



# NOTA DI LAVORO

142.2010

---

## **REDD in the Carbon Market: A General Equilibrium Analysis**

---

By **Francesco Bosello**, Fondazione Eni Enrico Mattei, University of Milan, Euromediterranean Center for Climate Change

**Fabio Eboli, Ramiro Parrado and Renato Rosa**, Fondazione Eni Enrico Mattei, University of Venice, Euromediterranean Center for Climate Change

# SUSTAINABLE DEVELOPMENT Series

Editor: Carlo Carraro

## REDD in the Carbon Market: A General Equilibrium Analysis

By Francesco Bosello, Fondazione Eni Enrico Mattei, University of Milan, Euromediterranean Center for Climate Change

Fabio Eboli, Ramiro Parrado and Renato Rosa, Fondazione Eni Enrico Mattei, University of Venice, Euromediterranean Center for Climate Change

### Summary

Deforestation is a major source of CO<sub>2</sub> emissions, accounting for around 17% of total annual anthropogenic carbon release. While the cost estimates of reducing deforestation rates vary considerably 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 reduces climate change policy costs - by approximately 80% with unlimited availability of REDD credits - and may drastically reduce carbon prices. Policy makers may, however, effectively control for these imposing limits to avoided deforestation credits use. Moreover, avoided deforestation has the additional positive effect of reducing carbon leakage of a unilateral European climate change policy. This is good news for the EU, but not necessarily for REDD regions. Indeed we show that REDD revenues are not sufficient to compensate REDD regions for a less leakage-affected and more competitive EU in international markets. In fact, REDD regions would prefer to free ride on the EU unilateral mitigation policy.

**Keywords:** Forestry, Avoided Deforestation, Climate Change, Emission Trading, General Equilibrium Modelling

**JEL Classification:** D58, Q23, Q54

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

*Address for correspondence:*

Renato Nunes Rosa  
Fondazione Eni Enrico Mattei  
Isola di S. Giorgio Maggiore  
30124 Venice  
Italy  
E-mail: [renato.nunesrosa@feem.it](mailto:renato.nunesrosa@feem.it)

The opinions expressed in this paper do not necessarily reflect the position of  
Fondazione Eni Enrico Mattei

Corso Magenta, 63, 20123 Milano (I), web site: [www.feem.it](http://www.feem.it), e-mail: [working.papers@feem.it](mailto:working.papers@feem.it)

# REDD in the Carbon Market: A general equilibrium analysis

Francesco Bosello\* Fabio Eboli<sup>o</sup> Ramiro Parrado<sup>o</sup> Renato Rosa<sup>o'</sup>

## Abstract

Deforestation is a major source of CO<sub>2</sub> 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 reduces climate change policy costs - approximately by 80% with unlimited availability of REDD credits - and may drastically reduce carbon prices. Policy makers may, however, effectively control for this imposing limits to avoided deforestation credits use. Moreover, avoided deforestation has the additional positive effect of reducing carbon leakage of an unilateral European climate change policy. This is good news for the EU, but not necessarily for REDD regions. Indeed we show that REDD revenues are not sufficient to compensate REDD regions for a less leakage-affected and more competitive EU in international markets. In fact, REDD regions would prefer to free ride on the EU unilateral mitigation policy.

**Keywords:** Forestry, Avoided Deforestation, Climate Change, Emission Trading, General Equilibrium Modelling

**JEL Classification:** D58, Q23, Q54

---

\*Fondazione Eni Enrico Mattei, University of Milan, Euromediterranean Center for Climate Change

<sup>o</sup>Fondazione Eni Enrico Mattei, University of Venice, Euromediterranean Center for Climate Change

---

<sup>o'</sup> Corresponding author:

Renato Nunes Rosa

Fondazione Eni Enrico Mattei

Isola di S. Giorgio Maggiore

30124 Venice

ITALY

[renato.nunesrosa@feem.it](mailto:renato.nunesrosa@feem.it)

---

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

## 1 Introduction

Tropical deforestation is a major source of CO<sub>2</sub> emissions and the main cause of biodiversity loss. According to the 2007 Fourth IPCC report, deforestation accounts for around 17% of total annual atmospheric carbon release (IPCC 2007). 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 already analyzed the potential for and costs of emission reduction through avoided deforestation. Estimates vary considerably depending on modelling assumptions, however it is widely accepted that avoided deforestation can offer large mitigation opportunities at a relatively low cost. This result is particularly robust as confirmed by studies conducted with different methodologies.

Thus for instance, Kindermann et al (2008) comparing the results from three different global forestry and land-use models show that a carbon price of 100\$ per ton of CO<sub>2</sub> could abate 2.8-4.7 of Gt of CO<sub>2</sub> from deforestation activities during the period 2005–2030, representing more or less 10% of total 2004 CO<sub>2</sub> emissions as reported by IPCC 2007. According to their analysis, the lowest-cost avoided deforestation opportunities are to be found in Africa, Central and South America and Southeast Asia.

Similar findings come from a branch of literature which “couples” forestry models with more economic oriented integrated assessment models in the attempt to nest forestry dynamics into a more realistic representation of the economic system. In this vein Sohngen and Mendelsohn, (2003) linked a global forestry model with the DICE model of Nordhaus and Boyer (2000) and suggest that forestry could cost effectively account for 30% of total carbon abatement across the century. Tavoni et al. (2007) used the World Induced Technological Change Hybrid model (WITCH) to analyse the impacts of introducing forestry mitigation opportunities on the costs of meeting a 550 ppmv CO<sub>2</sub> 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 specifically the role of avoided deforestation under a more stringent stabilization target (450 ppmv CO<sub>2</sub>). This

study explicitly models a potential emission trading market based on national emissions reduction commitments and allows for the possibility to “bank” emissions allowances. When REDD generated credits can be sold, forest emissions considerably decrease and total costs of the stabilization policy are lowered by 10-23%. Or alternatively, REDD could enable a additional reduction of 20ppmv of CO<sub>2</sub> equivalent concentration without policy costs increase.

The comprehensive Eliasch Review (2008) has investigated the impact of introducing credits from forestry activities and CDM into the European Union emissions trading scheme (EU ETS). The study concludes that a 50% supplementarity<sup>1</sup> would allow a 30% emissions cut at the same cost of a 20% cut with a 30% supplementarity during Phase III of the EU ETS. The role of forest credits is substantial: it could lower the costs of halving global carbon emissions from 1990 levels by up to 50% in 2030 and by up to 40% in 2050.

Finally, 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 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.

In this paper we address the role REDD may play in the European carbon market, in the context of a mitigation policy aiming to reduce EU emissions by 20% respect to 1990 in 2020. We use a multiregional Computable General Equilibrium (CGE) model. We not only discuss the likely implications of REDD for carbon market prices and policy costs but also examine carbon leakage, distributional aspects resulting from climate policies 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. 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

---

<sup>1</sup> the proportion of abatement effort that can be met with non-Annex I country credits

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 presents data and modelling framework. Section 3 discusses results and section 4 concludes.

## **2 The 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 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 are key to our investigation. We updated that, originally restricted to emission reduction from fossil fuel use, to account for emission reduction from avoided deforestation and the trading of carbon credits originated. As said, the model is a dynamic recursive one. However in the present study we use it in a simplified version basically projecting in just one time step all the system from 2001 (the calibration year) to 2020. 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 through 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 simplify, we assumed that each hectare lost to forest is gained to agriculture/pasture (and vice versa). Then, 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 FAO (UN FAO 2006) with Brown (2000) reporting information on timber extraction from primary and forest plantation .

The simulation exercise is performed for year 2020.

Three different scenarios are compared:

The no policy business as usual. This is a 2020 benchmark obtained perturbing the calibration year equilibrium (2001) in order to replicate regional population and GDP growth consistent with the A2 IPCC scenarios.

EU emission reduction policy without REDD: this assumes that the EU implements unilaterally a 20% emission reduction compared to 1990. At this stage we consider only one regional aggregate for the EU, thus this exercise is equivalent to one in which, within the EU, the burden of abatement can be allocated efficiently across sectors and countries through an EU carbon market.

EU emission reduction with REDD. Same 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 EU ETS selling REDD credits. Note that it is assumed that these regions can participate to the EU carbon market even without accepting 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 REDD countries to engage in deforestation actions and allows us to isolate its role in the policy context.

### **3 Results**

#### ***3.1 REDD and overall policy implication***

The EU unilateral mitigation policy imposes the region a reduction of 866 million tons of CO<sub>2</sub> originating a price on the carbon market of 46\$/t CO<sub>2</sub> (Table 1) at a cost for the EU as a whole of roughly 0.9% of its GDP compared to the baseline<sup>2</sup> (Table 2). The unilateral EU effort originates the well known leakage effect. Commodities produced in countries with a less stringent climate policy (in our case without a climate policy indeed) become more competitive as they are not charged with environmental taxes. They are thus increasingly demanded, and increasingly produced. Consequently emissions outside the EU also increase. The study highlights a quite strong leakage (+1.2 % of emissions in the non EU countries) offsetting roughly 45% of European reductions (see Fig. 1). This however should be interpreted as the most pessimistic

---

<sup>2</sup> These figures are perfectly in line with the existing literature. As a comparison we just quote the 2008 EC staff working documents on the cost of meeting the 20-20-20 EU target which estimate for the EU27 a cost ranging from the 0.54% to the 0.66% of GDP with a price ranging from 30 to 47€/t CO<sub>2</sub> (SEC 2008a,b).



possible outcome as it is assumed that no country outside the EU will put in place any emission reduction policy. Interestingly, in this context, it is the USA that contributes more to the world increased emissions, however emerging economies (LACA, FSU, MDE and China) also represent a significant share.

By opening the EU ETS to REDD credits the price of carbon is expected to drop to 8\$/t CO<sub>2</sub> (a reduction of the 83%). Basically the supply of REED credits, without restriction, could alone meet almost the totality of emission reduction required to the EU. Accordingly, the concern that an unrestricted use of REDD credits could flood the carbon market appears justified in this specific context. The EU would buy 6700 \$ million of imported pollution right, but “gaining” a drop of GDP costs from the original 1% to the 0.2% compared to the baseline.

The most interesting effect is probably that on leakage: the possibility for the EU to buy its reduction from REED countries is much less penalizing in term of competitiveness than unilateral reduction. EU commodities “suffer” less in international markets and symmetrically the competitive advantage for non EU countries is reduced. Increase in non EU emissions now offsets just the 12% of EU reduction and GDP gains in the non EU are lower (see table 2).

This trend applies to REDD countries as well.

On the one hand, SSA, EASIA and LACA increase their GDP in the REED compared to the no policy baseline scenario. Thus benefits from selling REDD credits to the EU are larger than their direct and indirect costs. We recall than in our exercise the first are triggered by lower land available to agriculture/pasture and lower raw wood supply to the timber sector (see below). On the other hand, all these regions are unambiguously better off if a carbon market is introduced in Europe without the possibility to use REDD credits (see 8<sup>th</sup> and 2<sup>nd</sup> columns in Table 2). While this may seem counter-intuitive, the explanation behind this result is actually straightforward since it is directly related with carbon leakage. For REDD countries, the EU loss of competitiveness in a unilateral mitigation action outweighs gains from selling REED, but to a more competitive EU. 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 is not uncommon especially when these last, as in our case, are small.

They indeed amount just to 0.08%, 0.21% and 0.09% of GDP for EASIA, SSA and LACA respectively.

Thus summarizing: a full opening of the ETS market to REDD credits would be in the EU interest, but not in that of REDD regions. Rephrasing this using the coalition theory jargon: the participation by REDD regions is profitable, but not internally stable. For them it would be better to free ride on the EU agreement. Note also that, in our context, gains from free-riding arise only because of higher competitiveness and not because of an improved environmental quality brought about by EU emission reductions.

It is worth stressing that this result should be interpreted with care: it is driven by the economic leakage which is one of the most difficult aspect to measure.

Firstly, it is determined by the shape of the agreement determining it. Larger participation and the possibility to sell REDD together with other emission reduction credits may lower its size.

Secondly, it depends on the evolution of the import/export composition in the world market on its turn influenced by technological factors which are very difficult to capture.

Thirdly, it depends on the substitution possibility between imported and domestic goods, i.e. Armington elasticities, which can change over time.

### ***3.2 Effects on land and timber sectors.***

A critical aspect regarding the use of REDD credits in an international carbon market concerns its eventual impact on land and agricultural prices on regions selling avoided deforestation credits. To show the relevance of this effect, Figures 2 and 3 contrast the change in land and timber prices estimated by our exercise, i.e. considering impacts on land and timber supply (“modified model” in figures), with those originated by an exercise in which these are not included (“unmodified model” in figures).

When direct land use effects resulting from reduced deforestation are not modelled, we observe that land prices are marginally affected when the European carbon market is opened to this type of credit. In contrast, when these are taken into account and no restrictions are imposed to the used of REDD credits, land prices increase by 1.1% for

SSA, 2% for EASIA and 1.4% for LACA with respect to business as usual levels. One could expect to observe a higher increase in land prices especially considering that the current policy would reduce deforestation rates in the year 2020 by 22% compared to business as usual. However in term of agricultural/pasture land this means a lower availability of just the 0.9% compared to BAU. As a consequence also the effects on food prices are negligible. A policy requiring more stringent efforts, eventually involving more partners, would likely affect land prices in these regions on a higher scale.

We observe a very similar result regarding changes in timber prices. When timber flows are not directly modelled to take into account land use change impacts, prices remain almost unaffected. However when these are explicitly modelled, timber prices increase by 2.6% in LACA, 3.4% in EASIA and 4.7% in SSA.

An interesting case is that of the LACA region: indeed the EU climate policy (with and without REDD) would *decrease* land and timber prices below business as usual levels when direct effects on land and timber are not considered. This is a typical sectoral recomposition effect: although LACA economies are more competitive when the EU implements its mitigation policy, (indeed LACA GDP increases and its terms of trade improve), these gains are concentrated in the raw material and heavy industry sectors and not in agriculture and forestry whose demand and production fall. When the policy-induced land and timber scarcity are correctly modelled however, their prices increase.

### ***3.3 Restrictions and incentives to selling REDD credits***

In this section we analyse the consequences of introducing limits to the use of REDD credits in the European Trading System. Restriction levels are defined as the maximum amount of total reduction efforts that can be met by Europe using REDD credits. Restrictions can be justified to control the carbon price decrease and maintain a sufficient dynamic stimulus to the development of environmental friendly and energy saving technologies, but also, in the light of what said, as an incentive to REDD countries to sell credits and not free ride on the EU mitigation policy.

Table 1 and 2 present, respectively, the different levels of CO<sub>2</sub> prices and policy costs under various restriction levels. As can be expected, under the EU perspective, both carbon prices and policy costs increase with restrictions. Limiting the use of REDD credits therefore consists of an effective option to preventing an eventual flooding of “cheap” credits into the European carbon market and to keeping carbon prices high enough to stimulate investments in greener technologies, however at the expenses of higher policy costs.

A good compromise between these two conflicting instances could be represented by a 30% restriction to REDD credits: the carbon price would be reduced by approximately 32%, against the 83% reduction when no limits to these type of credits are imposed; at the same time the policy cost measured in terms of GDP loss compared to the baseline equals 0.6%, against 1% in the case where no REDD credits are allowed to enter the ETS. The carbon leakage would remain quite high though, still offsetting 35% of European reductions.

Under the point of view of the REDD regions, first of all it can be noticed that revenues from selling credits are not linear with restrictions (Figure 4). They are determined by the elasticity along the supply curves of REDD credits. Thus they typically follow a bell shaped trend. Thus the largest revenues for SSA and LACA are experienced when restrictions approximately reach the 50%, whereas for EASIA when they are no larger than the 10%.

However, it is also clear that, except from the case of SSA when the use of REDD credits is limited to 5-10%, no restriction is able to make REDD regions better off participating to the market, than not participating and having the EU mitigating with unilateral action.

It is thus confirmed that in our specific exercise indirect effects on competitiveness overcompensate direct REDD revenues from selling credits.

Table 1. CO<sub>2</sub> Price

	Access to REDD credits in the ETS market (100% = full)								
	0%	5%	10%	15%	20%	25%	30%	50%	100%
<i>CO<sub>2</sub> Price \$/t</i>	46	43	40	38	35	33	31	23	8
<i>% reduction wrt full access to REDD credits use</i>		-6%	-12%	-17%	-22%	-27%	-32%	-50%	-83%

Table 2. GDP: % changes w.r.t BAU

	ETS w/o REDD	ETS REDD 5% Limit	ETS REDD 10% Limit	ETS REDD 20% Limit	ETS REDD 30% Limit	ETS REDD 50% Limit	ETS unlimited REDD
<i>USA</i>	0,012	0,012	0,011	0,009	0,008	0,006	0,003
<i>Europe</i>	-0,952	-0,895	-0,839	-0,733	-0,635	-0,463	-0,160
<i>FSU</i>	0,420	0,387	0,355	0,297	0,246	0,170	0,103
<i>KOSAU</i>	0,079	0,075	0,071	0,064	0,056	0,044	0,023
<i>CAJANZ</i>	0,050	0,048	0,045	0,040	0,035	0,027	0,010
<i>NAF</i>	0,318	0,294	0,270	0,227	0,188	0,129	0,079
<i>MDE</i>	0,184	0,171	0,158	0,134	0,112	0,078	0,039
<b>SSA</b>	<b>0,172</b>	<b>0,174</b>	<b>0,174</b>	<b>0,169</b>	<b>0,158</b>	<b>0,130</b>	<b>0,058</b>
<i>SASIA</i>	0,054	0,051	0,048	0,042	0,037	0,027	0,008
<i>CHINA</i>	0,041	0,038	0,035	0,031	0,026	0,019	0,008
<b>EASIA</b>	<b>0,047</b>	<b>0,044</b>	<b>0,041</b>	<b>0,035</b>	<b>0,030</b>	<b>0,021</b>	<b>0,006</b>
<b>LACA</b>	<b>0,064</b>	<b>0,062</b>	<b>0,061</b>	<b>0,057</b>	<b>0,053</b>	<b>0,043</b>	<b>0,023</b>

Note: in bold REDD regions

Figure 1. Carbon Leakage (in % of European emission reductions)

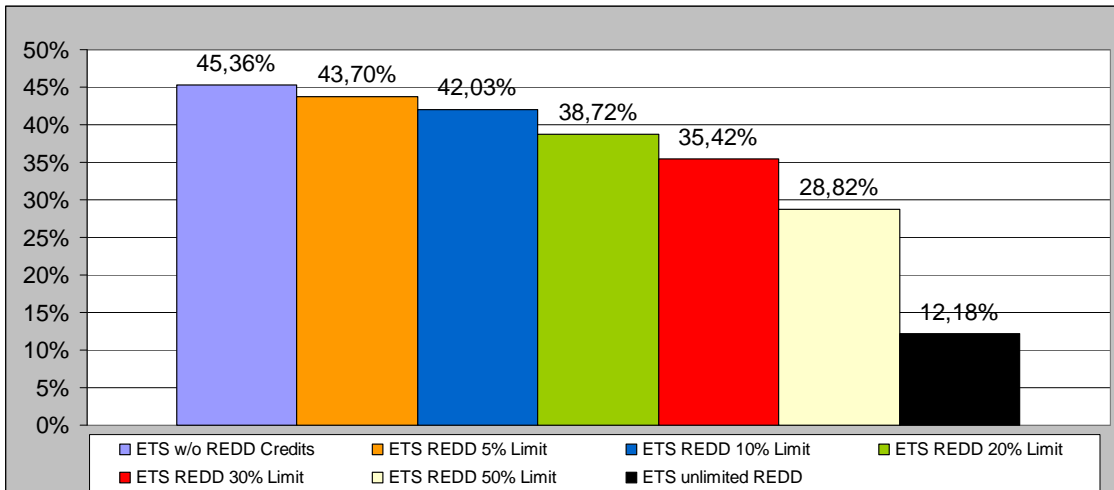


Figure 2. Land Price: % Changes w.r.t BAU

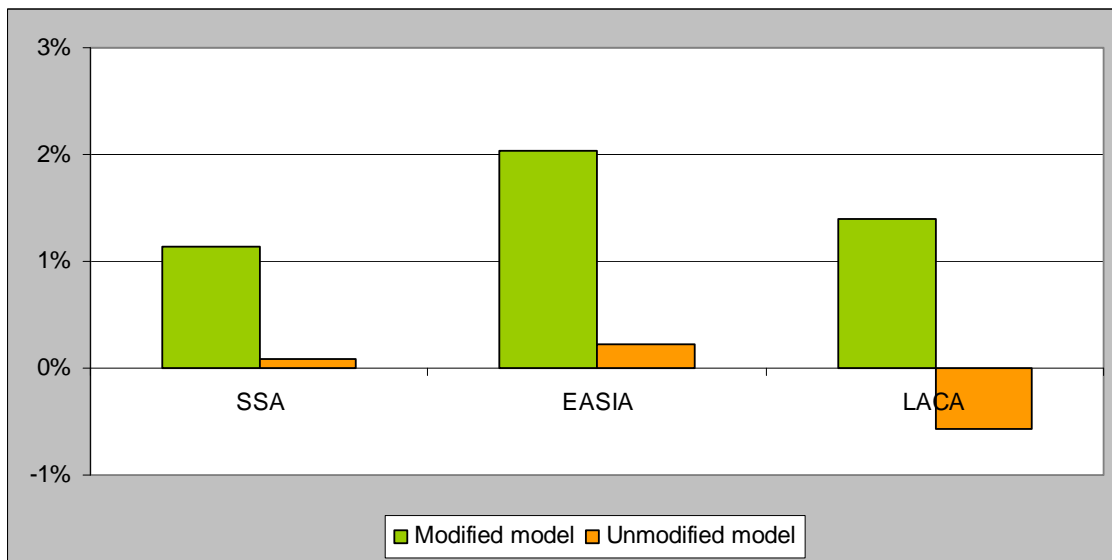


Figure 3. Timber Price: % Changes w.r.t BAU

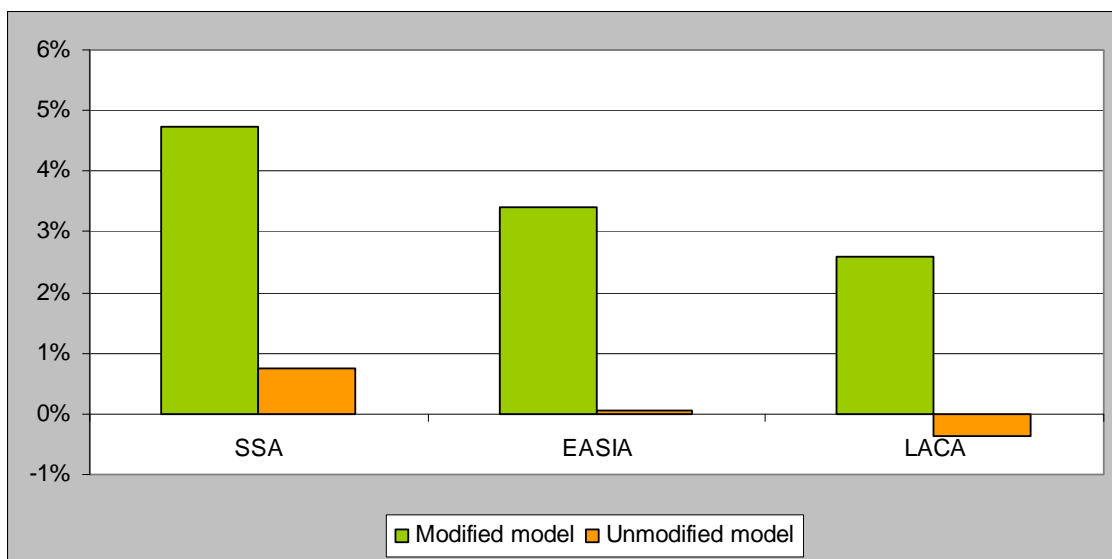
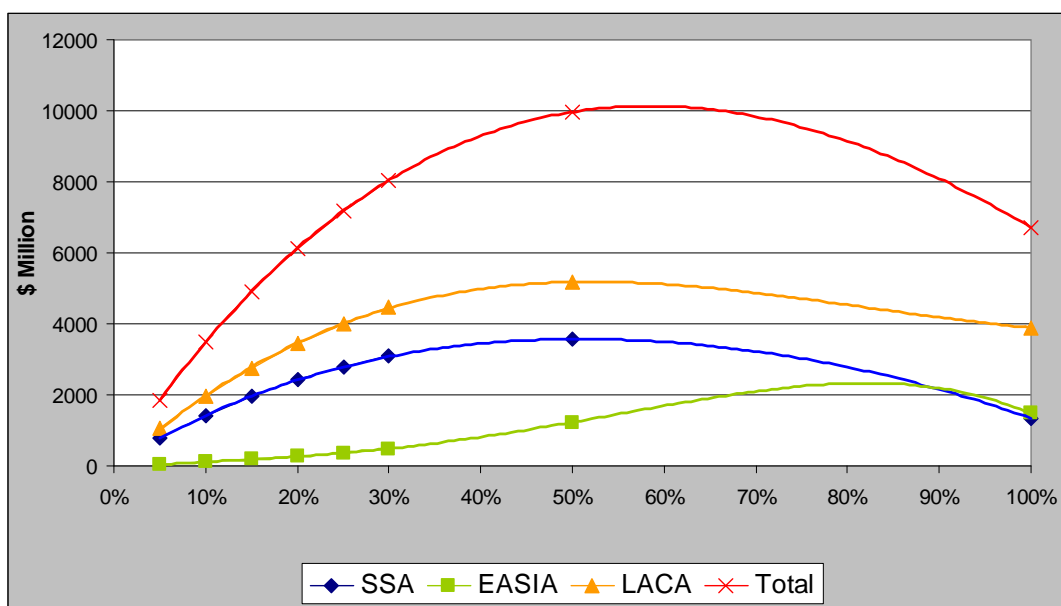


Figure 4. REDD credits revenues



Note: 100% means no restriction to REDD credits use, 0% means no possibility to use REDD credits

#### 4 Conclusions

In this paper we addressed the role REDD may play in the European carbon market assuming that the EU reduces its CO<sub>2</sub> emissions by 20% with respect to 1990 levels in year 2020. We used a multiregional Computable General Equilibrium (CGE) model and, differently from previous studies, we account for both direct and indirect effects occurring on land and timber markets resulting from lower deforestation rates. These, endogenously driven by carbon price signals, then trigger changes in land available to agricultural/pasture activities and in raw timber supply to the wood industry according to estimated functions which are implemented into the model.

Consistently with previous works, we observed that including emissions reductions from avoided deforestation generates considerable policy cost savings peaking up to 80% when no restriction to REDD credit use is imposed. We also confirmed that an unlimited availability of REDD credits could “flood” the market, drastically reduce carbon prices (by 83%), and therefore possibly lower the incentive to develop energy and carbon saving technologies. This can be, however, effectively controlled limiting the access to avoided deforestation permits. For instance, a 30% restriction to REDD

credit use would anyway reduce the policy cost by 34%, but keeping carbon price at the acceptably high level of 31\$/t CO<sub>2</sub>.

Interestingly enough, REDD has the additional benefit of reducing carbon leakage effects resulting from the introduction of the EU climate change policy. While leakage amounts for almost 45% of European reductions under a European trading system excluding REDD, this number decreases to 12% when unlimited access to REDD credit is allowed. The trend in carbon leakage is “mirrored” by that of the economic leakage. Each reduction in the first is coupled with a lower decrease in the competitiveness of EU commodities in international markets. This has important policy implications. Allowing REDD surely entails gain for the EU. This is not necessarily so for REDD regions though. They benefit from the inflow of REDD revenues, but they also face a more competitive EU in the trade arena. Indeed, we showed that the second effect prevails on the first. In particular, GDP in REDD regions is higher when they sell avoided deforestation credits to the EU compared with a no EU policy scenario. Thus benefits from avoided deforestation are higher than the opportunity costs represented by a lower land available to agriculture and pasture activities and by a lower timber supply to the wood industry. Nonetheless, when EASIA, SSA and LACA sell credits to the EU their GDP is lower compared to the case in which the EU implements unilaterally its mitigation policy. In other words, REDD regions would find it preferable to free ride on the EU mitigation policy. Note that in this analysis we are not taking into account the environmental benefits triggered by EU emission reductions, but just those arising from international trade effects. If those were included, the free riding incentive would be even stronger. We also showed that, by and large, no restriction to REDD credit use can revert this outcome.

Finally, the use of REDD credits can effectively reduce de-forestation activities (by 22% in 2020 without restriction) and induce only moderate increases on land and timber prices in REDD regions (in a range of the 1%- 2% the first and of the 2.6% - 4.7% the second).

Many developments are foreseen for the present work.

Firstly, due to the crucial role played by the leakage effect, we would like to test the robustness of our results either to different parameterization of the Armington elasticities which drives the substitutability between domestic and imported



commodities (even though a plausible trend is that of an increase in this substitutability and accordingly that of a stronger leakage) or to a different design of the mitigation agreement. In this last respect an enlarged participation - for instance including all developed regions – will decrease the leakage and possibly reduce the incentive to free ride.

Secondly we would like to improve the dynamic nature of the whole exercise. At present we are using a recursive-dynamic model just projecting the whole system in one jump to 2020. In a next work we would use one year time-steps to implement more detailed time specific curves for de-forestation activities.

## References

- Bosetti V., Luobowski, R., Golub, A., Markandya, A., 2009, "Linking Reduced Deforestation and a Global Carbon Market: Impacts on Costs, Financial Flows, and Technological Innovation", *FEEM Nota di lavoro Paper 56.2009*
- Bosetti, V., C. Carraro, M. Galeotti, E. Massetti and M. Tavoni (2006), "WITCH: A World Induced Technical Change Hybrid Model", *The Energy Journal*, Special Issue. Hybrid Modeling of Energy-Environment Policies: Reconciling Bottom-up and Top-down, 13-38.
- Burniaux J-M., Truong, T.P., (2002) GTAP-E: An Energy-Environmental Version of the GTAP Model. GTAP Technical Paper n.16.
- Brown C., 2000, *The global outlook for future wood supply from forest plantations*, FAO working paper N°: GFPOS/WP/03
- Dimaranan, B.V. (2006), *The GTAP 6 Data Base*, Center for Global Trade Analysis, Department of Agricultural Economics, Purdue University.
- Dixon, Alistair, Niels Anger, Rachel Holden, and Erich Livengood, 2009, "Integration of REDD into the international carbon market: Implications for future commitments and market regulation". *Report prepared for the New Zealand Ministry of Agriculture and Forestry by M-co Consulting, New Zealand, and Centre for European Economic Research (ZEW), Germany.*
- Energy Information Administration (2007), "Annual Energy Outlook 2007, with projections to 2030", Report n° DOE/EIA-0383(2007), [www.eia.doe.gov/oiaf/aeo/](http://www.eia.doe.gov/oiaf/aeo/)
- Energy Information Administration (2009), "International Energy Outlook 2009", Report n° DOE/EIA-0484(2009), <http://www.eia.doe.gov/oiaf/ieo/index.html>
- Eliasch, Johann, 2008, "Climate Change: Financing Global Forests", Norwich, UK: The Stationery Office.
- Gusti, M., Havlik, P., Oberstenier, M., 2008, "Technical description of the IIASA model cluster", International Institute for Applied System Analysis (IIASA).
- Hertel, T.W. (1996) *Global Trade Analysis: Modeling and applications*. Cambridge University Press. Cambridge.
- IMAGE (2001), "The IMAGE 2.2 Implementation of the SRES Scenarios", RIVM CD-ROM Publication 481508018. Bilthoven. The Netherlands.

- IPCC, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.
- Kindermann, G., M. Obersteiner, B. Sohngen J. Sathaye, K. Andrasko, E. Rametsteiner, B. Schlamadinger, S. Wunder, R. Beach. 2008. "Global cost estimates of reducing carbon emissions through avoided deforestation." *Proceedings of the National Academy of Sciences*. 105(30): 10302–10307.
- Nordhaus, W., and J. Boyer, 2000. *Warming the World: Economic Models of Global Warming*. Cambridge, MA: MIT Press.
- Commission Staff Working Document (SEC) (2008a), "Document accompanying the Package of Implementation measures for the EU's objectives on climate change and renewable energy for 2020", SEC(2008) 85/3
- Commission Staff Working Document (SEC) (2008b), "Document accompanying the Package of Implementation measures for the EU's objectives on climate change and renewable energy for 2020. Vol II", SEC(2008) 85.
- Sohngen, B. and R. Mendelsohn. 2003. "An Optimal Control Model of Forest Carbon Sequestration." *American Journal of Agricultural Economics*. 85(2): 448-457.
- Tavoni, M., B Sohngen, and V. Bosetti. 2007. "Forestry and the carbon market response to stabilize climate." *Energy Policy*. 35(11): 5346-5353.
- UN Food and Agricultural Organization . 2006. *Global Forest Resources Assessment 2005: Progress towards sustainable forest management*. FAO Forestry paper 147. United Nations Food and Agricultural Organization. Rome, Italy.
- UNPD (2008), "World population prospects. The 2008 revision", on line material available at: <http://esa.un.org/unpp/index.asp>

***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*

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

ICES solves recursively a sequence of static equilibria linked by endogenous investment determining the growth of capital stock from 2001 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)*

<i>Region</i>	<i>GDP growth</i>
USA	52.7
Med_Europe	35.3
North_Europe	33.3
East_Europe	103.0
FSU	157.6
KOSAU	47.5
CAJANZ	33.2
NAF	165.0
MDE	146.2
SSA	199.6
SASIA	225.4
CHINA	275.6
EASIA	172.3
LACA	106.9

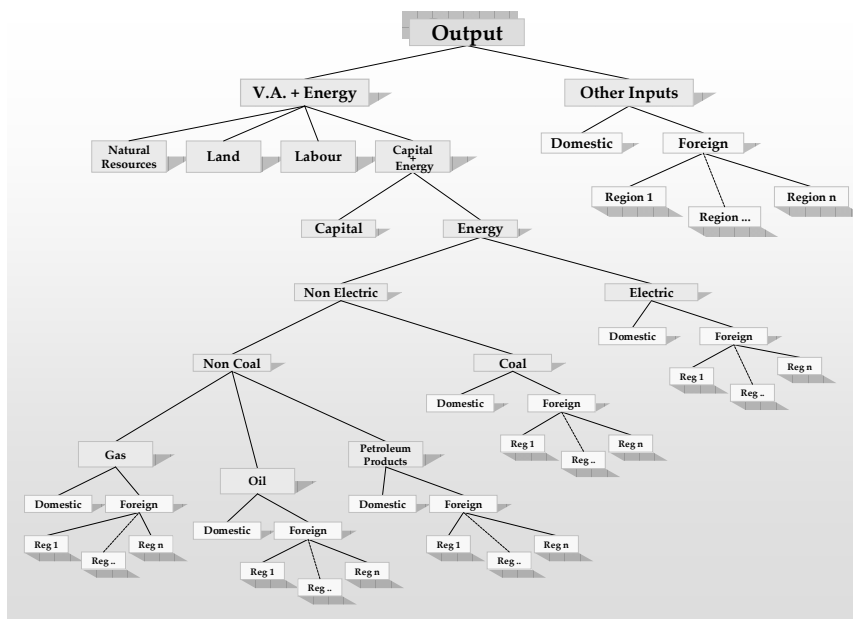
Assumptions on the evolution of population (taken from UNPD, 2008), energy efficiency (taken from Bosetti et. al., 2006), GHG emission and of major fossil fuel prices (based on EIA, 2007 and EIA, 2009) are also incorporated and reported in Table A3.

Table A3. Major exogenous variables growth rates for the BAU (% 2001-2020)

Region	Population	Energy efficiency	CO2	Fuel	Price
USA	15.6	12.8	21.6	Coal	16
Med_Europe	0.5	17.1	1.7	Oil	74
North_Europe	0.1	17.1	1.8	Gas	28
East_Europe	-4.6	40.4	28.6	Oil Products	40
FSU	-3.2	36.6	74.0		
KOSAU	9.4	27.5	10.1		
CAJANZ	-0.4	17.3	2.2		
NAF	31.7	26.8	65.5		
MDE	37.6	26.8	72.8		
SSA	46.9	22.0	129.2		
SASIA	29.9	44.7	115.5		
CHINA	12.3	47.5	145.7		
EASIA	24.3	43.5	75.3		
LACA	26.4	23.5	36.4		

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.

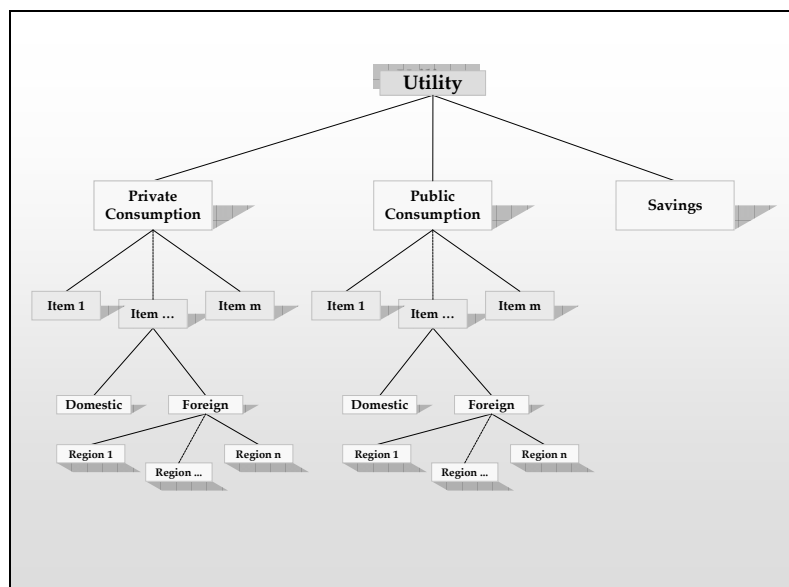
Public consumption is split in a series of alternative consumption items, again according to a Cobb-Douglas specification. However, almost all expenditure is actually concentrated in one specific industry: Non-market Services.

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*



## NOTE DI LAVORO DELLA FONDAZIONE ENI ENRICO MATTEI

### Fondazione Eni Enrico Mattei Working Paper Series

Our Note di Lavoro are available on the Internet at the following addresses:

<http://www.feem.it/getpage.aspx?id=73&sez=Publications&padre=20&tab=1>  
[http://papers.ssrn.com/sol3/JELJOUR\\_Results.cfm?form\\_name=journalbrowse&journal\\_id=266659](http://papers.ssrn.com/sol3/JELJOUR_Results.cfm?form_name=journalbrowse&journal_id=266659)  
<http://ideas.repec.org/s/fem/femwpa.html>  
<http://www.econis.eu/LNG=EN/FAM?PPN=505954494>  
<http://ageconsearch.umn.edu/handle/35978>  
<http://www.bepress.com/feem/>

### NOTE DI LAVORO PUBLISHED IN 2010

- GC 1.2010 Cristina Cattaneo: [Migrants' International Transfers and Educational Expenditure: Empirical Evidence from Albania](#)
- SD 2.2010 Fabio Antoniou, Panos Hatzipanayotou and Phoebe Koundouri: [Tradable Permits vs Ecological Dumping](#)
- SD 3.2010 Fabio Antoniou, Panos Hatzipanayotou and Phoebe Koundouri: [Second Best Environmental Policies under Uncertainty](#)
- SD 4.2010 Carlo Carraro, Enrica De Cian and Lea Nicita: [Modeling Biased Technical Change. Implications for Climate Policy](#)
- IM 5.2010 Luca Di Corato: [Profit Sharing under the threat of Nationalization](#)
- SD 6.2010 Masako Ikefuji, Jun-ichi Itaya and Makoto Okamura: [Optimal Emission Tax with Endogenous Location Choice of Duopolistic Firms](#)
- SD 7.2010 Michela Catenacci and Carlo Giupponi: [Potentials and Limits of Bayesian Networks to Deal with Uncertainty in the Assessment of Climate Change Adaptation Policies](#)
- GC 8.2010 Paul Sarfo-Mensah and William Oduro: [Changes in Beliefs and Perceptions about the Natural Environment in the Forest-Savanna Transitional Zone of Ghana: The Influence of Religion](#)
- IM 9.2010 Andrea Boitani, Marcella Nicolini and Carlo Scarpa: [Do Competition and Ownership Matter? Evidence from Local Public Transport in Europe](#)
- SD 10.2010 Helen Ding and Paulo A.L.D. Nunes and Sonja Teelucksingh: [European Forests and Carbon Sequestration Services : An Economic Assessment of Climate Change Impacts](#)
- GC 11.2010 Enrico Bertacchini, Walter Santagata and Giovanni Signorello: [Loving Cultural Heritage Private Individual Giving and Prosocial Behavior](#)
- SD 12.2010 Antoine Dechezleprêtre, Matthieu Glachant and Yann Ménière: [What Drives the International Transfer of Climate Change Mitigation Technologies? Empirical Evidence from Patent Data](#)
- SD 13.2010 Andrea Bastianin, Alice Favero and Emanuele Massetti: [Investments and Financial Flows Induced by Climate Mitigation Policies](#)
- SD 14.2010 Reyer Gerlagh: [Too Much Oil](#)
- IM 15.2010 Chiara Fumagalli and Massimo Motta: [A Simple Theory of Predation](#)
- GC 16.2010 Rinaldo Brau, Adriana Di Liberto and Francesco Pigliaru: [Tourism and Development: A Recent Phenomenon Built on Old \(Institutional\) Roots?](#)
- SD 17.2010 Lucia Vergano, Georg Umgieser and Paulo A.L.D. Nunes: [An Economic Assessment of the Impacts of the MOSE Barriers on Venice Port Activities](#)
- SD 18.2010 ZhongXiang Zhang: [Climate Change Meets Trade in Promoting Green Growth: Potential Conflicts and Synergies](#)
- SD 19.2010 Elisa Lanzi and Ian Sue Wing: [Capital Malleability and the Macroeconomic Costs of Climate Policy](#)
- IM 20.2010 Alberto Petrucci: [Second-Best Optimal Taxation of Oil and Capital in a Small Open Economy](#)
- SD 21.2010 Enrica De Cian and Alice Favero: [Fairness, Credibility and Effectiveness in the Copenhagen Accord: An Economic Assessment](#)
- SD 22.2010 Francesco Bosello: [Adaptation, Mitigation and "Green" R&D to Combat Global Climate Change. Insights From an Empirical Integrated Assessment Exercise](#)
- IM 23.2010 Jean Tirole and Roland Bénabou: [Individual and Corporate Social Responsibility](#)
- IM 24.2010 Cesare Dosi and Michele Moretto: [Licences, "Use or Lose" Provisions and the Time of Investment](#)
- GC 25.2010 Andrés Rodríguez-Pose and Vassilis Tselios (lxxvi): [Returns to Migration, Education, and Externalities in the European Union](#)
- GC 26.2010 Klaus Desmet and Esteban Rossi-Hansberg (lxxvi): [Spatial Development](#)
- SD 27.2010 Massimiliano Mazzanti, Anna Montini and Francesco Nicolli: [Waste Generation and Landfill Diversion Dynamics: Decentralised Management and Spatial Effects](#)
- SD 28.2010 Lucia Ceccato, Valentina Giannini and Carlo Gipponi: [A Participatory Approach to Assess the Effectiveness of Responses to Cope with Flood Risk](#)
- SD 29.2010 Valentina Bosetti and David G. Victor: [Politics and Economics of Second-Best Regulation of Greenhouse Gases: The Importance of Regulatory Credibility](#)
- IM 30.2010 Francesca Cornelli, Zbigniew Kominek and Alexander Ljungqvist: [Monitoring Managers: Does it Matter?](#)
- GC 31.2010 Francesco D'Amuri and Juri Marcucci: ["Google it!" Forecasting the US Unemployment Rate with a Google Job Search index](#)
- SD 32.2010 Francesco Bosello, Carlo Carraro and Enrica De Cian: [Climate Policy and the Optimal Balance between Mitigation, Adaptation and Unavoided Damage](#)

SD	33.2010	Enrica De Cian and Massimo Tavoni: <a href="#">The Role of International Carbon Offsets in a Second-best Climate Policy: A Numerical Evaluation</a>
SD	34.2010	ZhongXiang Zhang: <a href="#">The U.S. Proposed Carbon Tariffs, WTO Scrutiny and China's Responses</a>
IM	35.2010	Vincenzo Denicolò and Piercarlo Zanchettin: <a href="#">Leadership Cycles</a>
SD	36.2010	Stéphanie Monjon and Philippe Quirion: <a href="#">How to Design a Border Adjustment for the European Union Emissions Trading System?</a>
SD	37.2010	Meriem Hamdi-Cherif, Céline Guivarch and Philippe Quirion: <a href="#">Sectoral Targets for Developing Countries: Combining "Common but Differentiated Responsibilities" with "Meaningful participation"</a>
IM	38.2010	G. Andrew Karolyi and Rose C. Liao: <a href="#">What is Different about Government-Controlled Acquirers in Cross-Border Acquisitions?</a>
GC	39.2010	Kjetil Bjorvatn and Alireza Naghavi: <a href="#">Rent Seekers in Rentier States: When Greed Brings Peace</a>
GC	40.2010	Andrea Mantovani and Alireza Naghavi: <a href="#">Parallel Imports and Innovation in an Emerging Economy</a>
SD	41.2010	Luke Brander, Andrea Ghermandi, Onno Kuik, Anil Markandya, Paulo A.L.D. Nunes, Marije Schaafsma and Alfred Wagtenonk: <a href="#">Scaling up Ecosystem Services Values: Methodology, Applicability and a Case Study</a>
SD	42.2010	Valentina Bosetti, Carlo Carraro, Romain Duval and Massimo Tavoni: <a href="#">What Should We Expect from Innovation? A Model-Based Assessment of the Environmental and Mitigation Cost Implications of Climate-Related R&amp;D</a>
SD	43.2010	Frank Vöhringer, Alain Haurie, Dabo Guan, Maryse Labriet, Richard Loulou, Valentina Bosetti, Pryadarshi R. Shukla and Philippe Thalmann: <a href="#">Reinforcing the EU Dialogue with Developing Countries on Climate Change Mitigation</a>
GC	44.2010	Angelo Antoci, Pier Luigi Sacco and Mauro Sodini: <a href="#">Public Security vs. Private Self-Protection: Optimal Taxation and the Social Dynamics of Fear</a>
IM	45.2010	Luca Enriques: <a href="#">European Takeover Law: The Case for a Neutral Approach</a>
SD	46.2010	Maureen L. Cropper, Yi Jiang, Anna Alberini and Patrick Baur: <a href="#">Getting Cars Off the Road: The Cost-Effectiveness of an Episodic Pollution Control Program</a>
IM	47.2010	Thomas Hellman and Enrico Perotti: <a href="#">The Circulation of Ideas in Firms and Markets</a>
IM	48.2010	James Dow and Enrico Perotti: <a href="#">Resistance to Change</a>
SD	49.2010	Jaromir Kovarik, Friederike Mengel and José Gabriel Romero: <a href="#">(Anti-) Coordination in Networks</a>
SD	50.2010	Helen Ding, Silvia Silvestri, Aline Chiabai and Paulo A.L.D. Nunes: <a href="#">A Hybrid Approach to the Valuation of Climate Change Effects on Ecosystem Services: Evidence from the European Forests</a>
GC	51.2010	Pauline Grosjean (lxxxvii): <a href="#">A History of Violence: Testing the 'Culture of Honor' in the US South</a>
GC	52.2010	Paolo Buonanno and Matteo M. Galizzi (lxxxvii): <a href="#">Advocatus, et non Iatro? Testing the Supplier-Induced-Demand Hypothesis for Italian Courts of Justice</a>
GC	53.2010	Gilat Levy and Ronny Razin (lxxxvii): <a href="#">Religious Organizations</a>
GC	54.2010	Matteo Cervellati and Paolo Vanin (lxxxvii): <a href="#">"Thou shalt not covet ...": Prohibitions, Temptation and Moral Values</a>
GC	55.2010	Sebastian Galiani, Martín A. Rossi and Ernesto Schargrodsky (lxxxvii): <a href="#">Conscription and Crime: Evidence from the Argentine Draft Lottery</a>
GC	56.2010	Alberto Alesina, Yann Algan, Pierre Cahuc and Paola Giuliano (lxxxvii): <a href="#">Family Values and the Regulation of Labor</a>
GC	57.2010	Raquel Fernández (lxxxvii): <a href="#">Women's Rights and Development</a>
GC	58.2010	Tommaso Nannicini, Andrea Stella, Guido Tabellini, Ugo Troiano (lxxxvii): <a href="#">Social Capital and Political Accountability</a>
GC	59.2010	Eleonora Patacchini and Yves Zenou (lxxxvii): <a href="#">Juvenile Delinquency and Conformism</a>
GC	60.2010	Gani Aldashev, Imane Chaara, Jean-Philippe Platteau and Zaki Wahhaj (lxxxvii): <a href="#">Using the Law to Change the Custom</a>
GC	61.2010	Jeffrey Butler, Paola Giuliano and Luigi Guiso (lxxxvii): <a href="#">The Right Amount of Trust</a>
SD	62.2010	Valentina Bosetti, Carlo Carraio and Massimo Tavoni: <a href="#">Alternative Paths toward a Low Carbon World</a>
SD	63.2010	Kelly C. de Bruin, Rob B. Dellink and Richard S.J. Tol: <a href="#">International Cooperation on Climate Change Adaptation from an Economic Perspective</a>
IM	64.2010	Andrea Bigano, Ramon Arigoni Ortiz, Anil Markandya, Emanuela Menichetti and Roberta Pierfederici: <a href="#">The Linkages between Energy Efficiency and Security of Energy Supply in Europe</a>
SD	65.2010	Anil Markandya and Wan-Jung Chou: <a href="#">Eastern Europe and the former Soviet Union since the fall of the Berlin Wall: Review of the Changes in the Environment and Natural Resources</a>
SD	66.2010	Anna Alberini and Milan Ščasný: <a href="#">Context and the VSL: Evidence from a Stated Preference Study in Italy and the Czech Republic</a>
SD	67.2010	Francesco Bosello, Ramiro Parrado and Renato Rosa: <a href="#">The Economic and Environmental Effects of an EU Ban on Illegal Logging Imports. Insights from a CGE Assessment</a>
IM	68.2010	Alessandro Fedele, Paolo M. Panteghini and Sergio Vergalli: <a href="#">Optimal Investment and Financial Strategies under Tax Rate Uncertainty</a>
IM	69.2010	Carlo Cambini, Laura Rondi: <a href="#">Regulatory Independence and Political Interference: Evidence from EU Mixed-Ownership Utilities' Investment and Debt</a>
SD	70.2010	Xavier Pautrel: <a href="#">Environmental Policy, Education and Growth with Finite Lifetime: the Role of Abatement Technology</a>
SD	71.2010	Antoine Leblois and Philippe Quirion: <a href="#">Agricultural Insurances Based on Meteorological Indices: Realizations, Methods and Research Agenda</a>
IM	72.2010	Bin Dong and Benno Torgler: <a href="#">The Causes of Corruption: Evidence from China</a>
IM	73.2010	Bin Dong and Benno Torgler: <a href="#">The Consequences of Corruption: Evidence from China</a>



- IM 74.2010 Fereydoun Verdinejad and Yasaman Gorji: [The Oil-Based Economies International Research Project. The Case of Iran.](#)
- GC 75.2010 Stelios Michalopoulos, Alireza Naghavi and Giovanni Prarolo (lxxxvii): [Trade and Geography in the Economic Origins of Islam: Theory and Evidence](#)
- SD 76.2010 ZhongXiang Zhang: [China in the Transition to a Low-Carbon Economy](#)
- SD 77.2010 Valentina Iafolla, Massimiliano Mazzanti and Francesco Nicolli: [Are You SURE You Want to Waste Policy Chances? Waste Generation, Landfill Diversion and Environmental Policy Effectiveness in the EU15](#)
- IM 78.2010 Jean Tirole: [Illiquidity and all its Friends](#)
- SD 79.2010 Michael Finus and Pedro Pintassilgo: [International Environmental Agreements under Uncertainty: Does the Veil of Uncertainty Help?](#)
- SD 80.2010 Robert W. Hahn and Robert N. Stavins: [The Effect of Allowance Allocations on Cap-and-Trade System Performance](#)
- SD 81.2010 Francisco Alpizar, Fredrik Carlsson and Maria Naranjo (lxxxviii): [The Effect of Risk, Ambiguity and Coordination on Farmers' Adaptation to Climate Change: A Framed Field Experiment](#)
- SD 82.2010 Shardul Agrawala and Maëlis Carraro (lxxxviii): [Assessing the Role of Microfinance in Fostering Adaptation to Climate Change](#)
- SD 83.2010 Wolfgang Lutz (lxxxviii): [Improving Education as Key to Enhancing Adaptive Capacity in Developing Countries](#)
- SD 84.2010 Rasmus Heltberg, Habiba Gitay and Radhika Prabhu (lxxxviii): [Community-based Adaptation: Lessons from the Development Marketplace 2009 on Adaptation to Climate Change](#)
- SD 85.2010 Anna Alberini, Christoph M. Rheinberger, Andrea Leiter, Charles A. McCormick and Andrew Mizrahi: [What is the Value of Hazardous Weather Forecasts? Evidence from a Survey of Backcountry Skiers](#)
- SD 86.2010 Anna Alberini, Milan Ščasný, Dennis Guignet and Stefania Tonin: [The Benefits of Contaminated Site Cleanup Revisited: The Case of Naples and Caserta, Italy](#)
- GC 87.2010 Paul Sarfo-Mensah, William Oduro, Fredrick Antoh Fredua and Stephen Amisah: [Traditional Representations of the Natural Environment and Biodiversity Conservation: Sacred Groves in Ghana](#)
- IM 88.2010 Gian Luca Clementi, Thomas Cooley and Sonia Di Giannatale: [A Theory of Firm Decline](#)
- IM 89.2010 Gian Luca Clementi and Thomas Cooley: [Executive Compensation: Facts](#)
- GC 90.2010 Fabio Sabatini: [Job Instability and Family Planning: Insights from the Italian Puzzle](#)
- SD 91.2010 ZhongXiang Zhang: [Copenhagen and Beyond: Reflections on China's Stance and Responses](#)
- SD 92.2010 ZhongXiang Zhang: [Assessing China's Energy Conservation and Carbon Intensity: How Will the Future Differ from the Past?](#)
- SD 93.2010 Daron Acemoglu, Philippe Aghion, Leonardo Bursztyl and David Hemous: [The Environment and Directed Technical Change](#)
- SD 94.2010 Valeria Costantini and Massimiliano Mazzanti: [On the Green Side of Trade Competitiveness? Environmental Policies and Innovation in the EU](#)
- IM 95.2010 Vitoria Cerasi, Barbara Chizzolini and Marc Ivaldi: [The Impact of Mergers on the Degree of Competition in the Banking Industry](#)
- SD 96.2010 Emanuele Massetti and Lea Nicita: [The Optimal Climate Policy Portfolio when Knowledge Spills Across Sectors](#)
- SD 97.2010 Sheila M. Olmstead and Robert N. Stavins: [Three Key Elements of Post-2012 International Climate Policy Architecture](#)
- SD 98.2010 Lawrence H. Goulder and Robert N. Stavins: [Interactions between State and Federal Climate Change Policies](#)
- IM 99.2010 Philippe Aghion, John Van Reenen and Luigi Zingales: [Innovation and Institutional Ownership](#)
- GC 100.2010 Angelo Antoci, Fabio Sabatini and Mauro Sodini: [The Solaria Syndrome: Social Capital in a Growing Hyper-technological Economy](#)
- SD 101.2010 Georgios Kossioris, Michael Plexousakis, Anastasios Xepapadeas and Aart de Zeeuw: [On the Optimal Taxation of Common-Pool Resources](#)
- SD 102.2010 ZhongXiang Zhang: [Liberalizing Climate-Friendly Goods and Technologies in the WTO: Product Coverage, Modalities, Challenges and the Way Forward](#)
- SD 103.2010 Gérard Mondello: [Risky Activities and Strict Liability Rules: Delegating Safety](#)
- GC 104.2010 João Ramos and Benno Torgler: [Are Academics Messy? Testing the Broken Windows Theory with a Field Experiment in the Work Environment](#)
- IM 105.2010 Maurizio Ciaschini, Francesca Severini, Claudio Socci and Rosita Pretaroli: [The Economic Impact of the Green Certificate Market through the Macro Multiplier Approach](#)
- SD 106.2010 Joëlle Noailly: [Improving the Energy-Efficiency of Buildings: The Impact of Environmental Policy on Technological Innovation](#)
- SD 107.2010 Francesca Sanna-Randaccio and Roberta Sestini: [The Impact of Unilateral Climate Policy with Endogenous Plant Location and Market Size Asymmetry](#)
- SD 108.2010 Valeria Costantini, Massimiliano Mozzanti and Anna Montini: [Environmental Performance and Regional Innovation Spillovers](#)
- IM 109.2010 Elena Costantino, Maria Paola Marchello and Cecilia Mezzano: [Social Responsibility as a Driver for Local Sustainable Development](#)
- GC 110.2010 Marco Percoco: [Path Dependence, Institutions and the Density of Economic Activities: Evidence from Italian Cities](#)
- SD 111.2010 Sonja S. Teelucksingh and Paulo A.L.D. Nunes: [Biodiversity Valuation in Developing Countries: A Focus on Small Island Developing States \(SIDS\)](#)
- SD 112.2010 ZhongXiang Zhang: [In What Format and under What Timeframe Would China Take on Climate Commitments? A Roadmap to 2050](#)

- SD 113.2010 Emanuele Massetti and Fabio Sferra: [A Numerical Analysis of Optimal Extraction and Trade of Oil under Climate Policy](#)
- IM 114.2010 Nicola Gennaioli, Andrei Shleifer and Robert Vishny: [A Numerical Analysis of Optimal Extraction and Trade of Oil under Climate Policy](#)
- GC 115.2010 Romano Piras: [Internal Migration Across Italian regions: Macroeconomic Determinants and Accommodating Potential for a Dualistic Economy](#)
- SD 116.2010 Messan Agbaglah and Lars Ehlers (lxxxix): [Overlapping Coalitions, Bargaining and Networks](#)
- SD 117.2010 Pascal Billand, Christophe Bravard, Subhadip Chakrabarti and Sudipta Sarangi (lxxxix): [Spying in Multi-market Oligopolies](#)
- SD 118.2010 Roman Chuhay (lxxxix): [Marketing via Friends: Strategic Diffusion of Information in Social Networks with Homophily](#)
- SD 119.2010 Françoise Forges and Ram Orzach (lxxxix): [Core-stable Rings in Second Price Auctions with Common Values](#)
- SD 120.2010 Markus Kinader (lxxxix): [The Repeated Prisoner's Dilemma in a Network](#)
- SD 121.2010 Alexey Kushnir (lxxxix): [Harmful Signaling in Matching Markets](#)
- SD 122.2010 Emiliya Lazarova and Dinko Dimitrov (lxxxix): [Status-Seeking in Hedonic Games with Heterogeneous Players](#)
- SD 123.2010 Maria Montero (lxxxix): [The Paradox of New Members in the EU Council of Ministers: A Non-cooperative Bargaining Analysis](#)
- SD 124.2010 Leonardo Boncinelli and Paolo Pin (lxxxix): [Stochastic Stability in the Best Shot Game](#)
- SD 125.2010 Nicolas Qu  rou (lxxxix): [Group Bargaining and Conflict](#)
- SD 126.2010 Emily Tanimura (lxxxix): [Diffusion of Innovations on Community Based Small Worlds: the Role of Correlation between Social Spheres](#)
- SD 127.2010 Alessandro Tavoni, Maja Schl  ter and Simon Levin (lxxxix): [The Survival of the Conformist: Social Pressure and Renewable Resource Management](#)
- SD 128.2010 Norma Olaizola and Federico Valenciano (lxxxix): [Information, Stability and Dynamics in Networks under Institutional Constraints](#)
- GC 129.2010 Darwin Cort  s, Guido Friebe and Dar  o Maldonado (lxxxvii): [Crime and Education in a Model of Information Transmission](#)
- IM 130.2010 Rosella Levaggi, Michele Moretto and Paolo Pertile: [Static and Dynamic Efficiency of Irreversible Health Care Investments under Alternative Payment Rules](#)
- SD 131.2010 Robert N. Stavins: [The Problem of the Commons: Still Unsettled after 100 Years](#)
- SD 132.2010 Louis-Ga  tan Giraudet and Dominique Finon: [On the Road to a Unified Market for Energy Efficiency: The Contribution of White Certificates Schemes](#)
- SD 133.2010 Melina Barrio and Maria Loureiro: [The Impact of Protest Responses in Choice Experiments](#)
- IM 134.2010 Vincenzo Denicol   and Christine Halmenschlager: [Optimal Patentability Requirements with Fragmented Property Rights](#)
- GC 135.2010 Angelo Antoci, Paolo Russu and Elisa Ticci: [Local Communities in front of Big External Investors: An Opportunity or a Risk?](#)
- SD 136.2010 Carlo Carraro and Emanuele Massetti: [Beyond Copenhagen: A Realistic Climate Policy in a Fragmented World](#)
- SD 137.2010 Valentin Przylyuski and St  phane Hallegatte: [Climate Change Adaptation, Development, and International Financial Support: Lessons from EU Pre-Accession and Solidarity Funds](#)
- SD 138.2010 Ruslana Rachel Palatnik and Paulo A.L.D. Nunes: [Valuation of Linkages between Climate Change, Biodiversity and Productivity of European Agro-Ecosystems](#)
- SD 139.2010 Anna Alberini and Milan   asn  y: [Does the Cause of Death Matter? The Effect of Dread, Controllability, Exposure and Latency on the Vsl](#)
- IM 140.2010 Gordon L. Clark and Ashby H. B. Monk: [Sovereign Wealth Funds: Form and Function in the 21st Century](#)
- SD 141.2010 Simone Borghesi: [The European Emission Trading Scheme and Renewable Energy Policies: Credible Targets for Incredible Results?](#)
- SD 142.2010 Francesco Bosello and Fabio Eboli: [REDD in the Carbon Market: A General Equilibrium Analysis](#)

(lxxxvi) *This paper was presented at the Conference on "Urban and Regional Economics" organised by the Centre for Economic Policy Research (CEPR) and FEEM, held in Milan on 12-13 October 2009.*

(lxxxvii) *This paper was presented at the Conference on "Economics of Culture, Institutions and Crime" organised by SUS.DIV, FEEM, University of Padua and CEPR, held in Milan on 20-22 January 2010.*

(lxxxviii) *This paper was presented at the International Workshop on "The Social Dimension of Adaptation to Climate Change", jointly organized by the International Center for Climate Governance, Centro Euro-Mediterraneo per i Cambiamenti Climatici and Fondazione Eni Enrico Mattei, held in Venice, 18-19 February 2010.*

(lxxxix) *This paper was presented at the 15th Coalition Theory Network Workshop organised by the Groupement de Recherche en Economie Quantitative d'Aix-Marseille, (GREQAM), held in Marseille, France, on June 17-18, 2010.*