ETS) is an adequate way to model that compensation. Following this approach we modified the ETS module of the model in such a way that a developing country could choose to participate in the ETS permit market with two alternatives:

i. A region implementing avoided deforestation policies can participate with a binding quota in the ETS market with the additional abatement of reducing deforestation which in turn should lessen the common carbon price.
ii. A region can put into practice the avoided deforestation policy but does not need to participate in the ETS market with a binding quota. Nevertheless those regions can sell REDD abatement as credits to the ETS market allowing ETS countries to benefit of additional abatement with a lower price. Revenues from the sell of REDD permits accrue directly from countries in the ETS to countries implementing avoided deforestation policy.

With these modifications we can generate a set of simulations in order to better understand the advantages of implementing REDD policies and trading its credits in international carbon markets.

4 Discussion of Results

In this section we discuss the impacts of introducing REDD carbon credits into the ETS when Europe targets a 20% emission reduction bellow 1990 levels.

4.1 Carbon price and policy cost savings

We start our analysis discussing its effects on allowances carbon price. To account for a possible "flooding" of REDD credits into the carbon market we consider various levels of restrictions to this type of credit. Accordingly, we propose a range where the use of REDD credits account from 5% of total European emission reductions to the most extreme scenario where no limit is imposed. Table 1 presents the obtained carbon prices for the different considered scenarios.

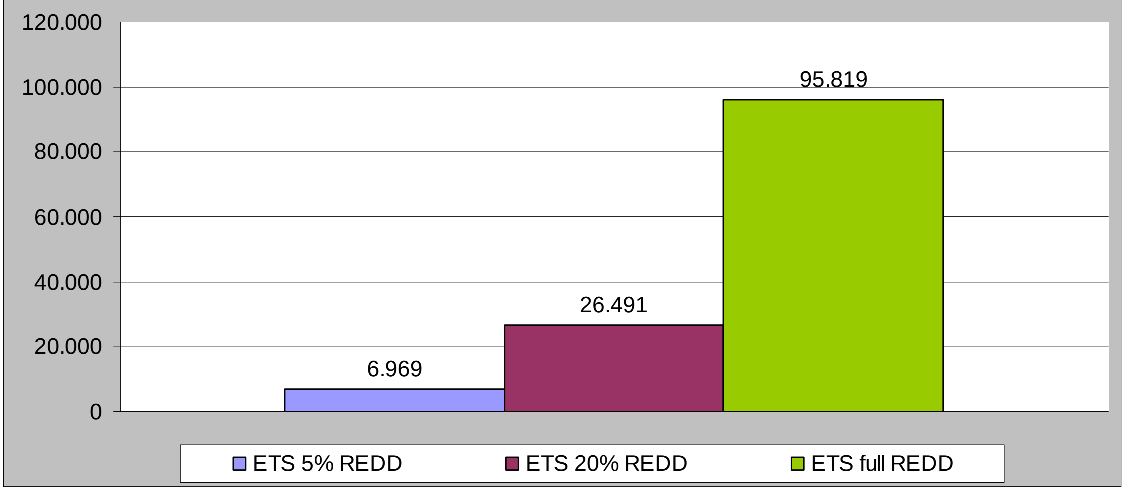
Table 1. CO_2 Price

		Limits to REDD credits							
	ETS	ETS 5% REDD	ETS 10% REDD	ETS 15% REDD	ETS 20% REDD	ETS 25% REDD	ETS 30% REDD	ETS 50% REDD	ETS full REDD
CO_2 Price	46	43	40	38	35	33	31	23	8
% reduction		-6%	-12%	-17%	-22%	-27%	-32%	-50%	-83%

Given the relatively small scale of the European carbon market, an unlimited availability of REDD credits drastically reduces carbon prices (83%). When the availability of such credits is limited, the carbon price reduction varies from -6 to -50%, depending on the imposed restriction.

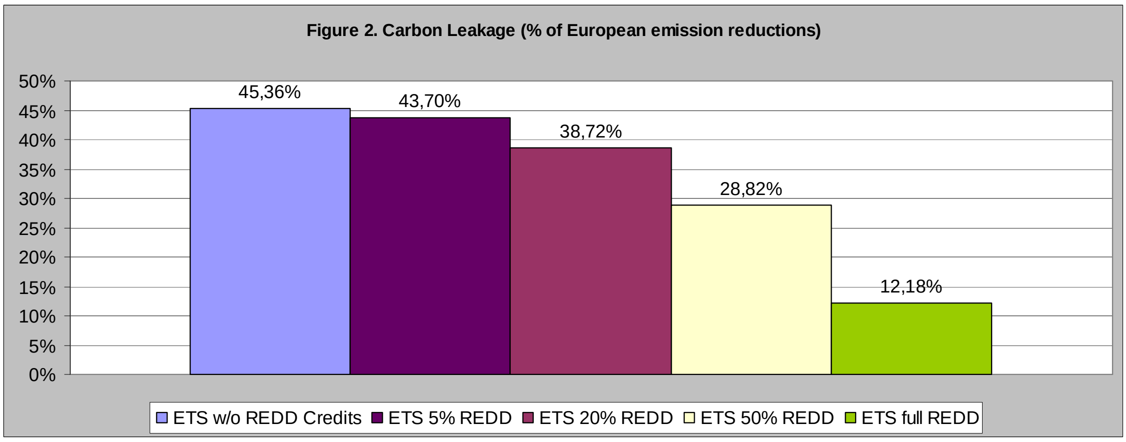
The option to limit the numbers of REDD allowances aiming to control carbon price reduction comes, however, at the cost of significantly decreasing policy cost savings (see Fig. 1). In fact, when no restriction is imposed, European economies reduce policy costs by approximately 83%, while limiting the use of REDD to 20% ot total european reductions decreases this number to around 23%. In absolute terms emission reduction from deforestation could lower costs from 6.9 - 95.8 Million US$, depending on the imposed limits of REDD credits use.

Figure 1. European Policy Cost Savings (Million US$)

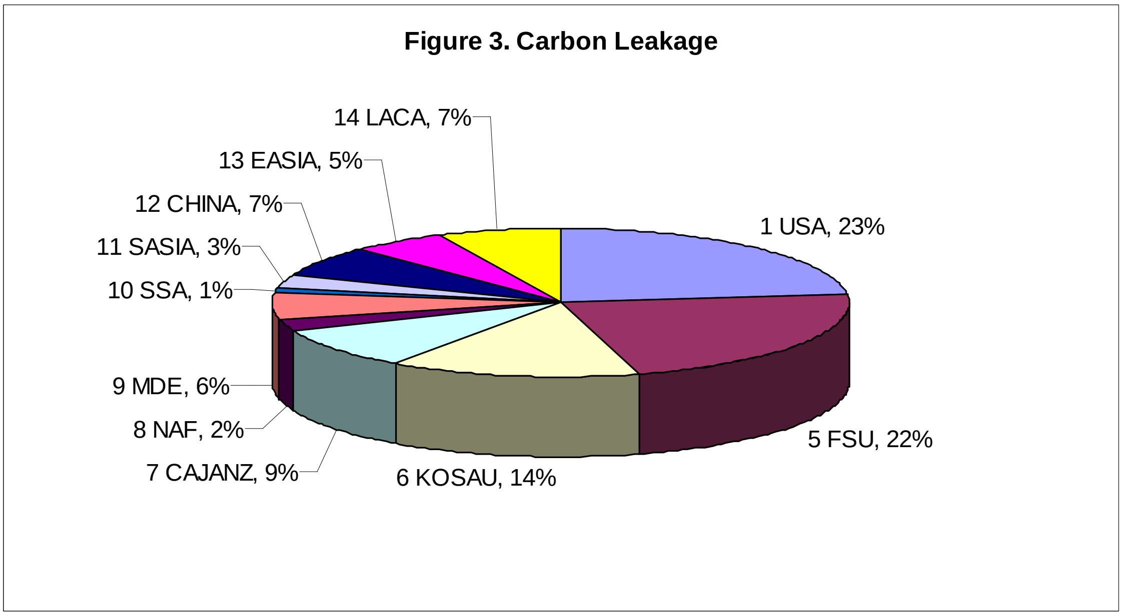


4.2 Carbon Leakage

Our results indicate that a ETS without REDD credits may seriuosly compromise european environmental efforts, as higher world emissions directly resulting from this policy amount for almost 45% of european reductions (see Fig. 2).



Given that the current study does not assume any other climate change policy in addition to the European carbon market, it is the USA that most contributes to the world increased emissions. Note, however, that emerging economies from regions like LACA, FSU, MDE and China also represent a significant share (See Fig. 3).

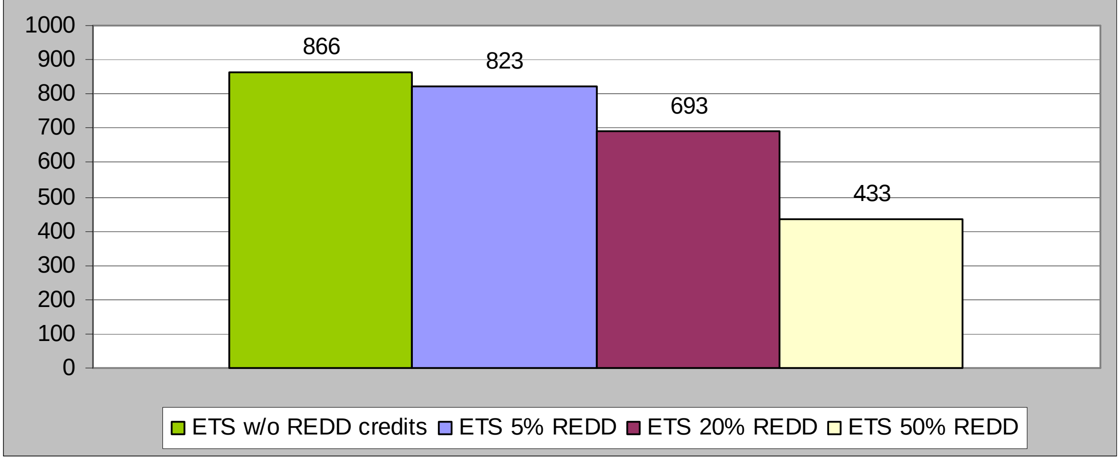


Interestingly enough, REDD has the beneficial aspect of not only reducing policy costs but also decreases carbon leakage. Indeed, if european countries are allowed to use

REDD credits to offset 50% of their reductions, carbon leakage decreases to 29%. Unlimited allowance of emission reductions from deforestation decreases this number to 12%.

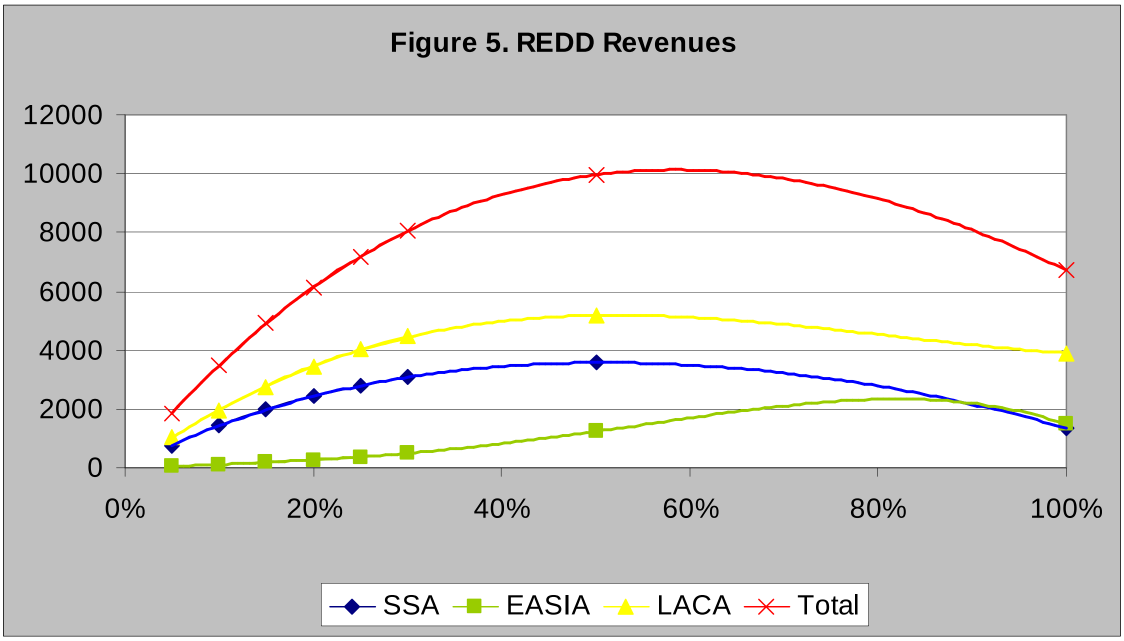
Increasing the number of REDD credits allowances implies, however, that european reduction efforts necesseraly decrease (see Fig. 4.). When the number of REDD credits equals 50% of required emission reductions, europe should decrease emissions by 433 Million tonnes of CO_2 against a 866 Million tonnes reduction that would be required if no REDD credits could enter the ETS. While this may generate concerns regarding the creation of a “greener” european economy it is important to note that in addition to the reduction in emissions from deforestation that compensante this decrease, carbon leakage is also reduced in 40 Million tonnes of CO_2.

Figure 4. European emissions reductions (Million tones of CO2)



4.3 Incentives for selling REDD credits

Finally, we focus our analysis in areas selling avoided deforestation credits. We first focus on revenues accruing from REDD credits (see Fig.5). For LACA and SSA, the regions with lowest-cost avoided deforestation opportunities, revenues follow a inverse U-shaped path, with a peak located around the 50% restriction on REDD credits use. While this may provide useful information to regions with low cost opportunities for reducing emissions from deforestation, the ultimate impact on overall GDP is a more appropriate measure to analyze incentives for these regions to participate in a carbon market trough the selling of REDD credits.



All three regions experience increases in GDP when compared to a scenario where no environmental policy is implemented (see Fig. 6). However, exception made to SSA, all regions are unanimously better off if a carbon market is introduced in Europe without the possibility to use REDD credits (See Fig. 7). While this may seem counter-intuitive, the explanation behind this result is actually straightforward. In fact, when European economies commit themselves to reduce emissions, exports from non European regions become relatively more competitive. This increase in competitivity leads to higher GDP growth. Accordingly, when REDD credits are allowed to enter the ETS market, European reduction efforts decrease and the effect trough which these economies become more competitive is reduced. The final result shows us that revenues from REDD credit selling is not enough to compensate this loss.

Figure 6. GDP Variation with respect to BAU (Million US$)

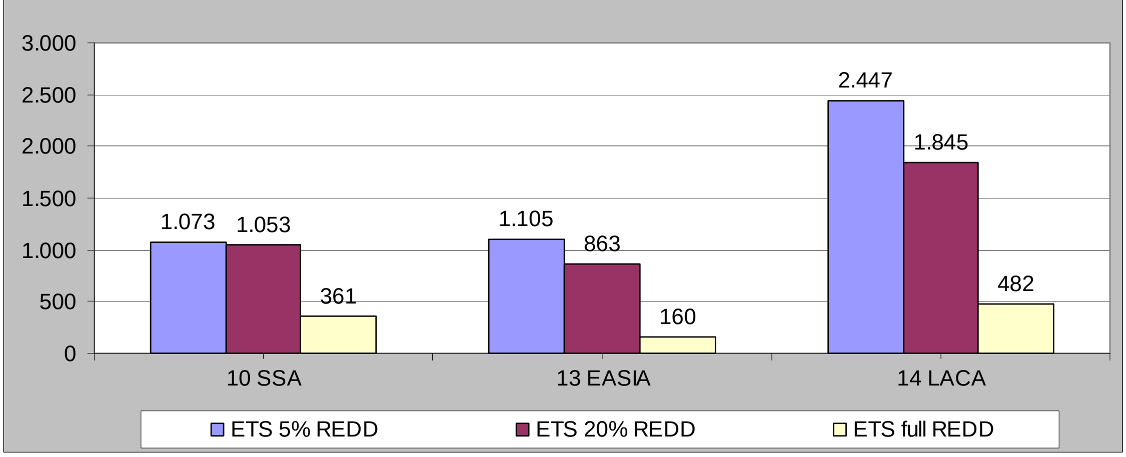
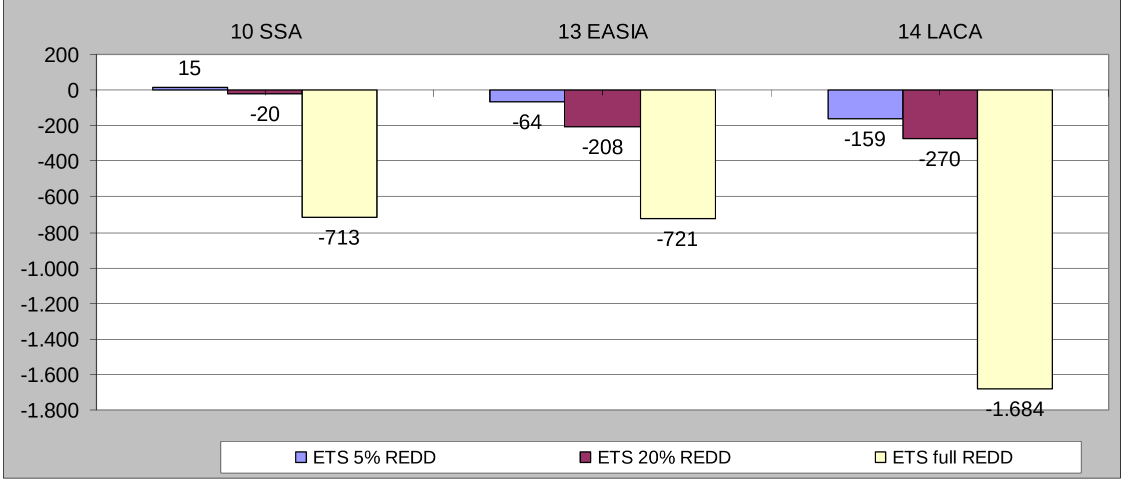


Figure 7. GDP Variation with respect ETS w/o REDD



4.4 Land prices

A critical aspect regarding the use of REDD credits in an international carbon market concerns its eventual impact on land and agricultural prices of regions selling avoided deforestation credits. In the present analysis we took this into account by decreasing the amount of land entering agricultural and cattle activities under the policy scenario vis-à-vis to a Business-as-usual scenario. Results showed, however, that this impact is rather small. While for EASIA and LACA changes in land prices due to the introduction of REDD are close to zero, for SSA this variation ranges between 0.3 to 2.4%, depending on the restriction to REDD credits use.

5 Conclusions

In this paper we address the role REDD may play in the European carbon market using a multiregional Computable General Equilibrium (CGE) model – the ICES model (Inter-temporal Computable Equilibrium System). To this end we used a set of estimates of global potential for reducing emission reduction from deforestation derived from the IIASA model cluster (Gusti et al. 2008) prepared for the Eliasch (2008) report. Unlike previous studies, we account for both direct and indirect effects occurring on land and timber markets resulting from lower deforestation rates.

We observed that including emissions reductions from avoided deforestation generates considerable policy cost savings. When no restriction is imposed, European economies reduce policy costs by approximately 83%. If the number of REDD allowances amounts to to 20% ot total european reductions decreases, policy costs are reduced by 23%. In absolute terms emission reduction from deforestation could lower costs from 6.9 - 95.8 Million US$. Given the relatively small scale of the European carbon market, an unlimited availability of REDD credits drastically reduces carbon prices by 83%. This can be, however, effectively controlled with limits to the number of avoided deforestation permits. When this limits equals 20% of total required emission reductions carbon prices decrease by 22% while still enabling a policy cost savings of 26.5 Million US$.

Interestingly enough REDD has the additional benefit of reducing carbon leakage effects resulting from the introduction of a European climate change policy. While leakage amounts for almost 45% of european reductions under a European trading system excluding REDD, this number decreases to 29% if the number of avoided deforestation allowances equals 50% of european emissions reductions. This conveys an important political message. Including REDD has therefore not only the virtue of early including emerging economies to global climate change police but may also control for negative effects of unilateral climate initiatives.
Finally, land price increase resulting from lower deforestation rates are only significant for Sub Saharan Africa, where a full availability or REDD credits in the European Trading System may lead to a 2.4% price increase.

6 References

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Annex I: ICES baseline

The baseline for future comparisons has been simulated for the period 2001-2050. Investment choices and thus capital stock are determined endogenously and other key economic variables in the calibration dataset of the model have been exogenously updated, to identify a hypothetical general equilibrium state in the future (this methodology is described in Dixon and Rimmer (2002)).

Since we are working on the medium to long term, we focused primarily on the supply side variables projecting changes in the national endowments of population/labour, land, natural resources, as well as variations in factor-specific and multi-factor productivity.

We obtained estimates of future regional labour stocks from UNDP (2008) whereas estimates of land endowments and agricultural land productivity have been obtained from the IMAGE model version 2.2 (IMAGE, 2001). A rather specific methodology was adopted to get estimates for the natural resources stock variables. Due to the uncertainty in the determination of their "true" amount we preferred to exogenously fix the price of the natural resources, making it a variable over time, in line with the GDP deflator, while allowing the model to endogenously compute the stock levels. In the specific case of oil, coal and gas we set their price evolution to mimic what was forecasted by EIA (2009). By changing the calibration values for these variables, the CGE model has been used to simulate a general equilibrium state for the future world economy. This is the benchmark for all subsequent exercises. The regional and sectoral detail of ICES adopted for this exercise are in table A1.

Table A1. Regional and sectoral disaggregation of the ICES model

Regions		*Sectors*	
USA:	United States	Rice	Other industries
Med_Europe:	Mediterranean Europe	Wheat	Market Services
North_Europe:	Northern Europe	Other Cereal	Non-Market Services
East_Europe:	Eastern Europe	Vegetable Fruits	
FSU:	Former Soviet Union	Animals	
KOSAU:	Korea, S. Africa, Australia	Forestry	
CAJANZ:	Canada, Japan, New Zealand	Fishing	
NAF:	North Africa	Coal	
MDE:	Middle East	Oil	
SSA:	Sub Saharan Africa	Gas	
SASIA:	India and South Asia	Oil Products	
CHINA:	China	Electricity	
EASIA:	East Asia	Water	
LACA:	Latin and Central America	Energy Intensive industries	